University of Applied Sciences
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# Milestones for Decommissioning of Offshore Wind Parks

## An Operational Approach to Decommissioning of Offshore Wind Parks

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# Contents

# 1. Introduction

The decommissioning of offshore wind parks is a project that has different phases. The phases entail planning, administration and management, engineering and design, preparation for operation, and the operation itself and lastly post-decommissioning activities. Under each phase, there are certain activities that are mentioned in this document.

Planning includes study and arrangement of all possible activities for and during the project, estimation of requirements including machinery and personnel to execute the project and associate time to carry out each activity and finally to allocate Work-Breakdown Structure (WBS) to each action.

Administration and management activities cover all phases of the project from making decision based on international and national regulations, recommended practices, common practices, granting consents, perform safety analysis of the operations, commercial issues, execution of the project and obtaining required approval and certificate.

The engineering includes basic and detail design (or FEED), preparation of procedures, drawings and simulations of operations. Engineering should be carried out according to common practices, national and internarial regulations, conventions, protocols, annexes, resolutions, circulars, standards, recommended practices and so forth. The engineering process shall be optimized in order to achieve the DecomTools objectives which are cost reduction by 20%, $CO_2$ emission mitigation by 25% and increasing knowledge and know-how i.e. in regard to safety measures.

Preparation for operation and the operation itself includes all pre-decommissioning activities such as offshore and onshore mobilization, a pre-decommissioning survey, the disassembly of wind park components such as wind turbines, offshore high voltage substations (OHVS) and associated structures. Furthermore, removal of cables, recovery of means of cable and foundation protections such as grout bags, mattresses and so on. Lastly transportation of material to port(s) or decommissioning yard(s) and handling of material there.

Post-decommissioning is one of the phases that must be carried out after execution of all activities in order to obtain approval from clients to prove successful completion of the projects in compliance with project documents and agreed standards which includes a post-decommissioning survey, issuance of final dossier as well as obtaining Provisional Acceptance Certificate (PAC) and Final Acceptance Certificate (FAC).

The intention to prepare this document is to mention all possible activities and milestones that must be conducted in order to commence and complete the decommissioning of an offshore project. Noticing that offshore wind parks have different specifications such as the size of the turbines, number of turbines, water depth, distance from shore and topology of the park. Each of these parameters can have profound impact on the engineering and execution of decommissioning operations'. Thus, the possibility to prescribe a method for all kind of wind parks is not possible. There is not one size fits all procedure to be suitable for all wind parks, however, it is possible to classify the different wind parks in order to come up with different decommissioning methods for each category. Then the solutions should be optimized in order to attain the DecomTools objectives. In this document the author made the effort to list crucial activities that need to be executed for decommissioning of offshore wind parks. It is not a prescription and does not include all details of activities, but the major sequences have been listed herewith. Having considered that some activities are in critical path of project and some others can be executed as meanwhile activities, so, according to this document, we will be able to allocate time for each activity in order to make estimation for a total decommissioning project. Noticing that there is a direct relation between time in offshore and project cost, therefore, it can contribute to estimate cost of a decommissioning project. Eventually minimizing the time in offshore will lead to significant cost reduction as well as $CO_2$ mitigation.

## 2. List of Abbreviations

| | |
|---|---|
| **FEED** | Front End Engineering Design |
| **OWP** | Offshore Wind Park |
| **OWF** | Offshore Wind Farm |
| **WT** | Wind Turbine |
| **WP** | Wind Park |
| **PMS** | Preventive Maintenance System |
| **CBM** | Condition-Based Maintenance |
| **BSH** | Bundesamt Für Seeschifffahrt Und Hydrographie (Federal Maritime And Hydrographic Agency,Germany) |
| **ROV** | Remotely Operated Vehicle |
| **OHVS** | Offshore High Voltage Substation |
| **UXO** | Unexploded Ordnance |
| **USBL** | Ultra-Short Baseline, |
| **SSBL** | Super Short Base Line |
| **DGPS** | Differential Global Positioning System |
| **CLV** | Cable Laying Vessel |
| **CLB** | Cable Laying Barge |
| **HLV** | Heavy Lifting Vessel |
| **C/B** | Cargo Barge |
| **NDT** | Nondestructive Testing |
| **HDD** | Horizontal Directional Drilling |
| **QC** | Quality Control |
| **DP** | Dynamic Positioning |
| **ILT** | Internal Lifting Tool |
| **ELT** | External Lifting Tool |
| **TP** | Transition Piece |
| **MGR** | Marine Growth Removal |
| **GHG** | Greenhouse Gas Emission |
| **WMS** | Marine Warranty Survey, Marine Warranty Surveyor |
| **PAC** | Provisional Acceptance Certificate |
| **FAC** | Final Acceptance Certificate |
| **IMO** | International Maritime Organization |

**3. Initial Study**

3.1 Feasibility study for Decommissioning.

3.2 Feasibility study for repowering/granting consent for repowering.

3.3 Feasibility study for major overhaul/extension of life cycle.

**Suppose The Made Decision Is To Decommission The A OWP**

**4. Technical Study to Make a Business Model**

4.1 Check the Preventive Maintenance System (PMS) and the Condition-Based Maintenance (CBM) data base of the OWP to see the condition of machinery and recently changed components (such as blades, generator, gear box etc.) in order to evaluate the potential for reusing.

4.2 Conduct a functional test of components, if necessary.

4.3 Check if there is any demand for functional equipment (do marketing).

4.4 Find out the salvage value of material.

4.5 Ultimately find out the different ways to increase the salvage value, like repair of components and selling functional material.

**5. Start the Administrative Activities to Grant Consent for Decommissioning**

**6. Grant Consented for Decommissioning**

Procedure approved by authority, financial security takes place etc.

**7. Giving Notification to the Sea Users**

Notification should be given to the shipping traffic, fishing industry, utilities developers and other sea user about the commencement and duration of the operation. The developer has to announce to the port authority, hydrographic offices and national authorities, then they will do the necessary arrangement (need to be checked nationally with responsible organization like BSH).

**8. Conduction of Pre-Decommissioning Survey**

8.1 Review post-installation ROV survey documents and recorded videos.

8.2 Conduct a ROV survey from laid cable (log the burial depth, joints, crossed cables, pipeline etc.).

8.3 Conduct a ROV survey from OHVS and wind turbines structure in order to assess the situation of seabed, scour protection, sediment condition/ mobility and etc.

8.4 Log the dimension (estimated weight) and location of protection/obstacles, free span correction and crossings.

8.5 Inform the authorities in case of finding unexploded ordnance (UXO) (moving of old ordnance on seabed due to strong currents is possible)[1&2] (TenneT , 2017).

8.6 Inform concerned parties in case of finding benthic habitat (like flora and fauna)[1].

8.7 Inform responsible authorities in case of finding marine archaeology[1].

8.8 Log in-service cable(s), pipeline(s) or other subsea asset(s) which are crossed or are in vicinity of disused cable(s)/structure(s).

- In order to carry out pre-decommissioning survey the following resources are needed:
  - I. A suitable survey vessel equipped with:
  - II. Survey ROV
  - III. Side-scan sonar
  - IV. USBL Beacon (Figure 1)
  - V. Multi beam echo sounder
  - VI. Air balloon
  - VII. Positioning equipment like Gyro, DGPS, etc.
  - VIII. Experts, etc.

**Figure 1:** USBL Beacon (Sonardyne)

## 9. Preparation for Cable Removal

[1] (Offshore Generating Cable Connections, 2015)
[2] (TenneT concludes contract for UXO survey at cable route Borssele offshore grid, 2017)

9.1 Explosion/recovering of ordnance(s), in case of finding during survey.

9.2 Taking effective and appropriate measure in case of finding special benthic habitat, marine archaeology etc.

9.3 Collection of obstacles, mattresses, tubular protection, placed rock, grout bags, free span correction etc.

- In order to achieve this part, mobilization of state-of-the-art machinery is needed such as:
  - I. A vessel equipped with:
  - II. Seawater certified crane
  - III. Mass flow excavator (figures 2 and 3)
  - IV. Air lift (Figures 4 and 5)
  - V. Hydro jetting tool (Figure 6 and 7)
  - VI. Mechanical cutter[3] (Figure 8, 9 and 10)
  - VII. Work class ROV
  - VIII. Side-scan sonar
  - IX. USBL Beacon
  - X. Air balloon
  - XI. Lift bag etc.


**Figure 2**: Mass Flow Excavator (Seatools, n.d.)

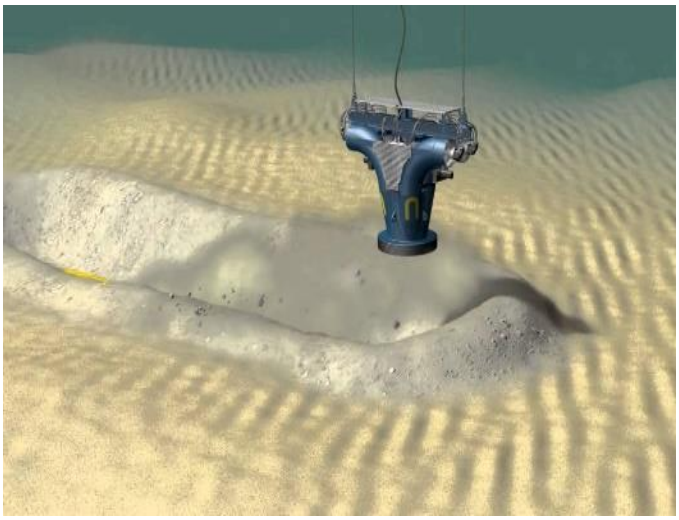


**Figure 3:** Mass Flow Excavator (N sea, 2014)

[3] Mechanical cutters employ either a cutting wheel or an excavation chain to cut a narrow trench into compacted seabed or rock (DNV-RP-J301, 2014, p. 103)

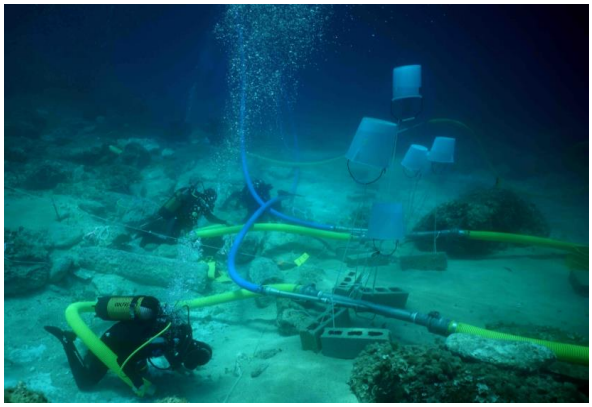


**Figure 4**

**Figure 5**

**Figure 4:** Seabed cleaning with Airlift Technology (Department of Classics, Stanford University, 2015)

**Figure 5:** Seabed cleaning with airlift technology (Divernet, 2017)

**Figure 6**


**Figure 7**

**Figure 6:** Hydro Jetting Tools (Jetting Sleds) (Power Cable Laying Jetting Sleds, 2013)

**Figure 7:** ROV Hydro Jetting Tools (Helix Energy Solution , 2019)

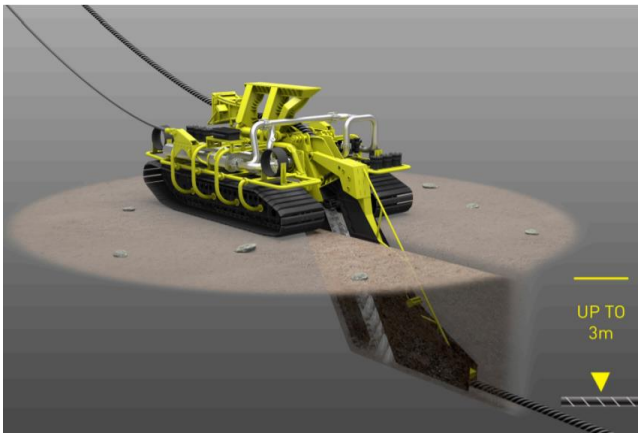



**Figure 8:** Mechanical Cutter (Dvorak , 2015)

**Figure 9:**Mechanical Cutter, Trenchformer (Boskalis, n.d.)[4]

[4] This is Trenchformer which can excavate the seabed with both hydro jet and mechanical cutter (Figure 11 shows the same machine)

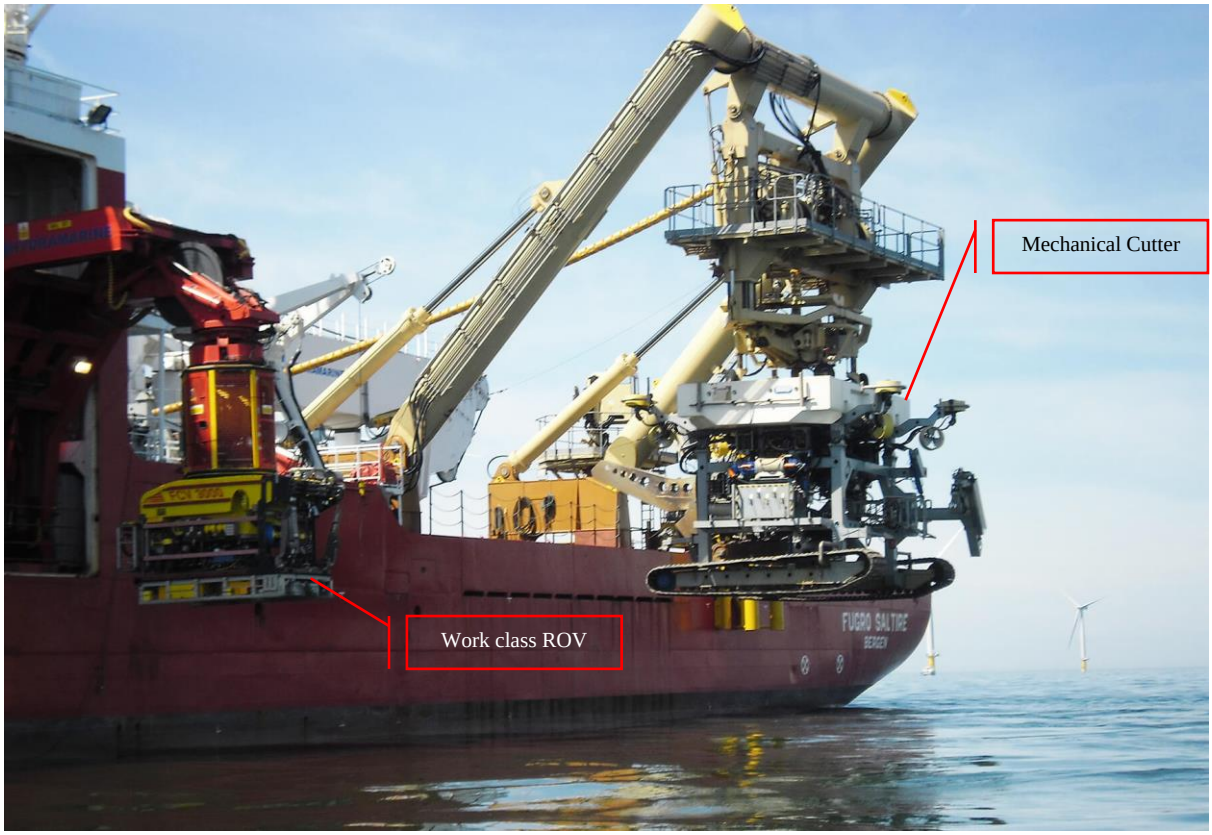



**Figure 10:** Launching of Mechanical Cutting Tools and ROV from Vessel (Dvorak , 2015)

**Figure 11:** Deployment of Mechanical Cutting Tools from land fall (Boskalis Subsea, 2014)

9.4 Disconnection of cable(s) from onshore substation and grid either physically or electrically.

9.5 Discharging cables from any electrical potential and testing to make sure that it is safe for decommissioning operation.

9.6 Cutting cables from J/I tube and connection of a balloon to the end of cable for tracking the cut point (there is similar procedure with the abandonment and recovery of offshore pipelines).

9.7 Preparation for land fall cable disconnection (inspection of transition joint pit, shore erosion etc.)

9.8 In order to conduct shore mobilization for cable removal, tubular removal and restoration at least the following machineries are needed:

I. Winches
II. Rollers
III. Crane
IV. Excavator Machine
V. Electric Generator
VI. Mobile accommodation etc.

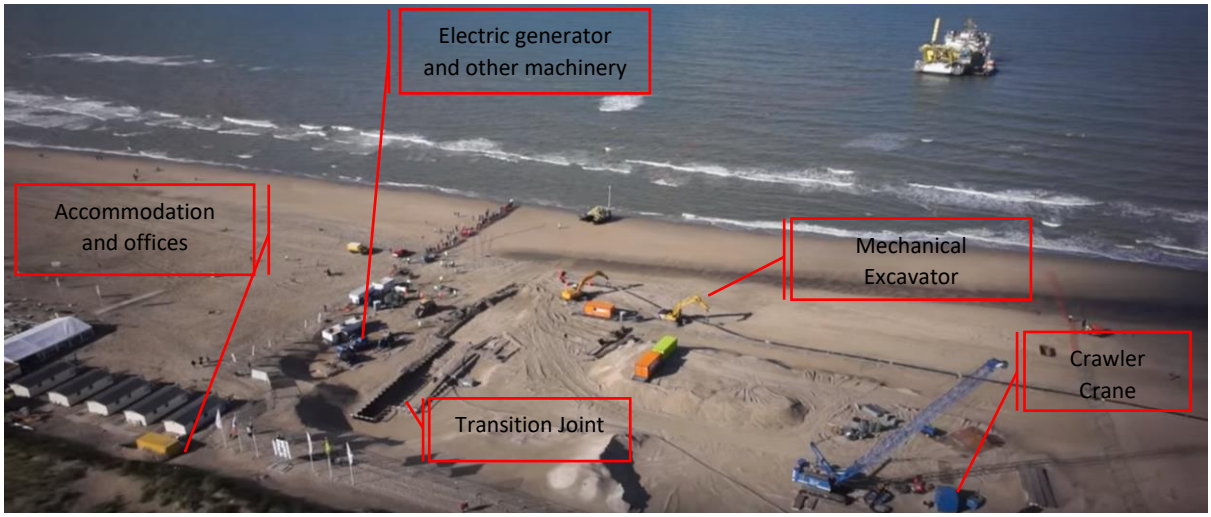



**Figure 12:** An Aerial Photo of Cable Shore Pulling (Boskalis Subsea, 2014)


**Figure 13:** Some Necessary Equipment for Export Cable Installation (Boskalis, 2016)

## 10. Onshore Mobilization For Disconnection Of Cable(s) From Onshore Substation

If there is not any plan for new wind farm development nor lifetime extension nor repowering and the final decision is to decommission an offshore wind park, then, all the laid cable(s) from offshore to onshore substation shall be collected thoroughly. Collection of laid cable(s) is relatively depending on the land fall condition, the distance of onshore substation from nearshore and so on. However, the following equipment and machinery are needed mostly[5]:

I. Excavator machine /backhoe dredger
II. Mobile electric generator
III. Trenching tools
IV. Winch and reel
V. Rollers
VI. Trucks
VII. Crawler crane
VIII. Cutting tools etc.

## 11. Offshore Cable Removal

Since there are two different cables in OWP including inter array and export cable, the consideration for decommissioning of each type is different as well. Also, there are two different approaches for decommissioning. One of them is decommissioning without any development of new OWP in the same area or the development of new OWP in the consented area. However, in most conditions, offshore mobilization for cable removal requires the following equipment:

I. Cable laying vessel (CLV) (This kind of vessel is normally equipped with all major and necessary equipment)
II. Hydro jetting tools (in the loose seabed)[6]
III. Ploughing tools (see Appendix 7)
IV. Mechanical cutting tools[5]
V. Grapnel equipment
VI. Side-scan sonar
VII. Mass flow excavator (for rock placement collection mostly)
VIII. Balloon and accessories for marking cables
IX. Work class ROV with capability to utilize cutting tools in manipulator

[5] (DNV-RP-J301, 2014, p. 101)
[6] The use of hydro jetting tool, mechanical cutter, plough etc. depend on seabed formation

X. Cable cutting tools

XI. Calibrated USBL beacon (also beacon can calibrate offshore)

XII. Lifting gears equipment including shackles, slings, webbing sling etc

XIII. Handling tools such as pulling head, pulling grip etc

## 11.1 Inter Array Cable Removal

a. Cut the cables from J/I Tubes with ROV preferably

b. Recover the cables to the CLV carousel (turntable or drum or reel or tank or other equipment)

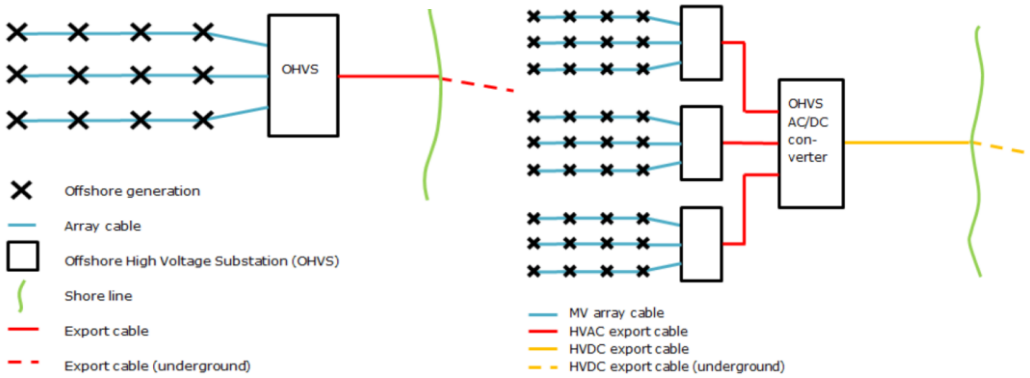
**Important note:** In any condition, inter array cables should be collected.

## 11.2 Export Cable Removal

For decommissioning of export cables, there exists four different scenarios as following:

### 11.2.1 Park with OHVS and Development of New OWP in the Same Location

- If there is OHVS, then keep the export cable from OHVS to shore.
- If there is OHVS, there is possibility to keeping the export cable(s) from WTs to the OHVS (this should be studied case by case, depending on the topology of OWP, the number of reserve J/I Tubes)




**Figures 14**. Two topologies of offshore wind park, OWP with OHVS (Cigre, 2015, pp. 46,47)

### 11.2.2 Park with OHVS and without Development of New WP in the Same Location

- In any condition, the given proposal should be entire removal of cables and OHVS

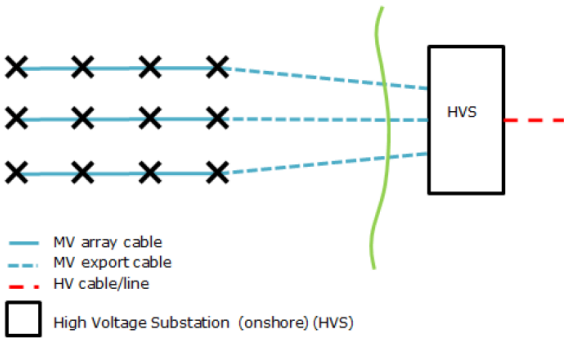
### 11.2.3 Park without OHVS and Development of new WP in the Same Location

- In this situation, keeping export cable(s) for future wind park is recommended since it can connect one block of wind turbines directly to the shore. This means saving cost of procurement, installation and decommission etc. However, the new designed OWP

will have higher production capacity. So, thicker cables and electrical components with higher capacity will be required.

### 11.2.4 Park Without OHVS and without Development of New WP in the Same Location

In any condition, the given proposal should be the entire removal of cables.




**Figures 15**. Topology of offshore wind park, OWP without OHVS (Cigre, 2015, p. 46)

## 12. Onshore Cable Removal

Making decision for onshore cable removal absolutely depends on the plan for the development of new OWP.

### 12.1 Having A Plan for New OWP Development

If there exist a plan for the development of a new WP in the consented location or vicinity of that location, the cable from the transition joint to the onshore substation can be kept as it was (such as inside tubular or buried cable) in order to be used for a new planned wind park. Therefore, demolition of the transition pit and a restoration of the constructed route to the substation is not necessary.

### 12.2 No Development of New OWP

If the plan is non-development of any wind park in the consented area or any location which can use the existing infrastructure, the entire removal of cable shall be proposed. More importantly, all installed protection like HDD tubular (Figure 13), crossing support and other means of artificial protections of cable such as rock placement shall be restored to the pre-installation condition.

## 13. Offshore High Voltage Substation (OHVS)

The following scenarios exists for the decommissioning of OHVS as following:

### 13.1 Development of New OWP in the Same or the Vicinity of the Old OWP

If there is any plan for the development of new OWPs even a couple of miles away from the OHVS, it makes sense to keep the OHVS and to use it (it needs to be evaluated case by case).

### 13.2 No Development of any OWP

Decommissioning of an OHVS shall take place immediately after the cable removal or before. It is recommended to carry out decommissioning of the OHVS after all cables have been removed. Since there is not any cable on seabed, mooring vessel(s) for removal can be utilized. Removal of OHVS has two different phases which are the following:

**Note:** It is possible that after the end of life cycle of OHVS, the authorities want to use the OHVS for another application, for instance change it to a restaurant or accommodation. This decision needs to be made in advance.

## 14. Removal of Topside (Deck)

14.1 Two surveys normally take place before decommissioning from seabed and OHVS structure. A ROV seabed survey in order to see if there is any debris on the seabed and a survey of the topside structure to make sure nothing is loose on the topside.

14.2 Hazardous material and equipment (such as fire and gas detectors) shall be dismantled before heavy lifting operation as preparatory jobs.

14.3 For OHVS removal, heavy lifting vessel (HLV) should be mobilized.

14.4 The vessel should position itself via either mooring anchors or DP system (vessel heading should have 180° difference with respect to prevailing wind direction, probably the same as installation heading).

14.5 If the HLV does not have enough deck space (which it normally does not have), a cargo vessel should be mobilized.

14.6 In addition to a normal construction team, welders, fitters and an electrician team should be mobilized as well.

14.7 Cables from hang-off should be disconnected.

14.8 All the electrical connections between OHVS and jacket should be disconnected.

14.9 All the obstacles for lifting shall be removed. (any overhangs such as lights structure, part of helideck etc.)

14.10 If the lifting trunnion were cut after installation which is normal practice, new ones should be welded, then the required NDT tests should be executed.

14.11 The cargo vessel should be moored to the HLV.

14.12 Lifting riggings should be connected to the HLV crane and the other side should be rigged to topside either spreader bar or directly to lifting trunnions.

14.13 Hold back riggings should be connected to the auxiliary winches (tugger winch) and other side should be connected to the topside (wherever is needed).

14.14 Cutting the topside legs should take place.

14.15 The topside should be lifted and located on the vessel deck.

14.16 The lifting riggings shall be kept until some portion of seafastening takes place.

14.17 Lifting riggings can be removed from lifting trunnions after getting approval from QC inspector.

14.18 Meanwhile seafastening shall be carried out (some points regarding seafastening has been mentioned under section 16 of this document)

**Note:** For decommissioning of OHVS, the best fleet type that can be mobilized is using a DP crane vessel (semi-submersible e.g.) and a cargo vessel. The cargo vessel can be moored to the HLV, so cargo vessel does not need to deploy the anchors. On the other hand, if a jack-up crane vessel is used, it is not possible to moor the cargo vessel to the jack-up considering the stability of the vessel.

## 15. Removal of Jacket and Piles

There are various types of jackets regardless of its number of legs. However, in some cases, the OHVS structure is mounted on monopod (or monopile) not a jacket, but the majority of them are jacket types and have legs:

I. Conventional jacket without batter (vertical pile) without grout
II. Conventional jacket without batter (vertical pile) with grout (See figure 24)
III. Conventional jacket with batter (inclined pile) with grout
IV. Conventional jacket with batter (vertical pile) without grout
V. Inclined Skirt pile sleeve (Chakrabarti, 2005, p. 1056)
VI. Vertical Skirt pile sleeve (Chakrabarti, 2005, p. 1056)
VII. Monopod or monopile structure
VIII. Gravity base structure[7] (DolWin2, n.d.)

[7] The gravity type support structure is a concrete based structure which can be constructed with or without small steel or concrete skirts. The ballast required to obtain sufficient gravity consists of sand, iron ore or rock that is filled into the base of the support structure (DNV, 2014, p. 25).

Figures 16 to 23 shows the various types of structures that have been used in offshore wind industry.

**Figure 16** Monopile Structure (Semco Maritime, n.d.)

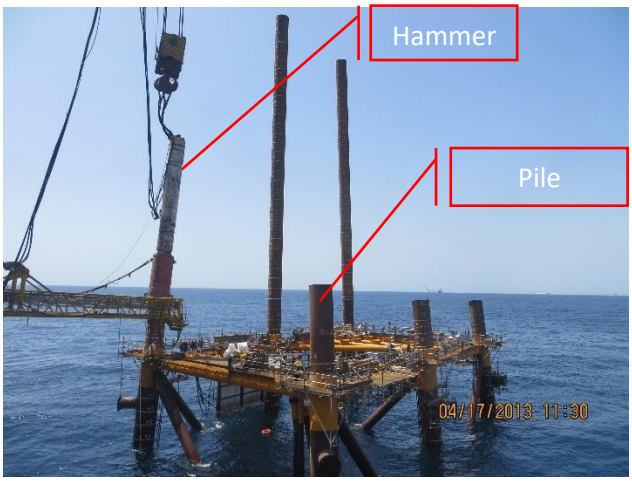



**Figure 17** Pile Driving of Conventional Jacket[8]

**Figure 18** Gravity-base Structure (TenneT, n.d.)

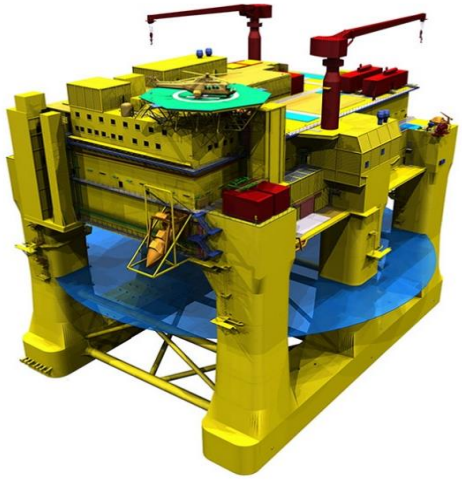


**Figure 19** Gravity Base Structure (DolWin Beta, n.d.)[9]


**Figures 20 & 21** Inclined Skirt Pile Sleeve Jacket (Heinen and Hopman, n.d.)

[8] Figure 17 is from the authors archive.
[9] The platform was anchored to the seabed by gravity alone (DolWin2, n.d.).


**Figures 22 and 23** Jacket with batter and without batter (BorWin1, n.d.)

### 15.1 Conventional and Non-Grouted Annulus Jacket Removal

If the structure is a conventional jacket without grouted annulus, there exists two different methods for removal of the jacket, the following are the removal activities with respective sequences:

#### 15.1.1 First Method

In this method at least a one-week workable weather window is required.

I. All scour protection around the jacket shall be removed (normally there is not scour protection around jacket structure, but it should be removed if there is any)
II. The crane vessel shall be positioned based on prevailing wind direction
III. The cargo vessel shall be moored to the HLV (ready at position)
IV. The shim plate (or crown plates) should be cut (for shim plate please refer to the figure 25)
V. The cut shim plate shall be placed on either HLV deck or on the cargo vessel (depending on deck lay out and cargo arrangement plan)
VI. Rig the crane to the jacket boat landing
VII. Cut the braces of the boat landing
VIII. Lift the boat landing and place it on the cargo vessel
IX. Carry out the seafastening of boat landing on the cargo barge
X. Rig the crane to the barge bumper
XI. Loosen the bolts of the barge bumper flange, releasing the chain shackles

XII. Lift the barge bumper, place it on the cargo vessel and carry out seafastening

XIII. Repeat the above 2 stages for all barge bumpers

XIV. Seabed about 1 meter shall be excavated around all jacket legs with air lift or mass flow excavators (so ROV or diver is needed)

XV. The diamond wire cutter shall be placed around the pile under the jacket mudmat (ROV or diver is needed)

XVI. The vessel crane should be connected with ILT to the pile which was cut

XVII. The cut pile should be lifted from top of the leg

XVIII. Then the pile shall be placed on the cargo vessel and seafastening shall be carried out

XIX. The above process shall be done for all other legs as well (from a safety perspective, the sequence of cutting the pile is: the second pile shall be in diagonal of the first cut pile)

**Note:** Even after removal of all the piles, jacket has unpiled stability based on API RP 2A. In other words, the jacket without any piles is stable on its mudmat.

XX. The next stage is to rig the lifting rigging to the HVL hook, also the other side should be connected to jacket lifting pad eyes

XXI. Lift the jacket and place on the cargo vessel

XXII. Keep the crane connected to the jacket until some portion of seafastening has been completed

XXIII. Derig the lifting rigging from jacket and release the HLV

**Note:** The cargo vessel maintained its position via mooring itself to the HLV. If the plan is to release HLV (the day rate of this vessel is high), then the cargo vessel needs to deploy its anchors in order to keep its position.

XXIV. Completion of seafastening and the NDT test

XXV. The next stage is to mobilize the smaller crane vessel, ROV and vibratory hammer for the entire pile extraction

XXVI. Extract and lift entire piles and placing them on the vessel deck

XXVII. Carry out seafastening of piles

XXVIII. Carry out post decommissioning ROV survey[10]

[10] Post decommissioning ROV survey can be done by a survey ship (day rate of HVL ships are considerably higher than a survey ship)

**Towing Option:** The other possibility is to install lift bag or buoyancy tank to jacket to be towed to the port (it is possible and minimize the cost) , but all holes and opening should be sealed in this method which there is not any proof-concept method and tool to do this so far except welding.

### 15.1.2 Second Method

The second method is a quicker operation but needs a larger crane vessel. However, at least a one-week workable weather window is required. The activities and sequences are as following:

I. All scour protection around the jacket shall be removed (normally there is not scour protection around jacket structure, but it should be removed if there is any
II. The crane vessel shall be positioned based on prevailing wind direction
III. The cargo vessel shall be moored to the HLV (ready at position)
IV. Rig the crane to the jacket boat landing
V. Cut the braces of the boat landing
VI. Lift the boat landing and place it on the cargo vessel
VII. Carry out the seafastening of the boat landing on the cargo barge
VIII. Rig the crane to the barge bumper
IX. Loosen the bolts of the barge bumper flange, releasing the chain shackles
X. Lift the barge bumper, place it on the cargo vessel and carry out seafastening
XI. Repeat the above 2 stages for all barge bumpers
XII. The shim plate (or crown plates) should not be cut (it means the jacket and piles are still connected, so we can consider them as one structure)
XIII. Seabed about 1 meter shall be excavated around all jacket legs with air lift or mass flow excavator (ROV or diver is needed)
XIV. The diamond wire cutter shall be placed around the pile under the jacket mudmat, (ROV or diver is needed)
XV. All the piles underneath the mudmat shall be cut

**Note:** Even after cutting all the piles, jacket has unpiled stability. In other words, the jacket remains stable on its mudmat

XVI. Lift the jacket and all the piles together and place them on the cargo vessel
XVII. Keep the crane until some portion of seafastening has been completed
XVIII. Release the lifting rigging from the jacket and release the HLV (in this case the anchors of the cargo vessel should be deployed in advance)

XIX. Completion of the seafastening and the NDT test

XX. The next stage is to mobilize the smaller vessel, ROV and vibratory hammer for entire pile extraction

XXI. Extract and lift the entire piles and place them on the vessel deck

XXII. Carry out seafastening of piles

XXIII. Carry out post decommissioning ROV survey

## 15.2 Conventional and Grouted Annulus Jacket Removal

If the structure is a conventional jacket with grouted annulus (for grouted annulus, please refer to figure 24). There exist two different scenarios for the jacket removal. The milestones and stages are mentioned as below:

### 15.2.1 First Method

In this method at least a one-week workable weather window is required.

I. All scour protection around the jacket shall be removed (normally there is not scour protection around jacket structure, but it should be removed if there is any)

II. Crane vessel shall be positioned based on prevailing wind direction

III. The cargo vessel shall be moored to the HLV (ready at position)

IV. The shim plate (or crown plates) should not be cut

V. Seabed about 1 meter need to be excavated around all jacket legs with an air lift or a mass flow excavator

VI. The diamond wire cutter[11] shall be placed around the pile under the jacket mudmat

VII. All the piles underneath the mudmat shall be cut

VIII. Lift the jacket and all the piles together and place on the cargo vessel

IX. Keep the crane until some portion of seafastening has been completed

X. Release the lifting rigging from jacket and release the HLV (in this case the anchor of cargo vessel should be deployed in advance)

XI. Completion of seafastening and NDT test

XII. The last stage is to mobilize smaller vessel, ROV and vibratory hammer for entire pile extraction

XIII. Extract and lift the entire piles and place them on the vessel's deck

[11] Dimond wire cutter is one of the most reliable cutting tools which cannot cut so quickly. Diamond wire saw is a quicker option.

XIV. Carry out seafastening of the piles

XV. Carry out post decommissioning ROV survey

**Note:** There are a number of crane vessels that are designed and constructed for decommissioning of offshore oil and gas structures, like pioneering spirit (48 000t lifting capacity), Sleipnir (with 20 000t crane capacity , SAIPEM 7000 (14 000t lifting capacity), Thialf (14 200t lifting capacity) etc. However, the weight of the jackets in renewable energy are not as heavy as in the oil and gas industry. Hence, in many cases, it is feasible to mobilize the above-mentioned crane vessels which are extremely expensive. On the other hand, from a stability perspective, considering that these vessels are huge, they are much more stable and weather condition have minor impact on their operation and stability. In the annex 9, specification of some of heavy lifting vessels can be found.

### 15.2.2 Second Method

In this method a smaller HLV vessel is needed. However, mobilization of a diving team (SAT or mixed diving system is necessary). So, the operation becomes more complex, hazardous, difficult and the duration of the operation is much more than a single lift (but the day rate of vessel is less). This method is employed in the oil and gas projects, but for the wind industry, it is not recommended due to smaller size and lighter weight of the jacket.

I. Item number 1 to 6 are similar

II. Mobilization of diving team (if the depth is less than 35m, the mixed diving needs to be mobilized, the deeper waters needs SAT diving)

III. The diamond wire cutter shall be placed around the jacket leg at each elevation (the jacket has different elevation)

IV. Rigging the lifting gears to the first elevation of the jacket

V. Cut the jacket structure at the 1$^{st}$ elevations

VI. Recover the diamond wire cutter to the surface

VII. Lift the first cut structure and place it on the cargo vessel

VIII. Commence seafastening of the cut structure on the cargo vessel

IX. Continue the above 4 stages until the last elevation is done.

X. The last stage is to use a vibratory hammer for the entire pile extraction

XI. Extract and lift the entire piles and place them on the cargo vessel

XII. Carry out seafastening of all piles

XIII. Carry out post decommissioning ROV survey

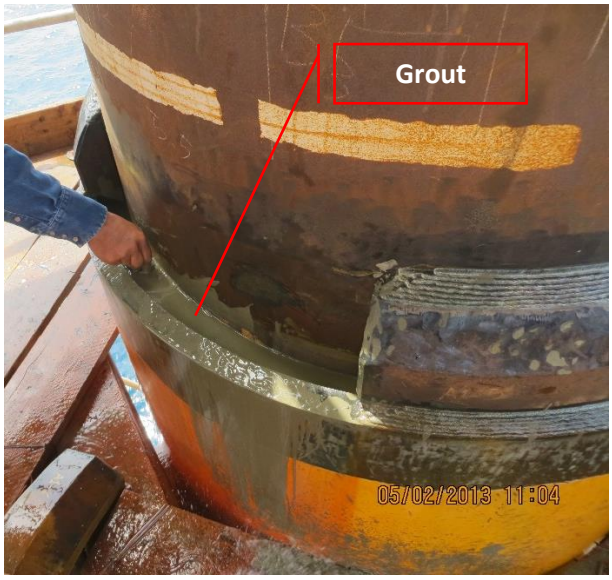



**Figure 24** Grouting annulus of Conventional Jacket[12]


**Figure 25** Welding of Shim Plates[12]

### 15.3 Jacket with Skirt Pile Sleeve

Decommissioning of this type of jacket is easier than the conventional jacket since the piles are outside of the jacket. More importantly, the length of driven piles is less than conventional jacket. The piles' length is approximately shorter equivalent to water depth which means the weight of piles is lighter than the conventional jacket. In other words, it needs less resources such as logistic, less machinery working hour and labor work etc.

I. All scour protection around the piles shall be removed (normally there is not scour protection around a jacket structure, but it should be removed if there is any)
II. The crane vessel shall be positioned based on prevailing wind direction
III. The cargo vessel shall be moored to the HLV (ready at position)
IV. Seabed about 1 meter shall be excavated around all piles sleeve with an air lift or mass flow excavator
V. The diamond wire cutter shall be placed around the pile under the pile sleeve
VI. All the piles underneath of the pile sleeve shall be cut
VII. Lift the jacket and place it on the cargo vessel
VIII. Keep the crane until some portion of seafastening has been completed on the cargo vessel[13]

[12]Figures 24 and 25 are from the authors archive
[13] This item shall be discussed and evaluated by welding and QC team

IX. Derig the lifting rigging from jacket

X. Completion of seafastening and NDT test

XI. Utilize the vibratory hammer for the entire pile extraction

XII. Placing the piles on the vessel's deck

XIII. Carry out seafastening of the piles

XIV. Repeat the above three stages for all the legs

XV. Carry out post decommissioning ROV survey

## 16. Offshore Wind Turbine Disassembly

With the passage of time, different turbine models were launched to the market which lead to different methods of assembly and erection. However, some of them have fundamental electrical and mechanical differences but still their installation method offshore are mostly similar.

### 16.1Mobilization of Crane Vessel and Specialist For Wind Turbine Disassembly

In this stage, it is not necessary to mobilize a semi-submersible and high lifting capacity vessel. The criteria that play a role for vessel selection are length of the boom, the overall stability of the vessel and the lifting capacity. In order to save operation time and cost, the decision for the selection of a lifting vessel depends on the water depth, number of turbines, hub height, and weight of the turbine components.

### 16.2Mobilization of Cargo Vessel

There are some factors that need to be taken into consideration for the selection of a cargo vessel such as the vessel's stability, deck load, deck space, dead weight, length, breadth and draft of the cargo vessel. If the utilization of jack-up vessel is an option, then cargo vessel shall be equipped with a suitable mooring system as well. The drawing of deck lay out shall be made in advance to see how the arrangement of the wind turbine components can be on the deck.

### 16.3 Preparation For Dismantling Of A Turbine

16.3.1 Shut down of the wind turbine (stop the rotation of the rotor)

16.3.2 Inspect if any part is loose or broken

16.3.3 Check the structural integrity and stability of the wind turbine structure

16.3.4 Disconnection of all cables from nacelle to the tower

16.3.5 Removal of dangerous and hazardous material from nacelle

16.3.6 Any other preparation like greasing or wire brushing of bolts

16.3.7 Dismantling of blades

The installation of blades mainly took place in three different ways as a last step of installing a wind turbine. However, the installation methods of blades were different, the first stage for dismantling of wind turbine is blades disassembly.

**I. Single Blade Installation**

In this method, all the blades were transferred offshore and the installation of them took place one by one offshore(see figure 26). Hub was assembled to the nacelle onshore. In some models of turbine, access to the bolts of blades is not provided (The Fugro Group Magazine, 2013, p. 15). Having noticed that disassembly of the blades in that specific turbines model is not possible, the blades shall be dismantled together with hub.

**Figures 26** Single Blade Installation Method ( Funke, 2016)

**II. Bunny Ear Configuration**

In this method, nacelle, hub and two blades were installed onshore and the last blades was installed offshore to the hub (see figure 27).

**Figure 27** Transportation of nacelle and blades with bunny ear configuration (International Cranes, 2013)

### III. Star Configuration

In this method, all three blades and the hub are assembled onshore. In other words, total rotor assembled onshore. Then the installation of assembled rotor to nacelle took place offshore (see figure 28).

**Figure 28** Transportation of Bunny ear configuration blades (International Cranes, 2013)

### 16.4 Placement of Blades on The Cargo Vessel and Seafastening

After the disassembly of the blades, they have to be placed on the vessel deck and secured with seafastening and lashings.

### 16.5 Blade and Hub Dismantling

In case of lack of access for single blade removal, the entire rotor shall be dismantled and placed on the vessel deck for further disassembly of blades.

### 16.6 Hub Dismantling

In majority of cases, the hub and nacelle can be dismantled as one component except when the star configuration is used during installation. In other words, when there is not any access to remove the single blade, blades and hub (entire rotor) will be dismantled as a one part.

### 16.7 Dismantling of Nacelle and Hub

The nacelle is one of the most critical components of a wind turbine. All major electrical and mechanical components are inside the nacelle. After removal of all blades, the next stage is to lift and relocate the nacelle along with the hub onboard the cargo vessel.

### 16.8 Seafastening of Nacelle and Hub

Under section 14 of this document, the seafastening of similar items is explained.

### 16.9 Towers Dismantling

Next stage after the removal of the nacelle is the removal of towers. The tower structure at one end is connected to the nacelle, and the other side is connected to the transition pieces. Owing to operation limitation such as wight of the tower, as well as cost reduction many of towers are made of different sections. So, if the mobilized crane vessel had enough boom length and lifting capacity, it is recommended to lift and remove all the tower sections in one piece.

### 16.10 Transition Piece Dismantling

The majority of the transition pieces (TP) are connected to the monopile via grout (see figure 29). In some cases, the connection were made with flange (Steel Wind Nordenham, n.d.)[14] (Nordsee One Gmbh, n.d.)[14] (Dokka Fasteners, n.d.)[14]. New methods for installation of transition pieces to foundation is under study. Hence, the dismantling process for grouted type and flange type etc. is different.

#### 16.10.1 Grouted Transition Piece

[14] (Steel Wind Nordenham, n.d.) (Nordsee One Gmbh, n.d.)

There are three different options for removal of the grouted transition pieces as following:

I. Removal of transition pieces and pile together via vibratory hammer (consultation with vibratory hammer manufacturer is needed)
II. Cutting the transition pieces at a certain level and then remove the transition piece and the monopile together.
III. Cutting the tip of monopile, lift the transition piece and then extract the monopile with a vibratory hammer.

### 16.10.2 Flange End Transition Piece

In this kind of design, the transition piece is connected via a flange to the monopile which make the decommissioning much easier and cheaper. Therefore, cutting is not needed and just the flanges shall be unbolted from the monopile.

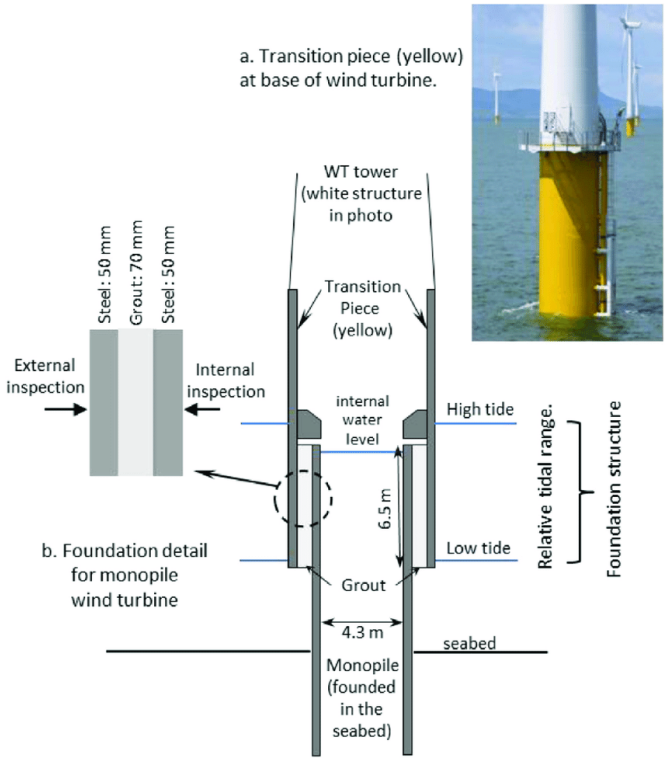



**Figure 29** The schematic shows the connection and overall dimension of a transition pieces to a monopile (Wilkinson, Gunn, & Holyoake, 2018)

## 16.11 Lifting and Seafastening of A Transition Pieces On The Cargo Vessel

After dismantling the transition piece (regardless of their connection method), they should be lifted and loaded on the cargo vessel, preferably vertically due to installed secondary steel structure to TP. The last stage is to secure them onboard the cargo vessel by means of seafastening.

### 16.12 Pile Extraction

The pile extraction is the last stage of the structure removal. Currently, the only available tool for pile extraction is the use of a vibratory hammer. A vibratory hammer can extract the driven pile entirely. However, there are some other methods which result the pile to be remained in situ which is not recommended due to remaining residual liabilities based on international regulations[15].

## 17. Marine Growth Removal[16]

Marine growths are adhered to the wind turbine and offshore high voltage substation foundations. Noticing that marine growths are marine live creature, removal of them can exert environmental and biological impact. So the consequences and influence of any removal method shall be studied by specialist. Thus, here we are just addressing the possible methods of removal regardless of biological and environmental impact. Three different scenarios are mentioned as following:

### 17.1 Marine Growth Removal Prior to The Commencement of Foundation Removal

The first scenario is to remove marine growth prior to dismantling of wind turbines and offshore high voltage substation. In other words, this job can be conducted prior to the removal of the foundations and can be considered as preparatory activity. This method highly likely has the lowest environmental and biological impact on these marine organisms. Figure 30 demonstrates marine growth removal which takes place offshore.

**Figure 30** Marine Growth Removal in situ offshore (Al Shoumoukh Marine Services, n.d.)

[15] IMO RESOLUTION A.672(16),§ 3

[16] Marine growth (or marine fouling) is the covering of marine plants, animals and other organisms found on those parts of man-made structures that are fully submerged in sea or intermittently immersed during the tidal cycles (Oil & Gas UK; The Voice of the Offshore Industry, 2013).

### 17.2 Marine Growth Removal Onboard Cargo Vessel

The second scenario for removal of marine growth is to undertake this activity after offloading the wind turbine foundation on the barge (mainly monopile structure). If there is access to the foundation, the vessel crew such as riggers can remove marine growth with water jet or other available technology on the deck until the barge reach the port. In this case, the removed species can be dumped to the sea.

### 17.3 Onshore Marine Growth Removal

The last scenario is to conduct MGR onshore. It means after offloading the material to the port or decommissioning yard, marine growth can be removed. Noticing that marine growths are living creatures, the relocation from offshore to onshore can have impact on the ecology and environment. Marine growth removal in the port or decommissioning yard can result in odor and pest nuisance which can pose problem for the working site (Oil & Gas UK; The Voice of the Offshore Industry, 2013, p. 16)

## 18. Seafastening and Grillage[17] of OWP Components

Seafastening is of significant importance due to its role in the project. A proper method of seafastening can have profound impact on the duration of the project, safety, cost and greenhouse gas emission (GHG). There are a couple of methods for seafastening of offshore modules for transportation at sea. The existing methods are given below:

### 18.1 Conventional Seafastening Method

In the conventional seafastening, the materials are tailored to the size and geometry of each module by welding such as skid, saddles, cradles and horse etc. Then the QC team has to wait for a period of time (sometimes three hours) for cooling down the temperature of the welded joint. Finally, NDT tests must be carried out to ensure safe transportation of the material. Furthermore, a load out and sail out certificate will be issued by Marin Warranty Surveyor (WMS) after demonstrating of successful non-destructive examination.

### 18.2 Automatic and Reusable Seafastening

[17] (DNV-OS-H202, 2015, p. 10) Grillage: structural load distributing elements installed to avoid excessive local loads

In this method, the portion of welding operation is smaller than the conventional seafastening. Also, the seafastening can be adjusted for other projects. There are some companies that invented new tools for seafastening. In the footnote of this page there are some links for further study[18].


**Figure 31** Reusable Seafastening (Conbit)

## 19. Transportation of Jacket, Topside and Wind Turbine to the Port

After loading and seafastening of OHVS components which are mainly jackets/monopods and topsides as well as the wind turbine material, they have to be transported to the port via either heavy lifting vessel or cargo vessel.

## 20. Cutting Seafastening in Port

As stated above, the seafastening can be skids, saddles, braces, grillages and any other material which were used to secure the offshore wind park material on the vessel. After arrival of the vessel to the port and mooring to the berth, they must be cut for further material handling and transportation ashore. It means less welding offshore will result less cutting onshore or vice versa. The efficient engineering of seafastening design will contribute to less utilization of material, cutting and welding time, labor time, and ultimately the vessel stand-by time.

## 21. Mobilization Of Machinery At Port For Further Transport Of Material

Shore mobilization can be trucks, onshore cranes, crane barge, Self-Propelled Modular Transporters (SPMT) , human resources and so forth.

## 22. Offloading the Transported Material to The Port

[18] https://conbit.eu/conbits-re-usable-sea-fastening-solution-monopiles-vickas/

[18] https://twd.nl/wp-content/uploads/2019/11/TWD-Track-Record-Offshore-Wind_WEB.pdf

After cutting the seafastening, all the material on the deck of the vessel(s) shall be transported via necessary machinery for further actions, segregation and recycling process.

## 23. Handling of Material Inside the Port

Based on feasibility studies, segregation and material sorting shall be carried out. Some are listed as following:

23.1 Reusable material shall be segregated such as electrical components (cable, generator etc.), gearbox, generator, yaw and pitch system etc

23.2 Defective components which need to be tested for further rectification. (if there is a minor defect or any problem that can be rectified for selling)

23.3 Defective materials which shall go for recycling

23.4 Sorting shall be carried out. For instance, blades and other composite material such as nacelle housing shall be separated

23.5 Cut and shred the material and make them ready for further processing.

## 24. Post-Decommissioning Survey

After removal of all material from sea, a ROV seabed survey shall be conducted to demonstrate that nothing remained in situ after decommissioning. Therefore, the contractor/ developer does not have any further liability after the entire decommissioning process.

## 25. Issuance of Provisional Acceptance Certificate (PAC)

On completion of the post-decommissioning survey, the contractor representative shall obtain approval of his client on the executed operations by issuing a PAC onboard the vessel. PAC is a document that certify scope of work has been fulfilled by contractor in compliance with contract and other contractual documents such as decommissioning procedure, designs and standards.

## 26. Issuance of Final Dossier and Final Acceptance Certificate (FAC)

The PAC and FAC here entail all the offshore related activities of the decommissioning project mostly and does not include onshore related activities such as material handling, shredding and recycling. Normally a contractor has a certain amount of time in order to issue the final dossier to the client. Obtaining approval on the FAC means completion of the decommissioning project.

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# Appendix 1

# USBL

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# Datasheet

## Wideband Sub-Mini Transponder/Responder (WSM)



### Description

Sonardyne's family of Wideband Sub-Minis (WSM) are a versatile range of USBL transponder/ responders designed for positioning ROVs, towfish and other mobile targets in water depths up to 4,000 metres.

Compact and rugged, WSMs incorporate the latest Sonardyne Wideband® signal technology which offers superior ranging accuracy, operation in a mulit-user, multi-vessel environment and fast USBL position updates.

In addition to supporting new Sonardyne Wideband® signals, WSMs also support traditional Sonardyne tone and HPR 300 and HiPAP® channels. A link allows the WSM to be configured for use with all of the popular MF frequency acoustic navigation systems.

The Type 8071 WSM is equipped with an omni-directional transducer and is depth rated to 1,000 metres making it suitable for a wide ranger of general USBL tracking application.

The Type 8070 WSM is a 4,000 metre rated unit and features a high-power directional transducer with an acoustic output comparable to Sonardyne's most powerful full size seabed transponders.

Both types of WSM have a depth sensor fitted as standard to aid USBL positioning accuracy and an external On/Off switch for ease of use and storage when not in use.

### Key Features

- Choice of 1,000 Metre or 4,000 Metre depth rating
- Choice of Omni-Directional or Directional beamshape with class leading acoustic power output
- Channel selection via serial data port by PC
- Transponder or Responder operating modes
- Depth sensor for improved USBL positioning performance
- Long-life NiMH battery
- Compact and rugged design
- Windows based software for test and setup
- External On/Off switch for ease of use and storage

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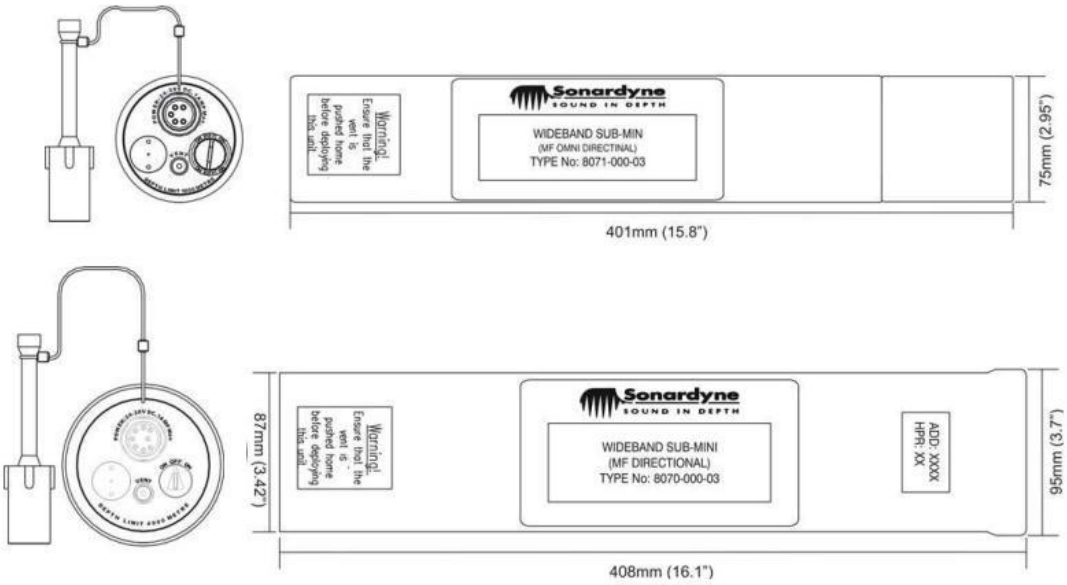
# Specifications

## Wideband Sub-Mini Transponder/Responder (WSM)




| Feature | | Type 8071 | Type 8070 |
|---|---|---|---|
| Depth Rating | | 1,000 Metres | 4,000 Metres |
| Operating Frequency | | MF (19-36kHz) | MF (19-36kHz) |
| Operating Channels | | All Sonardyne Wideband/Tone HPR 300 & 400 Channels | All Sonardyne Wideband/Tone HPR 300 & 400 Channels |
| Transducer Beamshape | | Omni-Directional | Directional |
| Transmit Source Level (dB re 1µPa @ 1m)(26-32kHz) | (External Power) | 190dB | 202dB |
| | (Battery – High Power) | 188dB | 199dB |
| | (Battery – Low Power) | 185dB | 196dB |
| Receive Sensitivity (dB re 1µPa) | High Gain | <100dB | <100dB |
| | Low Gain | <110dB | <110dB |
| Power Supply | | Long-Life Ni MH battery or ext. 24V via ROV's umbilical | Long-Life Ni MH battery or ext. 24V via ROV's umbilical |
| Number of Replies (Responder) | | Unlimited with External Power | Unlimited with External Power |
| Depth Sensor | | Standard | Standard |
| Maximum Update Period | | 750ms | 750ms |
| Quiescent Life | | 60 Days | 60 Days |
| Mating Connector | | Subconn MCIL5F | Subconn MCIL5F |
| Mechanical Construction | | Aluminium Alloy, Anodised | Aluminium Alloy, Anodised |
| Dimensions (LxDia) | | 401mm (15.8") x 75mm (2.95") | 408mm (16.1") x 95mm (3.7") |
| Weight in Air | | 2.7kg | 5.0kg |
| Weight in Water | | 1.4kg | 2.6kg |
| Battery Charger | | 7972-000-04 | 7972-000-04 |

Specifications subject to change without notice - 07/2009

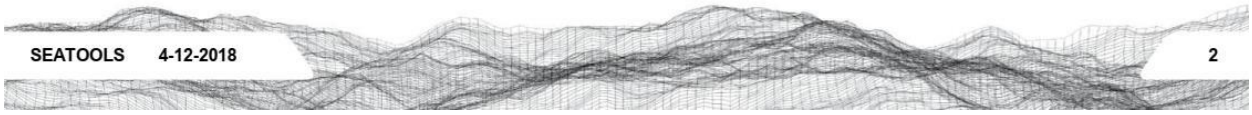
# Appendix 2

# Mass Flow Excavator


seatools
Carrera E – Precision Flow Excavation Spread
Introduction - December 4, 2018

# Contents

- Why mass flow excavation?
- Potential for improvement
  - Operational economics
  - Productivity
  - Environmental impact
  - Commercial risks
  - Safety
- Carrera E Precision Flow Excavation Spread
  - Overall impression
  - Dynamic positioning for surgical excavation
  - AHC LARS for workability and safety
  - A high level of automation
  - Footprint and all-electric drive

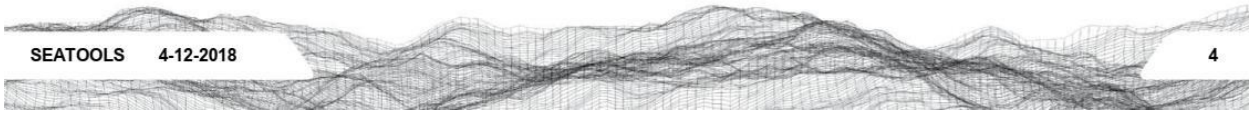


# Why mass flow excavation?

- Subsea excavation method whereby a large volume flow is applied to the seabed through which seabed is fluidized and the fluidized (non-cohesive) soil is transported
- Used for:
  - Burial, re-burial, or de-burial of assets
  - Seabed levelling
  - Rock dump removal
  - Free-span corrections
- Advantages of mass flow excavation:
  - Non-contact method (reduced risk of asset damage)
  - Initial position and orientation relative to asset (e.g. cable) less critical (in case of de-burial)
  - Allows for creation of tight curvatures (e.g. near monopile)
  - Wider range of seabed conditions (e.g. slopes, sand dunes)
  - Typical spread day rate lower in comparison with trenching spread
- Disadvantages of mass flow excavation (as it is now):
  - Relatively low production rates, especially in cohesive soils
  - Relatively much seabed disturbance
  - Largely uncontrolled (process)
  - Limited workability

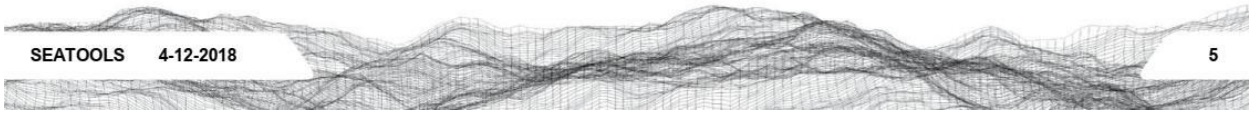
# Large potential for improvement

- The MFE market exhibits relatively little innovation: it is dominated by the same equipment as 15 years ago
- At Seatools, it is our belief that incorporating state-of-the-art subsea and ROV technology allows for different performance levels
- More specifically, we believe there is potential for strong improvement in:
  - Operational economics
  - Productivity
  - Environmental impact
  - Commercial risk
  - Safety



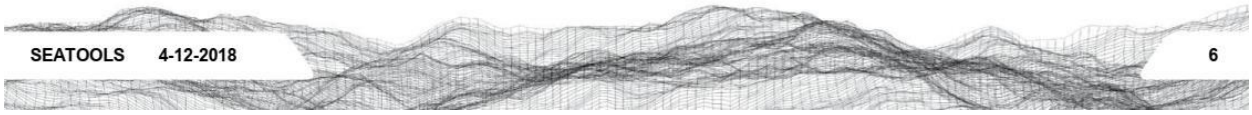
# Potential for improvement – Operational economics

- Direct and indirect cost drivers:
  - Day rate MFE and jetting spread
  - Cost of personnel (direct and indirect)
  - Cost of surveys
  - Vessel day rate
  - Costs related to (de-)mobilization (e.g. transportation)
- Potential for improved economics:
  - Reducing the number of operators
  - Reducing the (direct & indirect) costs related to surveys
  - Increase vessel independence (i.e. spot market opportunities and smaller vessels)
  - Improve productivity
  - Reducing (de-)mobilization time
- Potential for improved overall costs of MFE operations is large, especially for larger jobs



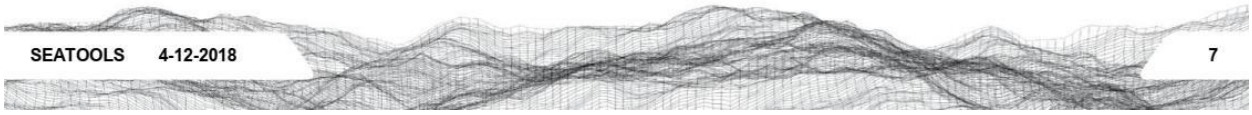
# Potential for improvement – Productivity

- Direct and indirect factors that influence productivity:
  - Generated flow rate and velocity
  - Positioning accuracy
  - Ability to locate product
  - Ability to cope with cohesive soils
  - Workability
  - Equipment reliability
  - Survey quality
- Potential for improved productivity:
  - Improve (3D) motion control of excavator
  - Increase installed power
  - Use more efficient work flow through which survey related time is reduced
- Potential for improved productivity is substantial, especially when motion control is improved



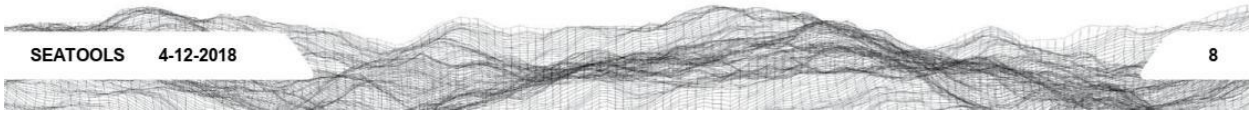
# Potential for improvement – Environmental impact

- Mass flow excavation creates environmental impact by:
  - Seabed disturbance
  - Hydraulic (oil) emissions to environment
  - Noise
  - Energy consumption
- Potential for reduced impact on environment:
  - Improve (3D) motion control of excavator which results in smaller trenches
  - Efficient all-electric drive to:
    - reduce noise
    - prevent hydraulic emissions
- Potential for reduced environmental impact is substantial, especially with tighter dredging tolerances



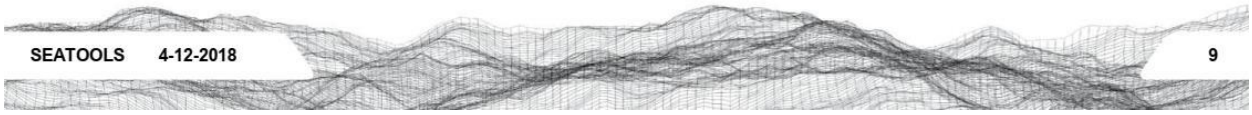
# Potential for improvement – Commercial risk

- Commercial risk in relation to MFE is induced by:
  - Risk of product damage (e.g. physical contact, overstressing pipeline through over dredging)
  - Mobilization window
  - Equipment downtime
  - Launch and recovery window
  - Lower than anticipated productivity
  - Not able to meet prescribed depth of burial
- Potential for reducing risk:
  - Improve (3D) motion control of excavator
  - Minimization of spread modules and required interfaces
  - Improve on dredge capability, especially in cohesive soil conditions
- Commercial risk for both MFE service provider, installation contractors, as well as the asset owner can be reduced significantly



# Potential for improvement – Safety

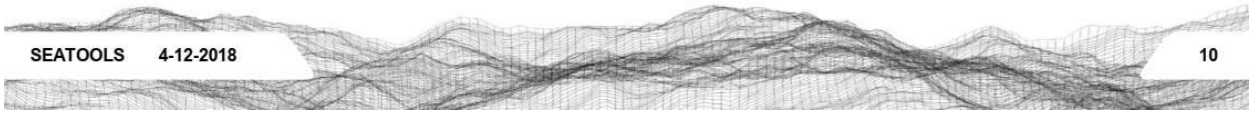
- Common safety issues in relation to MFE:
  - Launch and recovery operations, especially in case of crane deployment
  - Tugger wires handling
  - Large hydraulic hose bundle handling
- Potential for improving on safety:
  - Dedicated AHC LARS which does not require manual assistance
  - Eliminate need for tugger wires
  - All-electric subsea tool with integrated jetting capabilities to eliminate hose bundling
- Safety can be greatly enhanced while simultaneously improving on operational efficiency



# Conclusion from technology and market review

- A subsea flow excavation spread that:
  - features position control in all three dimensions
  - has smaller footprint and requires a minimum of vessel interfaces
  - has a more powerful all-electric drive
  - includes high levels of automation
  - includes survey capabilities

  will generate significant value in relation to all MFE performance criteria.
- Our solution: Carrera E Precision Flow Excavation Spread



# Carrera E – Precision Flow Excavation Spread

Non-contact, patent-pending, subsea flow excavation spread showcasing surgical precision under any environmental condition

- 3D motion control: full DP capabilities in combination with dedicated AHC LARS
- Integrated survey capabilities
- All-electric subsea drive with unrivalled 630+ kW power rating
- Deep water capability: excavator 3000 msw rating
- High level of automation
- Highly compact spread: 3 x 20ft container footprint


*Figure 1 Impression of Carrera E*

# Dynamic positioning for surgical excavation

- Included DP-functionalities:
  - Station keeping
  - Follow target
  - Auto-speed
  - Auto-track
  - Auto-swing
- The operator can pre-program a specific track (e.g. cable route) where after the Carrera E, and vessel, follow this track
- Through the combination with its integrated survey capabilities, the tool is also able to fully automatically follow a target (e.g. pipeline)
- Seatools ROV DP-technology widely used in FP-ROVs
- Value creation through:
  - Increased productivity
  - Reduced seabed disturbance
  - Faster backfilling through smaller trenches
  - Less operators and relieving operators from exacting labor

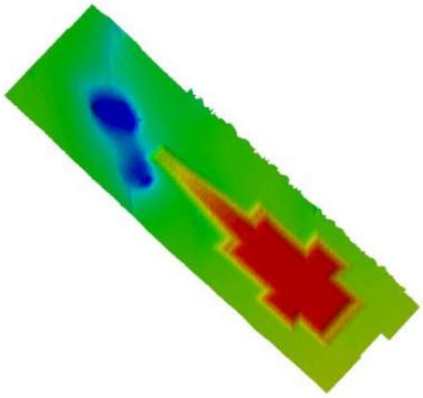


*Figure 2 Subsea rock bed created by Seatools' fall pipe ROV executed with highly accurate DP-technology. The same technology is applied to the Carrera E which allows for tight dredging tolerances.*

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# AHC LARS for productivity and safety

- The LARS, executed with Active Heave Compensation (AHC), generates value by:
  - Creating safe working environment (as opposed to a swinging tool in case of crane deployment)
  - Preventing physical contact with asset
  - Allowing for operating closer to the seabed. This results in (strongly) improved jetting performance
- Two AHC modes are included:
  - I. Basic mode. Provides moderate AHC accuracy and is to be used when performing MFE operations at significant standoff distances (> 2 meter)
  - II. High performance mode. Active in case a minimum of residual heave is allowed, such as when performing jetting operations close to the seabed or during surveying
- By means of up-front simulations, a minimum of required standoff distance plots can be provided. Minimum standoff distance is plotted as a function of actual heave conditions.

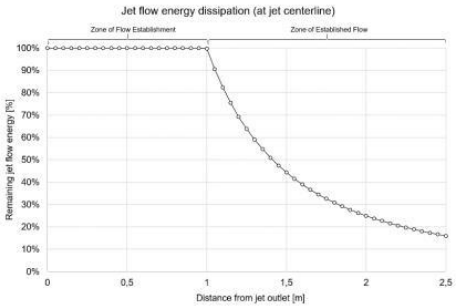


*Figure 3 Jet flow energy strongly degrades as a function of standoff distance. As a consequence, we deem active heave compensation essential for achieving adequate jetting performance*

# Integrated survey capabilities

- 3D motion compensation in combination with the integrated survey frame enable high-quality pre-process, intermediate, and post-process surveys
- The survey frame, able to carry high performance survey equipment such as Innomar SES-2000 quattro, can rotate along the tools' axis through which the vessel can operate in its favorable heading
- Value creation:
  - Far more efficient work flow (i.e. reduction of deployments)
  - Detailed feedback on (actual) excavation performance
  - Automatic asset identification and tracking (e.g. pipeline)
- The combined excavation and survey capabilities also allow for cost-efficient Post Lay Inspection and Burial campaigns: encountered depth of burial deviations can be corrected immediately

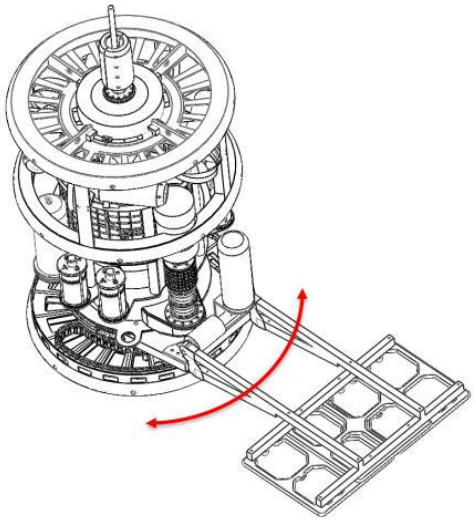

*Figure 4 Rotating survey frame supports a wide range of high-performance survey sensors*

# A high level of automation

- Like all other Seatools ROVs, the Carrera E comes with a high degree of automation. Resulting value creation:
  - Reduction of crew size. The complete spread can be operated by a crew of four in case of 24-hour operations
  - Relieving operators from exacting labor
- Two MFE related functionalities are under development:
  - Backfill mode. Automated motion patterns (e.g. zigzag across the cable route), combined with flow rates that are automatically varied as a function of cross-track distance. Allows for efficient and automated backfilling.
  - Auto-flow mode. This mode is especially beneficial during (for instance) (re-)burial projects whereby buried cables show 3D curvatures and depth of burial varies considerably. This mode automatically adjusts the volume flow rate according to the actual depth of burial along the track. This features enhanced operational efficiency, while minimizing overdredging and seabed disturbance.

*Figure 5 Seatools has an extensive track record in ROV automation. Like our fall pipe ROVs, the Carrera E comes with a large degree of process and navigational automation. Thanks to these ROVs high degree of automation, a complete ROV system, can be operated by a single operator.*

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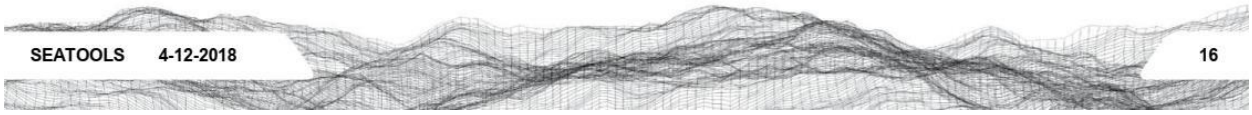
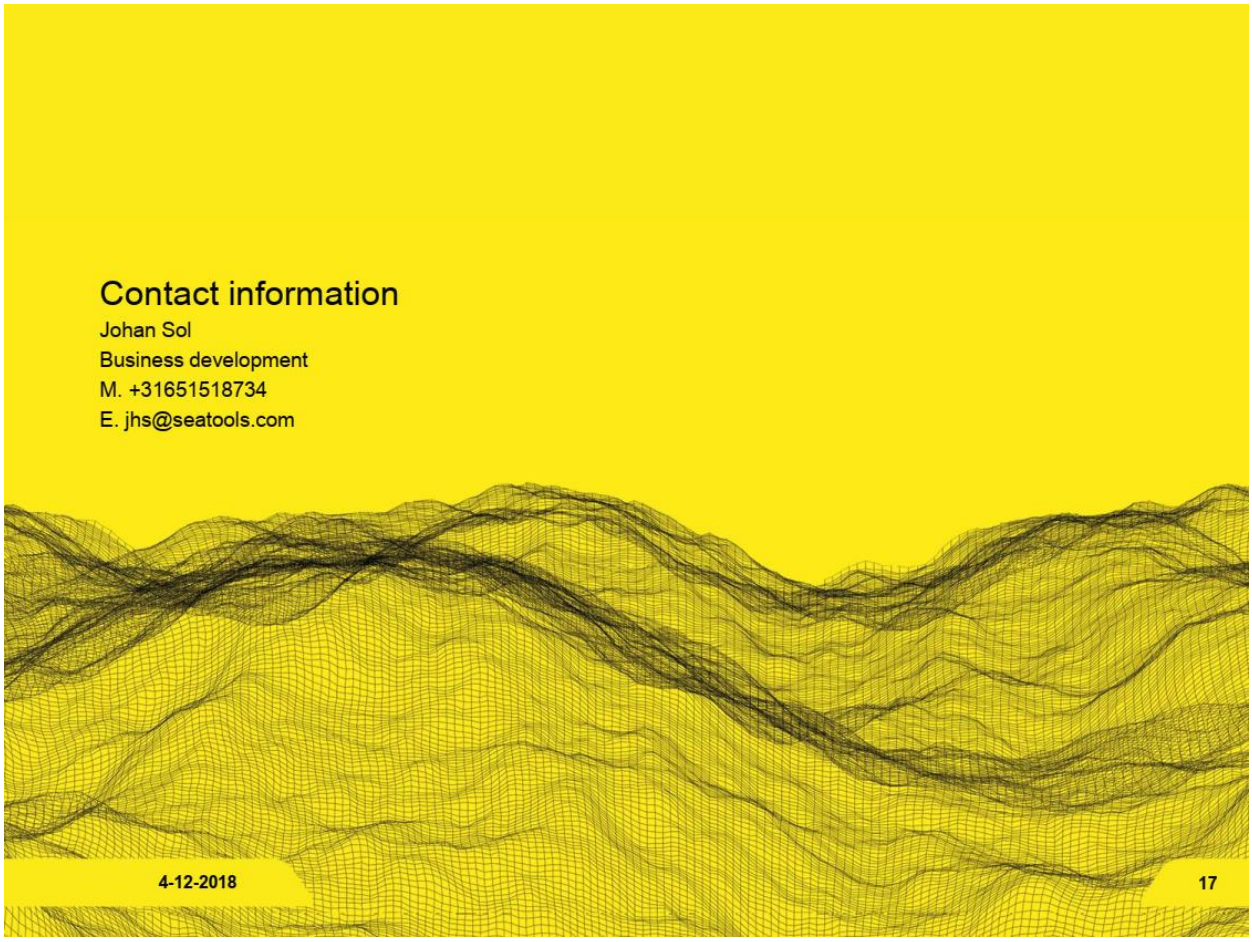
# Small footprint and all-electric drive

- The all-electric drive configuration has resulted in an extremely compact tool (58 kW/$m^3$, a 3 times higher power density in comparison with most competitive spread)
- The Carrera E spread further consist of:
  - LARS including umbilical winch (20 ft footprint, incl. tool)
  - Power container (20 ft footprint)
  - Spares container (20 ft footprint)
- Furthermore the spread consists of portable controls which can be placed at the bridge for direct communication with DPO
- The spread requires a minimum number of mechanical (e.g. no tugger wires) and electrical interfaces between the various modules and the host vessel
- Value creation:
  - Can be deployed from a wide range of vessels (incl. small vessels)
  - Short mobilization times

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4-12-2018
17

# Appendix 3

# Jet Sledge

ABB High Voltage Cables

# Jet sledge OJ200
# Simultaneous laying and burial tool

## ABB´s OJ200 is a jet sledge for simultaneous laying and burial of high-voltage cables

| Dimensions | |
|---|---|
| Length | 10.9m |
| Width | 5.0 mm |
| Height (stinger up) | 3.3 m |
| Weight in air | 16,7 t |
| Maximum product diameter | 250 mm |

| Burial | |
|---|---|
| Burial speed | 2-5m/min (100-300 m/operational hour) depending on soil conditions |
| Max depth of burial | 3.0 m (to top of cable) |
| Seabed type | Sand, gravel, silt and soft clays (20kPa at 3 meters sword depth) |
| Water jetting system | Submersible water supply by a 260 kW pump |
| Water depth | 8 - 40 meter |
| **Towing** | |
| Maximum towing load | 20 t |
| Average towing load | 5-10 t (depending on soil and depth of burial) |

Power and productivity for a better world™

ABB's OJ200 is a jet sledge intended for simultaneous laying and burial of high voltage cables with the capability to bury cables up to 3 meters in non cohesive soils. It is designed and manufactured by Engineering Technology Applications Ltd (ETA) who have an extensive track record of producing high quality jet sledges similar to the OJ200.

The jetting sledge is towed by the Cable Laying Vessel (CLV) and the cable, or multiple cables, are fed from the cable laying vessel into the bellmouth located at the top of the OJ200. From the bellmouth the cable(s) are safely guided through the stinger to exit at the required burial depth which is set in real time during the cable laying operations.

The stinger is equipped with jet water nozzles through which water is injected into the soil to loosen and to fluidize the sediments in front of, and around, the stinger which then passes though the fluidized soil, leaving the cable at the set burial depth. Behind the jet sledge the soil re-sediments, immediately providing protection to the cable and ensuring minimum disturbance to the seabed. The turbidity caused by the jet sledge OJ200 is kept as low as practically possible.

The OJ200 is equipped with a submersible water pump to both increase efficiency by eliminating pressure losses created in the hoses and to remove the need to handle the hoses between the CLV and the Jet Sledge.

ABB's OJ200 spread is equipped with cameras, lights and a range of sensors in order to allow real time monitoring of the cable catenary, tow force, pitch, roll, stinger depth, water depth etc., to ensure the integrity of the cable(s) and the correct measurement of the burial depth during installation.

Main advantages of using ABB's OJ200 for high voltage cable installations are:

- Simultaneous laying and burial of cables creating immediate protection of the cables thus eliminating the risks with exposed cables on the sea bed and the need of guard vessels.
- Real time, physical and thus very accurate measurement of the actual achieved burial depth.
- Cable detection system at the bellmouth and cameras and lights to detect cable catenary forward to ensure safe installation of the cable.
- Minimum environmental impact compared to other trenching methods.
- The submersible pump provides an increased efficiency and effectiveness of the OJ200 spread.

The OJ200 is owned, operated and maintained directly by ABB for the sole purpose of high voltage power cable installation projects. This ensures a high level of tool operating knowledge and experience is available to safeguard the cable during operations.

General
- Generally constructed from carbon steel and corrosion protected by painting.
- 300 meter umbilical cable

Surveillance
Sensors
- (Minimum) cable burial depth
- Pitch
- Roll
- Water depth
- Jett water pressure
- Water pump motor temperature
- Hydraulic system pressure
- Hydraulic reservoir volume
- Hydraulic pump motor temperature
- Cable entry in bellmouth position
- Tow tension

Camera systems
- 2 x mini color cameras
- 2 x 24 v light

Control system
On the OJ200:
- Hydraulic cylinders for stinger up/down

On the cable laying vessel
- 20 feet control cabin with desktop based control system
- The desktop based system communicates with the subsea analogue input device via an RS485 link.



For more information please contact:

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www.abb.com/cables



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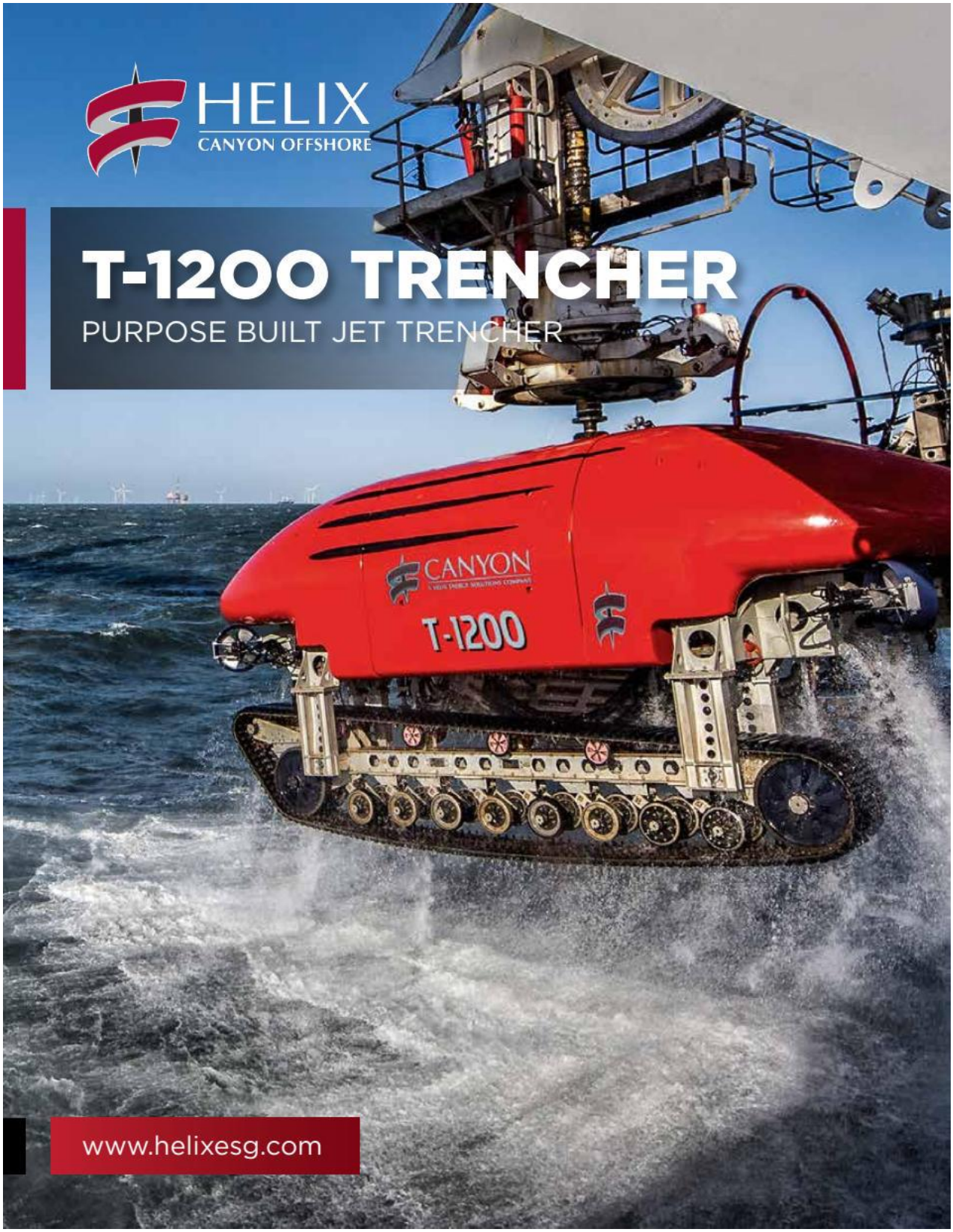
# Appendix 4

# Jet Trencher


HELIX
CANYON OFFSHORE
T-1200 TRENCHER
PURPOSE BUILT JET TRENCHER
CANYON
T-1200
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# T-1200 TRENCHER
## PURPOSE BUILT JET TRENCHER

The **T-1200**, a purpose built jet trencher that has significantly more jetting power – 1,200 hp – and is rated for 3,000 m.

The T-1200 trencher is the next generation of jet trencher drawing on the principles of T-750 whilst incorporating the latest technologies to meet the burial challenges of today. The T-1200 is capable of burying flexible/rigid products as well as power cables up to 3 metres below the seabed in its current configuration and in soil conditions of up to 120kpa. The T-1200 jet-trenching ROV can operate in water depths from 10m to 3,000m and has project verified experience from 10m water depths in the North Sea to 1,850m in the waters off Brazil. Whilst the jet leg current configuration allows trenching of products up to 915mm diameter, the versatility of the system can, with modifications, increase this envelope should the need arise.

Trenching speeds can vary depending on mode (tracked or skid), soil conditions, product diameter and the required depth of trench required, however speeds in sand over 400m/hr can be attained where speeds of 80-150m/hr are achievable for conditions where the soils are stiffer and harder to penetrate. The directly coupled water pumps together variable speed drives means that this 1200Hp system is equivalent to that of a conventional electro-hydraulic 1500Hp system that uses the power to water pumps less efficiently. The CFD modelled plenum takes the water from the pumps to the jet legs with minimal losses. The water system is designed to maximise water pressure and flow at the adjustable jetting nozzles which are distributed on the jetting swords to fluidize in front and between the swords, and if required to taper the trench wall. Its these design enhancements, coupled with unrivalled burial experience that puts the T-1200 and the T-1500 jet trenching systems as the most effective burial systems in their class.

### EXPERIENCE

Canyon Offshore currently operates and maintains 54 work class ROVs, 5 trenching systems, 2 ROVDrill systems and 3 DP III support vessels via strategic offices in key areas of the world.

### INNOVATION

Canyon Offshore works closely with our clients and vendors to seek and resolve complex technical developments to engineer practical solutions and implement in the most efficient, safe and economical ways possible.

### VALUE

Canyon Offshore is one of the most innovative and reliable specialty marine contractors in the world. Focusing on providing leading edge underwater, unmanned services in extreme environments, Canyon strives to deliver the highest value to its customers.

## MAIN CHARACTERISTICS

| | |
|---|---|
| Depth Capacity | 3,000 msw |
| Maximum Speed (Free Flying) | Forward = 2.8 knots<br>Lateral = 2.0 knots |
| Maximum Speed (Tracked) | Forward = 2,500 m/hr |

## DIMENSIONS (MAXIMUM)

| | |
|---|---|
| Width Over Buoyancy | 6,095 mm |
| Width Over Tracks | 5,600 mm |
| Length | 9,150 mm |
| Height | 5,164 mm |

## VEHICLE WEIGHT

| | |
|---|---|
| ***In Air (200 Kg Payload)*** | |
| Tracked Mode Configuration | 30,500 Kg |
| Skid Configuration | 27,500 Kg |
| ***In Water (200 Kg Payload)*** | |
| Tracked Mode Configuration | 1,000 to 1,500 Kg |
| Skid Configuration | 300 to 1,000 Kg |

## TRACK DRIVE SYSTEM

2 x underwater tracks, hydraulic driven

Able to track in > minimum soil strength – 3.5 kPA shear strength

## HYDRAULIC MANIFOLDS

2 x ROV, thruster control manifolds (proportional valves for pilot control of thruster motor)

3 x ROV, 12 station manifolds (12 function solenoid / proportional valve manifold)

## ELECTRICAL POWER SYSTEM

2 x 281 kW/375 hp electric motor, controlled by variable speed drive (VSD) surface transformers, directly coupled to 2 hp water pumps

1 x 281 kW/375 hp electric motor, coupled to a hydraulic pump providing power for LP water pumps, motive power and auxiliary functions

## REAR STINGER ASSEMBLY

Rear mounted, hydraulically deployed with variable control and feedback product monitoring stinger to provide calibrated real-time (continuous) burial depth indication (OPTIONAL)

## PROPULSION SYSTEM

Proportionally controlled thrusters

4 x 500 mm horizontal thrusters

4 x 500 mm vertical thrusters

## DEPTH SENSOR

High accuracy sensor, 0.1% over full scale for depth

## HEADING SENSOR

Octans gyro

## AUTO FUNCTIONS

Heading

Depth

Altitude

Product Tracking

## CAMERA & LIGHTING SYSTEM

1 x low light camera

3 x color cameras with focus and zoom

3 x mono inspection cameras

16 x LED lights

2 per dimming circuit standard

## CONTROL SYSTEM

Utilizes the evolutionary ICETM

Integrated control engine

Fully redundant Windows based on HMI computers

Dedicated real-time controllers

Intuitive graphical interactive diagnostics

User configurable GUI

Ergonomic pilot / co-pilot control consoles

Using touch screen control interfaces for diagnostics and other secondary functions

4 x 40 in HD plasma video wall

## DATA TRANSMISSION

Single mode fibrotic video and data multiplexer

8 x real-time video channels available

4 x full duplex RS232 @ 115 kpbs data channels

4 x full / half duplex RS485 / 422 / 232 channels

## PRODUCT BURIAL CAPABILITIES

| | |
|---|---|
| Product Size Range | up to 915 mm diameter (depending on soil conditions and burial depth) |
| Cohesive Soil | Up to 120 kPa (product specification and burial depth dependent) |
| Non-cohesive Soil | Sand, silt and gravel to 30 mm |
| Burial Depth | up to 3.0 m (soil and product dependent) |
| Burial Speed | 25 to 780 m / hr (soil / burial depth / product dependent) |

## SENSORS

Multi beam imaging sensors

Product location / tracking system (TSS 440/350) (or other tracking device)

## LAUNCH & RECOVERY SYSTEM

| | |
|---|---|
| Capability | Sea state 5 |
| Capacity | 3,300 m |
| Outreach | 10 m (tbc) |
| Lifting Speed | 30 m / min on bottom layer |

## EDUCATOR & BACKFILL

Standard rear tooling of an eductor complete with integral backwash jets to allow selection of eduction or backwash switchable remotely.

A back fill tool can also fitted to collapse the trench wall during a dedicated backfill pass after an open trench has been created

## JETTING SYSTEM

1m, 2m & 3m length burial swords

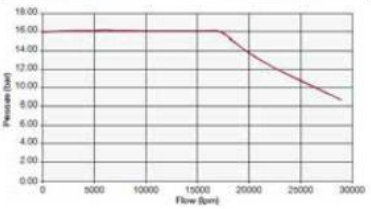
## HP WATER PUMPS

HP water pressure flow and jetting sword nozzle configuration will be engineered per execution of each project and dependent of soil conditions, project specification and burial requirements

To optimize vehicle performance, detailed setup of the trencher will form part of the project procedure package

| | |
|---|---|
| Total HP Output | Up to 17,500 LPM at 16 bar maximum pressure & up to 300,00 LPM at 8 bar dependent on nozzle configuration and sword length. Typical operating pressure 11 bar |

## HP WATER PUMP CURVE



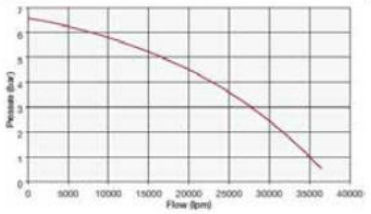
## LP WATER PUMPS

LP water pressure flow and jetting sword nozzle configuration will be engineered per execution of each project and dependent of soil conditions, project specification and burial requirements

To optimize vehicle performance, detailed set up of the trencher will form part of the project procedure package

| | |
|---|---|
| Total HP Output | up to 8,000 LPM at 6 bar maximum pressure & up to 35,000 LPM at 1 bar maximum flow dependent on nozzle configuration and sword length. Typical operating pressure 3 bar |

## LP WATER PUMP CURVE

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# Appendix 5

# Multi Method Trencher

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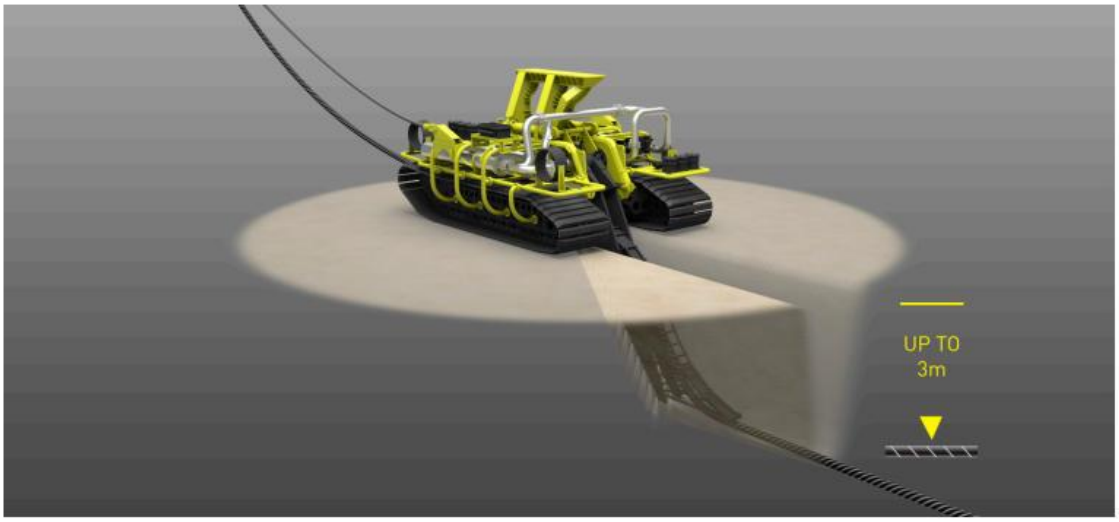
# EQUIPMENT SHEET

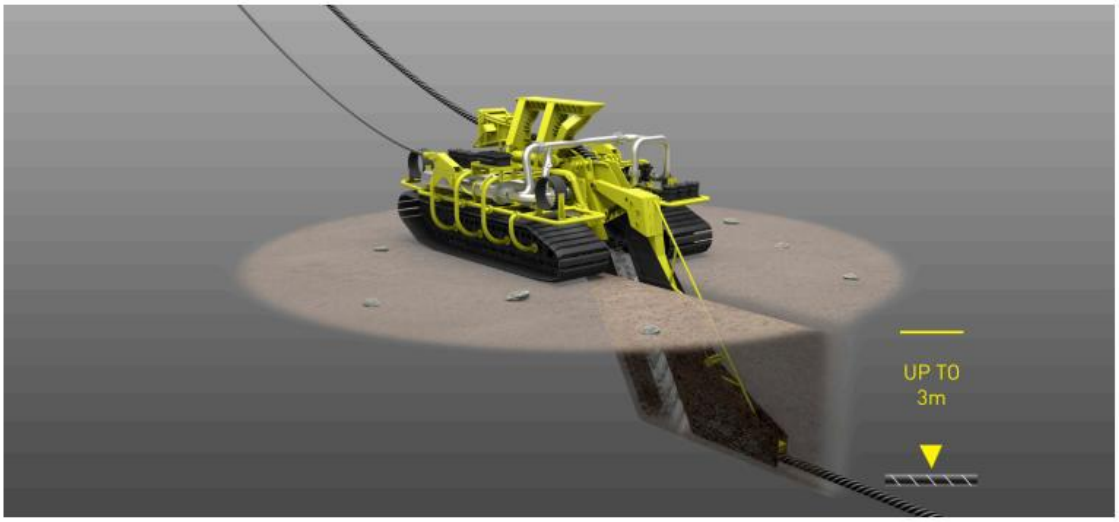
**TRENCHFORMER**

| FEATURES |
|---|
| Interchangeable tools: jet sword, chain cutter and disc cutter for trenching through a wide range of soil |
| Simultaneous lay and trenching |
| Post-lay and remedial trenching |
| Capability to operate on beach and through surf zone |
| Self-supporting spread; can be installed on various vessels or pontoons |
| Built-in depressor to ensure product is buried at required depth |
| Heading control for accurate steering and alignment |
| Low ground pressure due to optimized track surface |
| Combined power and fibre optics via single umbilical |
| Operation from one central control room |
| Extensive real-time monitoring and control system, including route, speed, performance and burial depth |
| Profiling sonars, obstacle avoidance sonars, pan & tilt colour cameras, USBL transponders, Rovins INS, bathy/alti/ conductivity & temperature sensor |

| MAIN DATA | |
|---|---|
| Supported products | Umbilicals, infield cables, export cables, interconnectors and flexibles up to ø280 mm, MBR up to 3.6 m |
| Trench depths | 3,0 m |
| Soils | Silts, sands, clays and rock |
| Length carriage | 7.2 m |
| Width carriage | 6.0 m |
| Height carriage | 4.0 m |
| Weights<br>Jetting config.<br>Chain cutting config. | Depending on configuration:<br>47-51 t (air), 39-42 t (submerged)<br>61-65 t (air), 50-53 t (submerged) |
| Ground pressure | Depending on config.: 19 to 23 kPa |
| Total installed power | 1,200 kW |
| Jet performance, option:<br>2 pumps + 1 redundant<br>3 pumps | <br>980 $m^3$/hr at 10.9 bar<br>1,440 $m^3$/hr at 11.3 bar |
| Trenching speed | Depending on soil conditions and configuration: up to 10 m/min |
| Traction | Depending on soil conditions: up to 200 kN traction force |
| Water depth | Up to 400 m |
| Seabed slope | 15° pitch, 10° roll |




**TRENCHFORMER IN JETTING CONFIGURATION**




**TRENCHFORMER IN CHAIN CUTTING CONFIGURATION**



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# Appendix 6

# Plough

## SEA STALLION
# POWER CABLE PLOUGH

### PRODUCT OVERVIEW
The *Sea Stallion* cable plough range has an extensive track record spanning almost 20 years in the burial of subsea cables. The latest generation boasts significant improvements over early versions whilst still incorporating the robust highly effective multi-bladed share system.

Considerable effort has resulted in reduced vessel fuel costs and improved the cable handling combined with the latest Ethernet control system.

### CUSTOMER SPECIFIC
Working directly with clients to deliver tailored subsea solutions the plough is customisable to meet project-specific requirements. The plough can be upgraded throughout its life cycle to confront new challenges using the latest technologies.

The plug & play design of the control equipment ensures customer components can be easily integrated using the self-diagnostic, multi -drop down, distributed control system. All IHC EB control systems are fully compliant with IEC 61508.

### CUSTOMER BENEFITS
Reduced costs:
- lower vessel fuel consumption
- increased operational window
- turnkey supply of equipment and vessel
- responsive 24/7 worldwide service
- attractive financing available.

### KEY TECHNICAL FEATURES
Better cable protection:
- pivoting bellmouth®
  - ultra-cable friendly cable path with reduced bend angles especially lowering the plough through the water column
  - lower residual cable tension
- lowering tow points
  - reduced skid forces vessel fuel costs
  - increased stability for better penetration
- full monitoring of cable tension and position.

### SAFE AND ENVIRONMENTALLY FRIENDLY
- buoyant umbilical, no requirement for floats
- biodegradable oil as standard.

IHC **THE TECHNOLOGY INNOVATOR.**

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## SPECIFICATION

| | |
|---|---|
| Trench depth | 0.0m to 3.3m |
| Soil strength | 5kPa to 350kPa |
| Cable OD | Ø30mm to Ø300mm |
| Cable MBR | 5.0m |
| Tow force | 150Te (continuous) |
| Steering | ±10° |
| Water depth | 1500m |
| Weight in air | 50Te (with jetting fitted) |
| Dimensions | Length 14.1m |
| (on deck) | Width 6.0m |
| | Height 6.6m (drawbar up) |

## OPERATION

| | |
|---|---|
| Share | Aggressive, multi blade |
| Plough handling | lifting drawbar |
| Cable handling | simultaneous lay & trench |
| Umbilical | buoyant |
| Launch & Recovery | sea State 5 ($H_{sig}$ = 3.0m) |

## CONTROL

| | |
|---|---|
| SCADA | Ethernet |
| Instrumentation | comprehensive with full data logging and remote diagnostics |

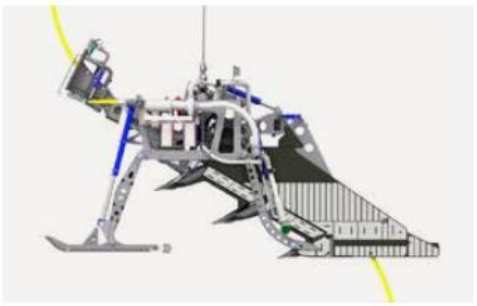
## SURVEILLANCE (TYPICAL)

| | |
|---|---|
| Cameras | 3 off low light, colour etc |
| Lamps | 6 off dimmable LED's |
| Heading | Gyro or compass |
| Sonar | obstacle avoidance |

## OPTIONS

| | |
|---|---|
| Jetting, dilation® | 150kW in share tips |
| | Beach operation |
| Post lay burial | subsea cable load/unload |
| | • crane, |
| | • bellmouth tines |
| | • tipping trough |
| | • pivoting depressor |
| Umbilical | ultra-low loss 6kV |

All details are typical. Please contact uk@royalihc.com for any client specific requirements.

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# Appendix 7

# ROV

**EQUIPMENT FLYER**


# FUGRO
# FCV® 3000 (150HP)

**The FCV 3000 is designed and built in-house by Fugro and offers the next generation of performance and capability to our world-wide customer base. The FCV 3000 reflects the Fugro commitment to Remote Technology Solutions and incorporates a range of internally developed expertise to help us deliver information from collected data, faster, better and with enhanced accuracy.**

Over the years Fugro has developed a wide range of innovative technology and solutions to better address our customers' needs, so it is logical that when we turn our attention to the objectives of our ROV Business Line, we build the new generation of capability on a stable platform of field proven components and include our own particular brand of innovation.

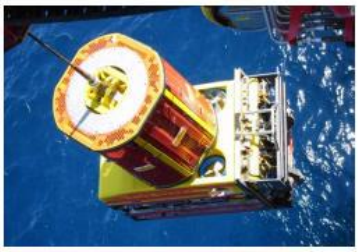
Key capabilities that are incorporated into the FCV 3000 is designed to improve the efficiency of the operations and address the need to provide greater spatial awareness to the Operations Team.

Together with its console installed Simulator the FCV 3000 offers:

- Real time visualisation of the local subsea environment – helicopter view
- Mission rehearsal tools – Simulation and Planning
- Semi autonomous functionality
- 3 Dimensional Dynamic Positioning
- Pilot Training whilst ROV is on deck

In addition to its ability to carry a full instrumentation package, the FCV 3000 has class leading mechanical / hydraulic tooling interfaces that include:

- Mechanical Interface: Fugro proprietary 4-point
- Through Frame Lift: 3,000 Kg at 3 g
- Tooling: up to 217 LPM @ 210 bar
- IHPU: 70 LPM @ 225 bar
- Bi-directional Solenoid: 15 Solenoid Valves
- Servo Valves: 8, being 7 Thruster + 1 spare
- Remote Control IVP : (Optional)
- High Flow IVP: (Optional)
- Skid Contol IVP: 10 x NG3 + 1 x NG6



*FCV 3000 (150HP) being launched.*

Like its in-house built predecessors, the FCV 3000 is part of an evolving system design that provides the customers with all of the essential demands of the deep water ROV System such as a 3.2 knot forward speed delivery by its 150 Hp hydraulic power system and high power vectored thrust design. This base level of standard capability, combined with the industry leading Sonar, Camera and Manipulator Systems of the 3,000 msw rated FCV 3000 will immediately allow the unit to be recognised as a market leading solution to the rigours of deep water intervention and support.

At the heart of the FCV 3000 is Fugro's proven control & communications system based on single-mode fibre-optic technology including Fugro's own design / build SMFO multiplexer, giving an exceptionally high data throughout and features switching in the event of failure of a fibre. The high end multiplexer handles up to 3 HD cameras and 12 conventional cameras (8 simultaneously) and provides a wide range of data communications protocols facilitating efficient integration of add-on tools and sensors.
The data highway of the FCV 3000 can cater for up to 20GB, which is sufficient to run the ROV, the TMS, 3 x HD cameras, full survey data suite including dual MBES (such as Reson 7125) and still have sufficient headroom to allow a range of other specialist sensors to be operated simultaneously.

# FCV® 3000 (150HP)

## Technical Specifications

| Dimensions | |
|---|---|
| Length | 3.3 m |
| Height | 1.7 m (excl TMS) |
| Width | 1.7 m (excl TMS) |
| Weight | 4.1 Te (incl 400 Kg payload) |

| Power | |
|---|---|
| Motor | 1 x 2850 VAC @ 112 kW (150 Hp) |
| Hydraulic Pump Flow | 217 LPM +70 LPM @ 60 Hz |
| Hydraulic Pump Pressure | 225 bar (main) |
| Single Phase Electric Supply | 10 KVA , 24 VDC & 115 VAC |
| Tooling | up to 217 LPM @ 60 Hz |

| Speed | |
|---|---|
| Forward / Aft | 3.2 knots |
| Lateral | 2.4 knots |
| Vertical up / down | 2.4 knots |

| Thrusters | |
|---|---|
| 4 x 15" vectored Horizontal | Fwd/Lateral: 806 Kgf |
| 3 x 15" vectored | Vertical: 826 Kgf |

| Sensors | |
|---|---|
| Heading | FOG / OCTANS |
| Pitch and Roll | FOG / OCTANS |
| Depth | Digiquartz 8CB4000-I |
| Altimeter | Simrad 1007 Digital Altimeter |
| Sonar | Simrad MS1071 6000 m digital |
| Cameras | 12 x SD Cameras, 8 at any one time |
| | 3 x HD Cameras (Optional) |
| Data | RS232, RS485 TTL Ethernet and Gb Ethernet |
| Lighting | 8 x 110 VAC 600W Dimmable lights |
| | 2 x 24 VDC Dimmable LED lights |

| Manipulators | |
|---|---|
| Manipulator 1 | Schilling TITAN 4 |
| Manipulator 2 | Schilling RigMaster |

| Control System | |
|---|---|
| Vehicle Control | Fugro Proprietary ERA-004 |
| FO Multiplexer | Fugro Proprietary SM 20GBit Bandwidth |
| Survey Module | Fugro Proprietary StarPort |

| Tooling | |
|---|---|
| Mechanical Interface | Fugro Proprietary – 4 point |
| Through Frame Lift | 3,000 Kg |
| Tooling IHPU | 70 LPM @ 210 bar |
| Bi-Directional Solenoid | 15 x Solenoid Valves |
| Servo Valves | 8, being 7 Thruster + 1 spare |
| Mini IVP | Optional |
| High Flow IVP | Optional |
| Skid Control IVP | 10 x NG3 + 1NG6 (proportional) |

| Power Requirements | |
|---|---|
| System (typical) | 350 KVA, 380-500 VAC<br>3-ph supply 50/60 Hz.<br>60 Hz for optimum performance |

**Main Lifting Umbilical**

37 mm Ø double armoured
Optimised design with single mode fibres in robust steel tube

| TMS | |
|---|---|
| Type | Top Hat , PSSL Type 4, 11 Te SWL |
| Tether | 600 m of 30 mm diameter tether |
| Dimensions | 1.8 m (Dia) x 2.0 m (H) |
| Weight: In Air/Water | 2.5 Te / 1.5 Te (inc 600 m tether) / Submerged |



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# Appendix 8

# Cable Laying Vessel

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# EQUIPMENT SHEET

**NDURANCE**
CABLE LAYING VESSEL


## CONSTRUCTION/CLASSIFICATION

| | |
|---|---|
| Built by | Samsung C&T corporation<br>ZPMC - Shanghai Zhenhua Heavy Industries Co.Ltd |
| Year of construction | 2013 |
| Classification | Lloyd's Register, offshore multifunctional accommodation barge, bottom strengthened for loading and unloading aground |

## FEATURES

- Completely new ship and turntable design.
- Diesel electric propulsion system.
- Accommodation on fore ship, total for 98 persons
- Two engine rooms.
- Beaching capability.
- Corridor under accommodation to handle projects at the bow.
- 6 point mooring system.
- Launch & recovery trencher with a-frame (SS5)

## MAIN DATA

| | |
|---|---|
| Dynamic positioning system | DP-2 |
| Length overall | 99.00 m |
| Breadth | 30.00 m |
| Moulded depth | 7.00 m |
| Design draught | 4.8 m |
| Displacement | 12,285 t |
| Turntable capacity | 5,000 t |
| Outer diameter | 26 m |
| Inner diameter | 3-6 m (adjustable) |
| Product cable size | 50-300 mm |
| Cable speed range | 0-1000 m/h |
| MBR cable highway | 4.50 m |
| Cable tensioners | 15 t |
| Crane | 25 t SWL at 25 m |
| Cable handling area | 35 m x 30 m |
| Max. sailing speed | 11.5 kn |
| Total installed power | 7,500 kW |
| Main engines | 7,280 kW |
| Azimuth thrusters | 2 x 1,250 kW + 2 x 1,000 kW |
| Bow thruster | 1 x 550 kW |

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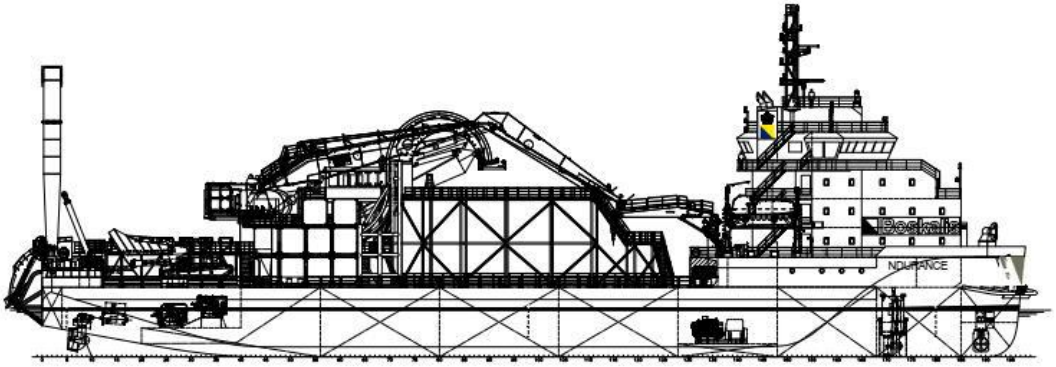
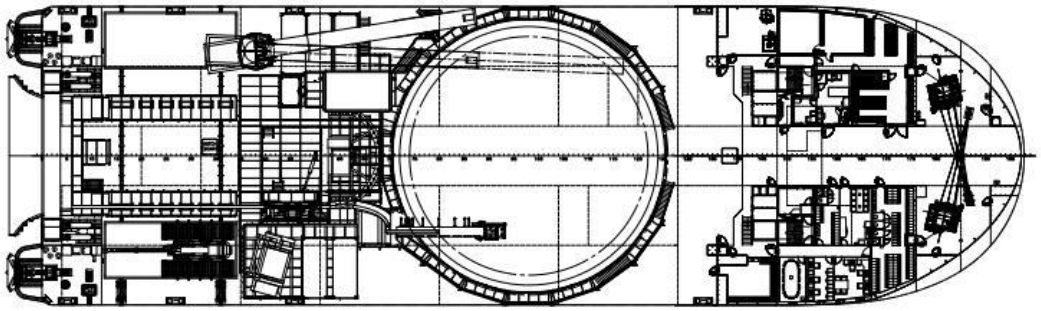
**NDURANCE**
CABLE LAYING VESSEL




**SIDE VIEW**



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# EQUIPMENT SHEET

**SPIRIT**
CABLE LAY VESSEL


## CONSTRUCTION / CLASSIFICATION

| | |
|---|---|
| Type of vessel | DP2 special serviceworkboat |
| Registration | The Netherlands<br>Vessel complies with SOLAS |
| Classification | Bureau Veritas + Hull + Mach + AUT UMS +Dynapos AM/ AT R Special Service |

## PROPELLING MACHINERY

Main engines 2 x Caterpillar 3512
Stern thrusters 2 x HRP 6111
Bow thrusters 2 x Caterpillar 3512B, 2 x HPR 6111 retractable Azimuth 1118 kW, 1 x electric driven tunnel thruster 650 kW

## GENERATORS

3 x 850 kW parallel running/PM system

1 x 200 kW emergency/harbour generator

## FEATURES

Accommodation for 60 persons, 1x hospital, 2x client offices, 1x conference room

## DYNAMIC POSITIONING SYSTEM

| | |
|---|---|
| Regulatory approved | BV Class AM/AT R |

## MAIN DATA

| | |
|---|---|
| Gross tonnage | 5,551 GT |
| Length overall | 90.0 m |
| Moulded width | 28.0 m |
| Moulded depth | 6.5 m |
| Draught max. | 4.70 m<br>(7.00 m bow thrusters down) |
| Draught min.<br>(includes standard cable lay equipment) | 1.90 m<br>(4.20 m bow azimuth down) |
| Speed max. approx. | 9 kn |

## CRANES & LIFTING APPLIANCES

| | |
|---|---|
| 6 Point mooring system | 6 nos 60 t pull/100 t hold, full CT |
| Drum capacity | 1,000 m Ø 48 mm anchor wire |
| Anchors | 6 nos 7 t SSHP, 5 t stevpris |
| Optional | pull winch for plough operations<br>125 t sust./180 t max. |
| Hydraulic deck crane | 18 t at 14 m radius |
| Main crane | Offshore knuckle boom crane<br>active heave compensation<br>boom length 34 m<br>lifting capacity 140 t |

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**SPIRIT**
CABLE LAY VESSEL

| TURNTABLE | |
|---|---|
| Loading capacity | 4,400 t |
| Outer diameter | 24 m |
| Inner core diameter | 6.6 m (adjustable to meet cable specifications) |
| Height of turntable | 5.5 (extendable to max. 7 m) |
| Surface area ring | 420 m² |
| Cable speed range | 0-1,000 m/hr (loading and laying) |
| Max product diameter | 450 mm |
| Max product weight | 150 kg/m |

| CABLE LAY EQUIPMENT | |
|---|---|
| Cable tensioners | 2 x 5 or 10 t (project specific) |
| Cable splice area | Deck space is available for jointing activities |

| TANK DIMENSIONS | |
|---|---|
| Fuel oil capacity | up to 1,400 m³ |
| Fresh water maker | 2 x 12 m³ |
| Fresh water tank capacity | ~300 m³ |
| Ballast tank capacity | ~2,000 m³ |
| Ballast pump discharge rate | 2 x 400 m³/hr |
| Sewage treatment plant | 1 |



04 – 2018

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# EQUIPMENT SHEET

**NDEAVOR**
CABLE LAYING VESSEL

## CONSTRUCTION / CLASSIFICATION

| | |
|---|---|
| Built by | Samsung C&T corporation<br>ZPMC - Shanghai Zhenhua Heavy Industries Co.Ltd |
| Year of construction | 2013 |
| Classification | Lloyds Register, offshore multifunctional accommodation barge, bottom strengthened for loading and unloading aground |

## FEATURES

- Completely new ship design
- Diesel electric propulsion system
- Accommodation on fore ship, total for 98 persons
- Two engine rooms
- Beaching capability
- Corridor under accommodation to handle projects at the bow
- 6-point mooring system
- Helicopter deck (T = 10 t / D = 20 m (Super Puma AS332L2))

*Optional:*

- Side stone dumping installation
- Fallpipe for subsea rock placement
- (Deepwater) seabed excavation system
- Solid ballasting pumping spread
- Construction support crane
- SAT / AIR diving & ROV support

## MAIN DATA

| | |
|---|---|
| Dynamic positioning system | DP-2 |
| Length overall | 99.00 m (excl. heli deck) |
| Breadth | 30.00 m |
| Moulded depth | 7.00 m |
| Design draught | 4,80 m |
| Displacement | 12,191 t |
| Turntable capacity | 2,000 t |
| Outer diameter | 18 m |
| Inner diameter | 4 m |
| Product cable size | 50-300 mm |
| Cable speed range | 0-1,000 m/h |
| MBR cable highway | 3.60 m |
| Cable tensioners | 10 t |
| Crane | 35 t at 20, 15 t at 30 |
| Cable handling area | 35 m x 30 m |
| Max. sailing speed | 11.5 kn |
| Total installed power | 7,500 kW |
| Main engines | 7,280 kW |
| Azimuth thrusters | 2 x 1,250 kW + 2 x 1,000 kW |
| Bow thruster | 550 kW |

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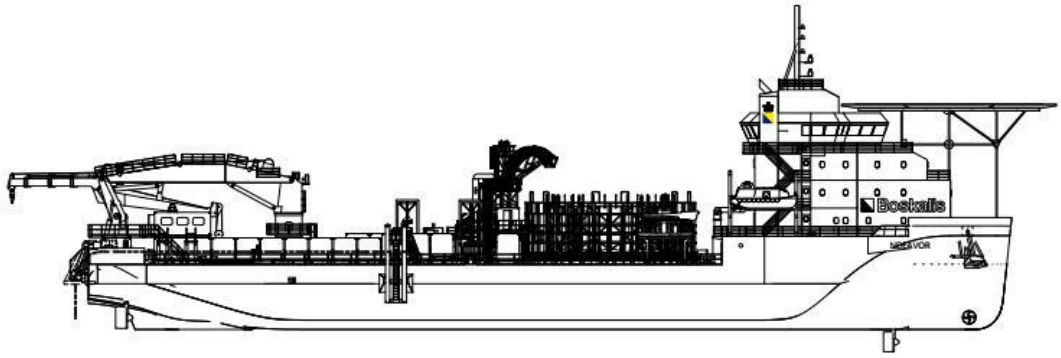
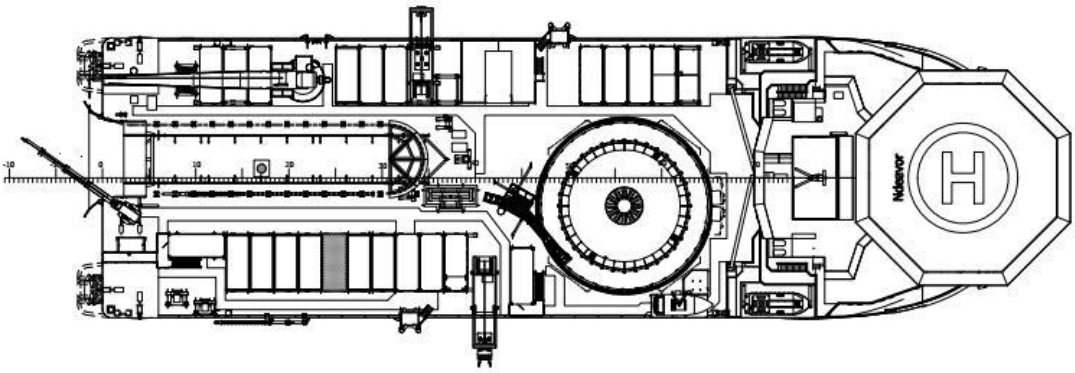
**NDEAVOR**
CABLE LAYING VESSEL




**SIDE VIEW**

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Renewables

Our Values

- Safety
- Integrity
- Sustainability
- Performance
- Collaboration
- Innovation


# Seaway Moxie

## Vessel Info

*Full specification overleaf*

***Seaway Moxie*** **is an installation support vessel designed and equipped to allow quick and safe 'walk to work' access to offshore installed assets such as offshore wind farms.**

- Length 74m x breadth 17m
- Deck area 190m²
- 3D motion-compensated extendable boom crane
- Offshore access gangway transfer system
- Accommodation for 60 persons

## Fast Facts

- 5t 3D motion compensated offshore crane
- Active motion-compensated (AMC) Gangway System
- Award winning vessel design
- Ability to work in significant wave heights up to 3.5m

*Seaway Moxie*

seaway 7

### General Information

| | |
|---|---|
| Type | **Offshore Service Vessel** |
| Classification | **DNV *1A1 with the following class notations: SF, E0, BIS, DYNPOS-AUTR, CLEAN DESIGN, COMFV(3), NAUT-OSV (A), SPS. IMO MSC.266(84) - Code for Special Purpose Ships, 2008.** |
| Flag | **Isle of Man** |

### Principal Dimensions

| | |
|---|---|
| Length overall | **74m** |
| Length between perpendiculars | **70.7m** |
| Breadth | **17m** |
| Depth from deck | **8m** |
| Maximum draft | **4.6m** |
| Design draft | **6.0m** |
| Deck load | **500t, 5t/m²** |
| Deck space | **190m²** |
| Gross tonnage | **4,367** |
| Net tonnage | **1,311** |

### Power and Propulsion

| | |
|---|---|
| Main Propellers | **2x Voith Schneider ECS Propellers and Cycloidal** |
| Rudders and associated transmission | |
| Power | **1,850kW approx.** |
| Motor speed | **0 – 1,200rpm** |
| Blade orbit diameter | **2,800mm** |
| Blade length | **2,340mm** |
| No. of blades: | **5** |

### DP Systems

The vessel is equipped with a DP-2 (Dynpos AUTR) system comprising the following reference system and sensors:

**2x Wind sensors with heating**
**3x Motion Reference Units (x-y direction)**
**2x Differential GPS Systems**
**1x Cyscan Laser Reference System**
**1x Radarscan Relative Position Sensor**

### Cranes

| | |
|---|---|
| Macgregor 3D motion compensated crane | |
| Capacity | **SWL 5t at 25m outreach** |
| Hook height | **30m above sea level** |

### Anti-Heel System

| | |
|---|---|
| Active anti-heeling system | |
| Wing tanks | **2x** |
| Pump with electric motor | **1x capacity approx. 400 m³/h** |

### Safety System

| | |
|---|---|
| Fast Rescue Crafts | **2x with aluminum hull, inboard diesel engine and water jet propulsion basin** |
| Single-point davit LARS | **2x inclusive of active heave compensated winch system for Fast Rescue Crafts** |
| Life rafts | **6x, 35 persons each, 3 on each side** |

The vessel has safety equipment according to SOLAS and flag state requirements.

### Workability

The vessel has been designed and has proven its ability to operate in up to 3.5m significant wave height, both for personnel transfers via gangway and cargo transfers using its specialized crane within its area of operation.

### Transfer Gangway

An uptime-supplied motion compensated gangway (transfer system) is installed on the C-deck mid-ship. The transfer system is based on an active motion compensated gangway system and can work in various modes.

Access to the transfer system is arranged directly from the C-Deck on a permanent basis thus allowing for easy and safe access of personnel.

### Accommodation

| | |
|---|---|
| Berths | **60 person** |

The Subsea 7 fleet comprises of vessels that have exceptional versatility, capable of operations worldwide including; pipelay, construction, survey, remote intervention, diving support, heavy lifting operations, renewables and decommissioning.

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Our Differentiators

Culture · Creativity · Relationships · Reliability · Solutions

# Appendix 9

# Heavy Lifting Vessels

Boskalis

# HEAVY LIFT VESSELS

# BOKALIFT 1
# DP-2 3000 T
# CRANE VESSEL

**CONSTRUCTION/CLASSIFICATION**

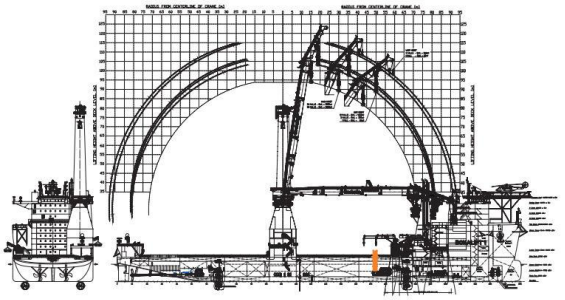
| | |
|---|---|
| Vessel built by | Guangzhou Shipyard International Co. Ltd. 2012 |
| Year of conversion | 2017 |
| Classification | BV I ✠ Hull ✠ Mach, Cleanship Ice, Class 1D |
| IMO | 9592850 |
| Call sign (flag) | 5BVH4 (Cyprus) |

**FEATURES**

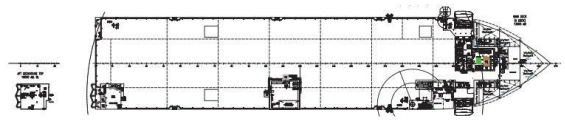
| | |
|---|---|
| Accommodation | 150 persons SPS compliant |
| Lifting Capacity<br>main block<br>auxiliary block | 3,000 T up to 28 m radius<br>1,200 T up to 50 m radius<br>800 T up to 81 m radius |
| whip hoist (double fall)<br>whip hoist (single fall) | 200 T up to 92 m radius<br>80 T up to 94 m radius |
| Lift height above deck<br>main block<br>auxiliary block | <br>90 m at 30 m radius<br>99 m at 35 m radius |
| Depth range auxiliary block | 1,128 T at 230 m water depth |
| Aux block, re-reeved for max. depth range | 330 T at 900 m water depth<br>Depth range whip block single line 1,900 m water depth |
| Cargo deck<br>Size<br>Rated<br>Max deck load | <br>6,300 m²<br>25 T/m²<br>15,000 T |
| Max. transit speed | 12.5 kn |
| Store crane | 2 x 30 T at 10 m radius<br>20 T at 16.5 m radius |
| Air draft | 85 m |
| Helideck | Suitable for S-61N and S-92 max take-off weight: 12.8 T |

**MAIN VESSEL DATA**

| | |
|---|---|
| DP System | Kongsberg DP-2 |
| Reference systems | DGPS<br>HiPaP |
| Vessel dimensions<br>Length oa<br>Breadth<br>Depth moulded<br>Operating draft | <br>216 m<br>43 m<br>13 m<br>8.5 m (expected) |
| Installed power<br>Main engines<br><br>Auxiliary engine | <br>4 x 3,840 kW<br>2 x 4,800 kW<br>1,110 kW |
| Propulsion<br>Main sailing<br>Retractables<br>Bow thrusters | <br>2 x 5,250 kW<br>4 x 3,500 kW<br>2 x 1,200 kW |
| Mooring system | Optional 8-point mooring system |
| Ballast capacity | 2 x 1,500 cum/hr |
| Anti-heeling system | 8 x 2,000 cum/h |



**SIDE VIEW**



**TOP VIEW**

# TAKLIFT 4

**CONSTRUCTION/CLASSIFICATION**

| | |
|---|---|
| Year of construction | 1981 |
| Classification | LR X 100 A 1 sheerlegs pontoon LA |
| Call sign | PHWS |

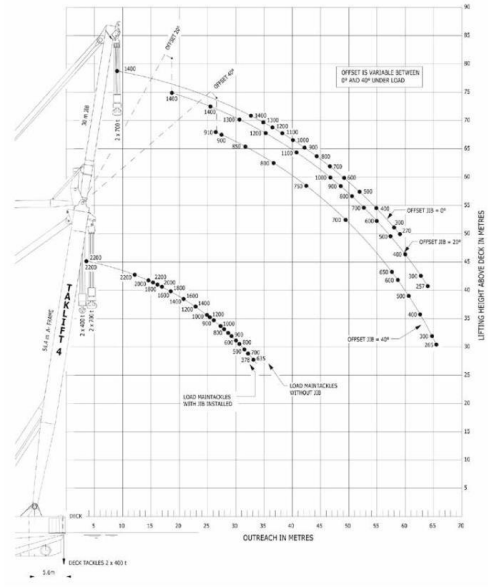
**FEATURES**

Accommodation for 30 people (can be increased).

**MAIN DATA**

| | |
|---|---|
| Gross tonnage | 5,695 R.T. |
| Net tonnage | 1,708 R.T. |
| Length | 83.20 m |
| Beam | 36.90 m |
| Depth | 7.00 m |
| Draught (minimum) | 3.00 m |
| Draught (maximum) | 6.02 m |
| Propulsion | 2 x 1,000 kW |
| Bowthruster | 2 x 440 kW |
| Aft | 3 x 25 tonnes capacity 500 m of 44 mm diameter wire rope<br>2 x 40 tonnes capacity 625 m of 48 mm diameter wire rope |
| Forward | 3 x 25 tonnes capacity 500 m of 44 mm diameter wire rope |

Notes:
- Both main tackles and jib tackles can operate together, load capacity on request.
- Loads in metric tons [ t ].




**CAPACITY DIAGRAM**

# TAKLIFT 7

| CONSTRUCTION/CLASSIFICATION | |
|---|---|
| Year of construction | 1976 |
| Registration | Rotterdam |
| Classification | GL X 100 A5 MC |
| Call sign | P H W N |

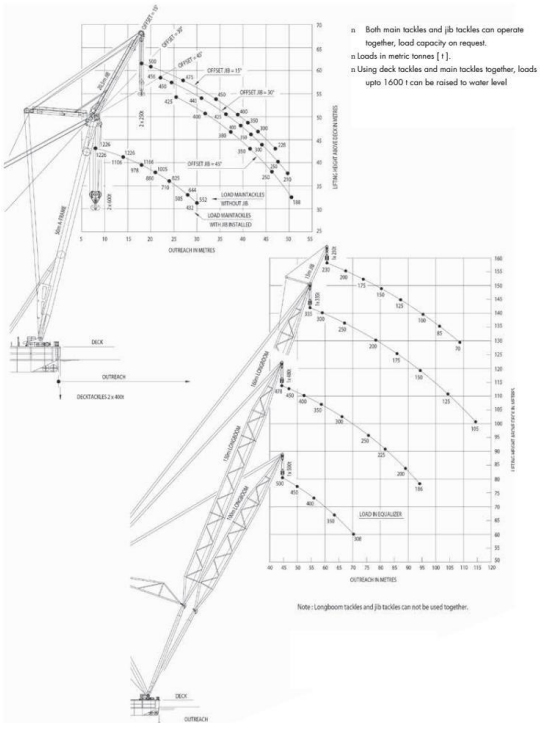
**FEATURES**

Accommodation for 36 persons (can be increased).

| ANCHOR WINCHES | |
|---|---|
| Aft | 1 x 10 t capacity 235 m of 56 mm Ø chain |

| MOORING WINCHES | |
|---|---|
| Aft | 3 x 10/5 t capacity 220 m of 28 mm Ø wire rope<br>2 x 30/10 t capacity 1000 m of 50 mm Ø wire rope |
| Forward | 4 x 10/5 t capacity 220 m of 28 mm Ø wire rope<br>2 x 30/10 t capacity 1000 m of 50 mm Ø wire rope |

| MAIN DATA | |
|---|---|
| Gross tonnage | 3,343 R.T. |
| Nett tonnage | 1,003 R.T. |
| Length overall | 72,56 m |
| Beam overall | 30.50 m |
| Depth | 5.50 m |
| Min. draught | 2.50 |
| Max. draught | 4.90 m |
| Sailing height min. | 49.00 m |
| Propulsion | 3 x 460 kW |
| Bowthruster | 2 x 386 kW |




**CAPACITY DIAGRAM**

# ASIAN HERCULES I

| CONSTRUCTION/CLASSIFICATION | |
|---|---|
| Year of construction | |
| Registration | Singapore |
| Classification | ABS ✠ A1Barge |
| Call sign | 9V3256 |

| PROPELLING MACHINERY | |
|---|---|
| 2 x AQM 632 | output 1194 kW |

| LIFTING CAPACITIES | |
|---|---|
| Main hoists | 2 x 500 t + 2 x 300 t |
| JIB II hoists | 2 x 200 t |
| JIB III hoists | 2 x 500 t |

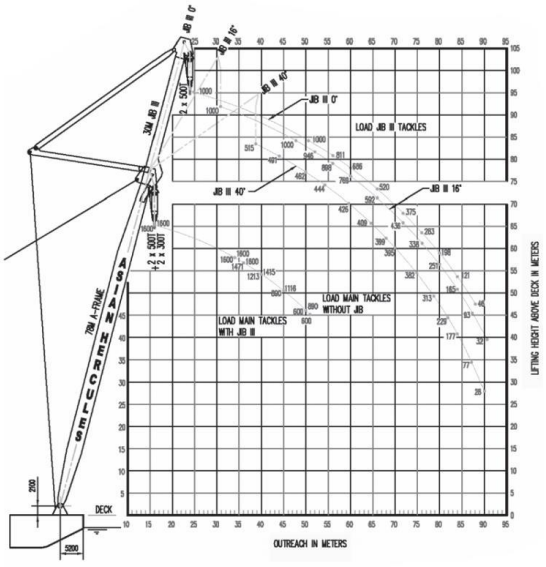
**SEA TRANSIT**

The vessel can transit across seas without load as per ABS unrestricted service with boom and outrigger resting backwards

**FEATURES**

Accommodation for 29 persons

| MAIN DATA | |
|---|---|
| Gross tonnage | 5,946 t |
| Nett tonnage | 3,407 t |
| Length overall | 70 m |
| Beam overall (moulded) | 42 m |
| Depth (moulded) | 7.2 m |
| Full Load Transit Draft | 4.387 m |
| Minimum Transit Draft (even trim) | |
| "A" frame stowed | 3.84 m |
| "A" frame upright | 2.80 m |
| Maximum draft after lift | |
| 2 x 800 t lift | |
| Fwd Draft | 5.75 m |
| Aft Draft | 3.00 m |
| 4 x 300 t lift | |
| Fwd Draft | 4.80 m |
| Aft Draft | 3.90 m |
| Speed | 5 knots |




**GUIDELINE CAPACITY DIAGRAM - ASIAN HERCULES JIB III**

- All loads are in metric tonnes and for inland water
- Following load capacities are on request:
  - 800 t balance beam details
  - 1000 t balance beam details
  - 1600 t balance beam details
  - Load balancing by combined lifting

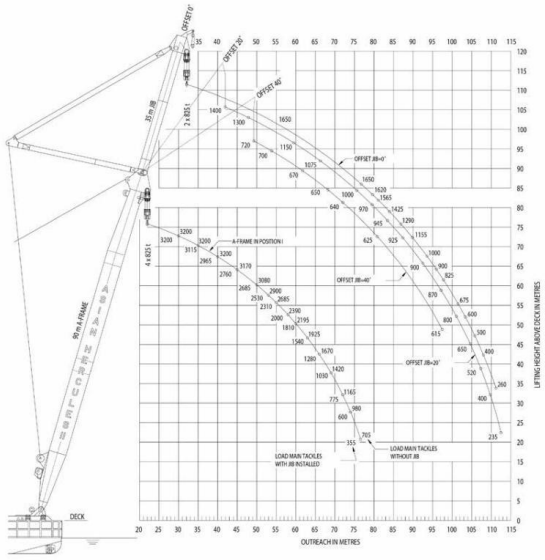
# ASIAN HERCULES II

| CONSTRUCTION/CLASSIFICATION | |
|---|---|
| Year of construction | 1997 |
| Classification | ABS A1(E) AMS |
| Call sign | P C I W |

| FEATURES |
|---|
| Accommodation for 24 persons (can be increased). |

| MOORING WINCHES | |
|---|---|
| 8 point mooring | 30 t. Cap. 1,000 m of 44 mm Ø wire rope |

| MAIN DATA | |
|---|---|
| Gross tonnage | 10,560 R.T. |
| Nett tonnage | 3,168 R.T. |
| Length overall | 91.35 m |
| Beam overall | 43.35 m |
| Min. draught | 2.75 m |
| Max. draught | 8.50 m |
| Sailing height min. | 56.00 m |
| Propulsion | 4 x 813 kW Azimuth |
| Deck load | 15 t/m² |




**CAPACITY DIAGRAM**

All loads are in metric ton [ t ] and for inland waters.
All load capacities are without traverses.
The following load capacities are on request;

- A-frame in position II and III
- Combined lifting with both main- and jib tackles
- Offshore

# ASIAN HERCULES III

| CONSTRUCTION/CLASSIFICATION | |
|---|---|
| Year of construction | 2015 |
| Registration | Singapore |
| Classification | ABS A1, + AMS - Heavy Lift Vessel |
| Call sign | 9V2514 |

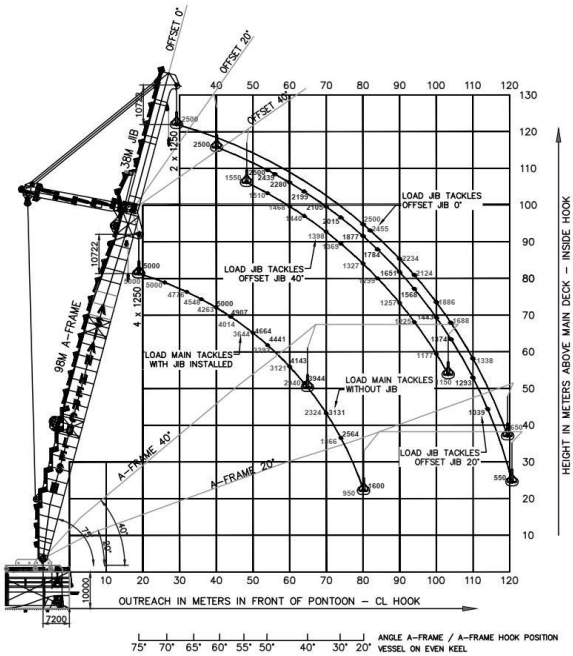
| MOORING WINCHES |
|---|
| 8 point mooring 60 t cap. 1,200 m of 46 mm dia. wire rope |

| WINCHES | |
|---|---|
| 2 units cargo winches capable of pulling 20 MT at 10 m/min | |
| 2 unit class anchor winch for handling the 6,975 kg HHP bow anchor via 76 mm grade 3 anchor chain | |
| Luffing | 2 units luffing winches providing maximum luffing speed of 1.00 m/min at full load |
| Main hoist | 4 units main hoisting winches for A-frame and 2 units for Jib, each capable of hoisting speeds 2 m/min at full load of 1250 MT and 5 m/min at light/no load |
| Jib adjustment | 2 units jib adjustment winches, mounted on the A-frame, for adjustment of the Jib without load from 00 to 400 in respect to the A-frame |
| 20 MT aux. hoist | 2 units aux. hoisting winches for A-frame and 1 unit for Jib each capable of hoisting speeds of 10m/min at full load of 20 MT |

| MAIN DATA | |
|---|---|
| Gross tonnage | 16,805 R.T. |
| Nett tonnage | 5,041 R.T. |
| Length overall | 106.42 m |
| Beam overall (moulded) | 52.00 m |
| Depth (moulded) | 10.00 m |
| Displacement | 26,456 t (even keel @ 5.50 m) |
| Speed | 7 knots (4 x each about 2,000 kW) |
| Deck loading | 20 mt/m² |
| Fuel bunker capacity | 2,021 m³ |
| Fresh water capacity | 474 m³ |
| Ballast water capacity | 14,438 m³ |

| FEATURES |
|---|
| Accommodation for 45 persons |

| GENERATORS | |
|---|---|
| Main generator | 4 units diesel engine driven generators of output capacity 4,364 kW in total |
| Emergency / Auxiliary generator | 1 unit diesel engine driven generator of output capacity 750 kW |




**GUIDELINE CAPACITY DIAGRAM - A-FRAME IN POSITION I**

- All loads are in metric tonnes and for inland water
- All load capacities are without traverses
- Following load capacities are on request:
  - A-frame position III
  - Combined lifting with both main and jib tackles
  - Offshore

# GIANT 7


| CONSTRUCTION/CLASSIFICATION | |
|---|---|
| Year of construction | 2015 |
| Classification | Lloyd's Register |
| Class notation | Crane Barge |
| Flag State | Belgium |
| Owner | Boskalis |
| Yard | Keppel Nantong Shipyard Co., Ltd. |

| MAIN DATA | |
|---|---|
| Length o.a. | 137.00 m |
| Breadth moulded | 36.00 m |
| Depth moulded (Main deck) | 8.50 m |
| Draft maximum | 6.45 m |
| Deadweight | 18,661 t |
| Displacement at summer draft | 28,357 t |
| Deck space (+/- accommodation) | 4,227 m² |

**ACCOMMODATION**

Cabins: 73 berths. Messroom and galley, hospital, recreation room, office space, conference room, spacious bridge/control room

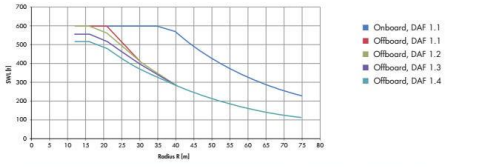
| BALLAST SYSTEM | |
|---|---|
| 4 x Ballast pump | 1,600 m³/hr |
| Tank capacity | 30,180 m³ |
| Drinkwater capacity | 855 m³ |
| Sewage storage | 1,979.2 m³ |
| Fuel oil | 1,056.4 m³ |

| CRANE | |
|---|---|
| Crane | Liebherr BOS 35000-600 |
| Main hook | 600 t (1,000 t optional) |
| Aux. Hook | 50 t |
| Rules and Regulations | DNV, EN 13852-2 |
| Certifying Authority | Lloyd's Register |
| Design Temperature | -10°C |
| Ambient Temperature | -25/+45°C |
| Wind Speed Operational | max. 25 m/s |
| Gust Boom Stowed | max. 63 m/s |

**MAIN HOIST LAOD CHARTS: 12-FALL REEVING**

Design code: DNV, "Standard for certification No. 2.22 Lifting Appliances". 2013
Calculation method: Default dynamic method
Conditions:
Crane location: Barge
Crane is lifting or from: 1. Onboard: Onboard – Onboard; 2. Offboard: Onboard – Barge
Max. Mean wind speed: 25 [m/s] Offlead: 2.5 / (5.0) [°]
Static trim of installation: 3 / (3) [°] Sidelead: 5.0 / (2.5) [°]
Static heel of installation: 3 / (3) [°]
Minimum elevation: 14 [m]
Maximum elevation: 26 [m]

**Please notice:**
Maximum allowable rope fleet angle: 5°



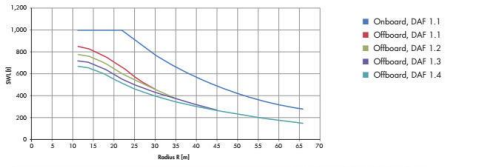

**600 T CONFIGURATION**

LIEBHERR

**MAIN HOIST LAOD CHARTS: 20-FALL REEVING**

Design code: DNV, "Standard for certification No. 2.22 Lifting Appliances". 2013
Calculation method: Default dynamic method
Conditions:
Crane location: Barge
Crane is lifting or from: 1. Onboard: Onboard – Onboard; 2. Offboard: Onboard – Barge
Max. Mean wind speed: 25 [m/s] Offlead: 4 [°]
Static trim of installation: 3 / (3) [°] Sidelead: 4 [°]
Static heel of installation: 3 / (3) [°]
Minimum elevation: 14 [m]
Maximum elevation: 26 [m]

**Please notice:**
Maximum allowable rope fleet angle: 5°




**1000 T CONFIGURATION**

LIEBHERR

# BORNEO

| CONSTRUCTION/CLASSIFICATION | |
|---|---|
| Year of construction | 2009 |
| Classification (dual class) | GL |
| Certification | SPS |

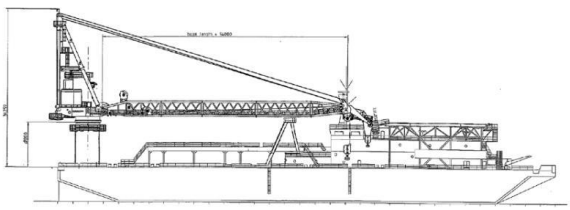
| MAIN DATA | |
|---|---|
| Deadweight | 5244 t |
| Length overall | 110 m |
| Breadth | 30 m |
| Depth | 7.6 m |
| Clear deck space | 1900 m² |
| Deck loading | 15 t/m² |

| FEATURES | |
|---|---|
| Accomodation | 152 p |
| 8 point Mooring system | |
| Payout speed | 300 m/min |
| Main Supply | 3 x 500 kVA |
| Helideck (S61N) | VA |

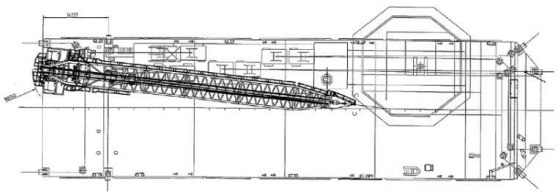
**CRANE**

500 t Liebherr Litronic pedestal crane
500 t @ 16m
150 t @44 m auxiliary crane

| CONSTRUCTION SERVICES |
|---|
| Mooring & Riser Installations |
| Subsea installations |
| Accomodation support |
| Pipelay |



**SIDE VIEW**



**TOP VIEW DECK LEVEL**

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The Netherlands
T +31 78 6969000
E offshore.energy@boskalis.com

www.boskalis.com/offshore


August 2017

MARINE CONTRACTORS

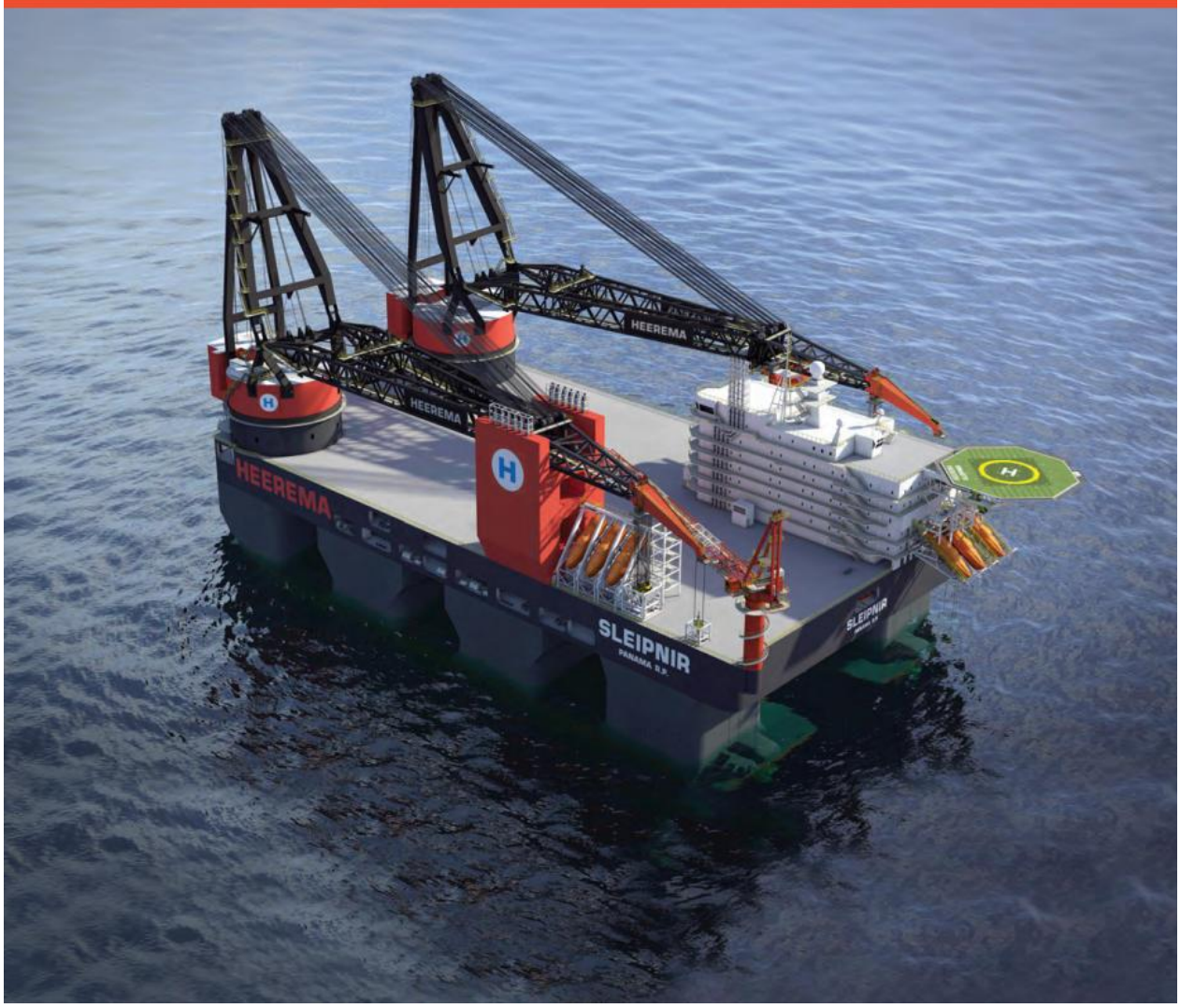
# Equipment

A HEEREMA COMPANY

Heerema Marine Contractors (HMC) is proud to introduce her new semi-submersible crane vessel: Sleipnir. The vessel will be equipped with two cranes of 10,000 tonnes lifting capacity each. The introduction of the Sleipnir enables HMC to meet customers' demand for lifting capacity beyond what the market can currently offer without compromising the robustness of the traditional lifting methodology that has proven itself since the founding of the company 55 years ago.

Sleipnir's features – such as lifting capacity, motion behavior and large deck area – all contribute to a superior performance of the vessel. This makes it the best technical and most effective tool for performing the offshore installation of small, large and complex facilities from shallow to ultra-deep water. With the introduction of the Sleipnir, HMC shows commitment to its clients towards the future and the ability to continue to serve the heavy installation and removal market for the next decades. This latest step in our fleet renewal program further reinforces our aim to remain an industry leader in offshore installation and removal services.

# Sleipnir




**Unique lifting capacity and crane design**
The unique lifting capacity and crane design of the vessel allow our clients to design larger and/or heavier topsides and jackets, which we can install fully integrated and commissioned.

This relocates the expensive offshore integration to an optimized onshore activity. The uniqueness of the crane is the boom design configuration in combination with the lifting capacity. This allows heavy lift installations even on high elevations.

**Excellent workability**
The design of the columns of the Sleipnir has been optimized to achieve maximum workability during lifting operations all around the world including swell dominated areas, offering our customers execution and schedule predictability.

**A large deck area**
The deck configuration of the vessel has been optimized to transport as many jackets, topsides or modules as possible. This way, the workability of the offshore operation improves significantly.

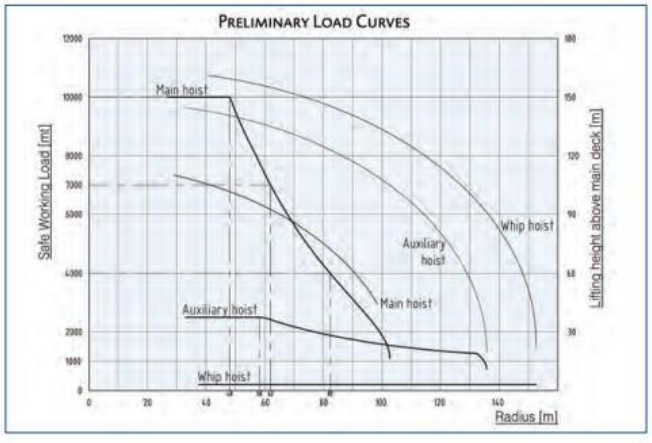
**Transit speed**
The new vessel will have a minimum service speed of 10 knots. Such transit speed will improve travel time between projects and will provide our clients with reduced overall mobilization duration and cost. Next to this, Sleipnir will be more environmentally friendly in fuel consumption.

**Environmental footprint**
In order to improve the environmental footprint of our operations, the Sleipnir will be powered by LNG. This feature might also support our clients' environmental and sustainability ambitions.

**Services**
With the introduction of the Sleipnir we can provide our clients with tailor-made solutions for:

- Installation of fixed and floating platforms
- Removal of offshore platforms
- Installation of subsea structures


## Two cranes, 20,000 tonnes lifting capacity



**Main Dimensions**

| | |
|---|---|
| Length overall | 220 m |
| Beam Overall | 102 m |
| Draft Range | 12 – 32 m |

**Deck Load**

| | |
|---|---|
| Heavy Lift Lay Down Area | 15 mT/m² |
| Main Deck | 10 mT/m² |
| Total Deck Load Capacity | 20,000 mT |
| Total Deck Area | 12,000 m² |

**Accommodation**

| | |
|---|---|
| Person | 400 Persons |
| Cabins | Single and double cabins |

**Helideck**

| | |
|---|---|
| Diameter | 28 m |
| Load Capacity | 15.6 mT |
| Suitable for | Augusta Westland EH101 / Sikorsky S-92 |
| Compliant to | IMO, LR, NMA, CAP437 |

**Auxiliary Crane**

| | |
|---|---|
| Deck Crane | One pedestal mounted, lattice boom crane |
| | 70 mT at 12 m radius |
| | 25 mT at 60 m radius |
| | 8 t at 72 m radius |
| | Range up to 2,000 m water depth |
| | Man riding certified |

**Portside and Starboard Heavy Lift Cranes**

| | |
|---|---|
| Type | Portside and Starboard bow mounted, Fully revolving, Tub crane |
| Boom Length | 144 m (from heel point to whip hoist) |
| Boom Clearance (to deck) | 28.0 m in stowed position |
| Main Hoist Capacity – Revolving | 10,000 mT between 27 – 48 m radius |
| | 7,000 mT at 62 m radius |
| | 4,000 mT at 82 m radius |
| Main Hoist Lifting Height | from -20 m up to 129 m (above waterline at 32 m draft) |
| Main Hoist Maximum Radius | 102 m |
| Auxiliary Hoist Capacity - Revolving | 2,500 mT between 33 – 58 m radius |
| Aux. Hoist Lifting Height | from -50 m up to 165 m (above waterline at 32 m draft) |
| Aux. Hoist Maximum Radius | 135 m |
| Whip Hoist Capacity – Revolving | 200 mT between 37 – 153 m radius |
| Whip Hoist Lifting Height | from -100 m up to 181 m (above waterline at 32 m draft) |
| Whip Hoist Maximum Radius | 153 m |
| Deep Water Lowering | heave compensated capacity per crane<br>1,000 mT at 1,000 m below sea level<br>760 mT at 1,500 m below sea level<br>240 mT at 3,000 m below sea level |

**Station Keeping / Propulsion System**

Thrusters:
Forward end – Four (4) retractable, underwater demountable fixed pitch, variable speed azimuth thrusters of 5.5 MW each.
Aft end- Four (4) underwater demountable fixed pitch, variable speed azimuth thrusters of 5.5 MW each.

DP System:
IMO equipment Class 3, Lloyd's Register DP(AAA)

Mooring System:
4 x 3 point mooring system
Stevpris Mk-6 anchors of 12 t each

**Power Generation**

Main Power:
96 MW total main power plant, consisting of 12 engines of 8 MW each, divided over 4 engine rooms

Fuel (dual):
Low sulphur Marine Gas Oil (MGO) and Liquified Natural Gas (LNG)

Emission Limits:
Compliant to IMO Tier III requirements

Thialf, the largest Deepwater Construction Vessel (DCV) operated by Heerema Marine Contractors (HMC), is capable of a tandem lift of 14,200 t. The dual cranes provide for depth reach lowering capability as well as heavy lift capacity to set topsides. This multi-functional dynamic positioned DCV is tailored for the installation of foundations, moorings, SPARs, TLPs and integrated topsides.

**Accommodation / helicopter deck**
The living quarters are equipped to accommodate 736 men. All quarters have heating and air conditioning facilities. The helicopter deck is suitable for a Boeing Chinook 234 (21 t take-off weight).

**Life-saving / fire-fighting**
Life-saving and fire-fighting equipment according to the latest Class and IMO requirements.

**Mooring system**
12 Delta Flipper anchors of 22.5 t each, on 3 1/8 inch wire ropes of 2,400 m (7,874 ft) long. Minimum breaking strength 480 t.

**Ballast system**
- Ballast pump capacity 20,800 cubic m³/hour.

**Power supply**
The Thialf is equipped with 12 diesel engines with the following capacities:
- 6 x 4,900 kW
- 4 x 4,500 kW
- 2 x 5,500 kW

**Diving system**
Containerized saturation diving system with diving bell can be made available.

**Deck load**
- Deck load capacity 15 t / m²
- Total deck load capacity 12,000 t

**Transit speed with 1 tug**
- Max. 7.0 knot at 12.5 m draft

# Thialf

**Main hoist lifting height**
95 m (312 ft) above work deck for each crane. Lowering depth of auxiliary hoists 460 m (1,500 ft) below work deck at minimum radius.

**Main hoist deepwater mode**
Main hoist: 900 t with hook at 850 m water depth up to 128 m above the water line. Special main hoist block: 1,025 t at 847 m water depth. Deep water blocks: 414 t at 2,741 m water depth (all based on main hoist at minimal radius and 26.6 m operating draft).

**Dynamic positioning system**
The Thialf is equipped with an NMD Class III Dynamic Positioning system with the following characteristics:

**Thrusters**
6 x 5,500 kW - 360 degrees azimuth, total thrust 420 t

**Modes of Operation**
- Manual
- Joy-stick
- Auto-pilot
- Auto DP mode
- Position mooring

**Special DP functions**
- Heavy lift
- Follow target
- External force compensation

**Position reference systems**
- 2x Satellite DGPS with 5 aerials
- 1x Mechanical taut wire (300m)
- 1x Artemis
- 2x Acoustic SSBL/LBL
- 1x Fan-beam laser
- 1x Tautwire system

**Dimensions**

| | | |
|---|---|---|
| Length overall | 201.6 m | 661 ft |
| Width | 88.4 m | 290 ft |
| Depth to work deck | 49.5 m | 162 ft |
| Draft | 11.9 – 31.6 m | 43 – 104 ft |
| GRT | 136,709 t | - |
| NRT | 41,012 t | - |

| Portside and starboard crane | Load | Outreach |
|---|---|---|
| Main hoist | 7,100 t | up to 31.2 m (102 ft) |
| Auxiliary hoist | 907 t | 36.0 – 79.2 m (120 – 260 ft) |
| Whip hoist | 200 t | 41.0 – 129.5 m (134 – 430 ft) |


# Balder

**Tool box feature**

| Typical deepwater installation activity | Dynamic positioning | Starboard crane with traction winches | Portside crane with fly-jib | Mooring line Deployment Winch | J-lay Tower | A&R Winch | Under-water hammers with girdle power pack |
|---|---|---|---|---|---|---|---|
| Mooring line deployment | + | + | | + | | | |
| Deepwater pile installation | + | + | | | | | + |
| Deepwater structures lowering | + | + | (+) | (+) | (+) | (+) | |
| Deepwater pipelay | + | | + | (+) | + | + | |
| Facilities and topsides installation | + | + | + | | | | |

Balder was built in 1978 and converted into a full Class III DP Deepwater Construction Vessel in 2002. This DCV concept combines the best of the well-known SSCV concept with a series of multi-functional deepwater tools. With these tools Balder is tailored for the full range of activities related to deepwater development.

**Accommodation / helicopter deck**
The living quarters can accommodate 374 men. The helicopter deck is suitable for a Sikorsky S-92.

**Life-saving / fire-fighting**
Life-saving and fire-fighting equipment according to the latest Class and IMO requirements.

**Ballast system**
Static and dynamic ballast system both fully computer supported. Ballast pump capacity 8,000 $m^3$ per hour. Dynamic ballast water handling 250 t per second.

**Deck load**
- up to 10 t / $m^2$
- Total capacity 8,000 t

**Dynamic positioning system**
The Balder is equipped with a full Class III Dynamic Positioning system with the following characteristics:

**Thrusters**
7 x 3,500 kW - 360 degrees azimuth

**Propulsion**
2 x 4,400 kW - controllable pitch

**Modes of operation**
- Manual
- Joy-stick
- Auto-pilot
- Full DP mode
- Full anchor mode

**Special DP functions**
- Track follow
- Heavy lift
- Follow floating
- External force compensation
- Pipe-lay

**Position reference systems**
- 2 x Satellite DGPS with anti-masking system
- 1 x Mechanical taut wire (500m)
- 1 x Artemis
- 2 x Acoustic SSBL/LBL
- 1 x Fan-beam laser
- Radius

**Dimensions**

| | | |
|---|---|---|
| Length overall | 154 m | 505 ft |
| Length of vessel | 137 m | 450 ft |
| Width overall | 106 m | 346 ft |
| Width vessel | 86 m | 282 ft |
| Depth to work deck | 42 m | 138 ft |
| Draft | 11 to 25 m | 36 to 104 ft |
| GRT | 75,374 t | - |
| NRT | 22,612 t | - |

| Portside crane | Load | Outreach in m | Outreach in ft |
|---|---|---|---|
| Main hoist guyed | 2,721 t | 23 – 65 m | 75 – 213 ft |
| Main hoist revolving | 1,995 t | 23 – 90 m | 75 – 295 ft |
| Auxiliary hoist | 997 t | 29 – 123 m | 95 – 404 ft |
| Whip hoist | 72 / 226 t | 31 – 127 m | 102 – 417 ft |

| Starboard crane | Load | Outreach in m | Outreach in ft |
|---|---|---|---|
| Main hoist guyed | 3,628 t | 24 – 52 m | 79 – 171 ft |
| Main hoist revolving | 2,993 t | 24 – 80 m | 79 – 262 ft |
| 1st Auxiliary hoist | 907 t | 28 – 91 m | 92 – 299 ft |
| 2nd Auxiliary hoist | 598 t | 31 – 100 m | 102 – 328 ft |
| Whip hoist | 72 / 226 t | 36 – 114 m | 118 – 374 ft |

The Aegir is a Monohull vessel with the capability to execute complex deep water infrastructure and pipeline projects in ultra-deep water. It also has sufficient lifting capacity to execute installation of fixed platforms in relatively shallow water.

A key attribute of the vessel is its fast transit speed. The extension of the existing fleet with the Aegir provides a unique fleet composition, which allows Heerema Marine Contractors to continue to offer unrivalled services to the offshore oil and gas industry on a world-wide basis.

# Aegir

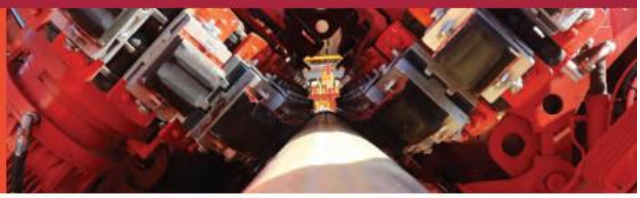
**Accommodation / helicopter deck**
The living quarters can accommodate 305 persons in single and double cabins. All cabins have heating and air conditioning facilities. The helicopter deck is suitable for Augusta Westland EH101 or Sikorsky S-92 helicopter, compliant with IMO, LR and NMA and CAP437 requirements.

**Life-saving / fire-fighting**
Life-saving and fire-fighting equipment have been provided for according to the latest class, IMO and NMA standards.

**Dynamic Positioning system**
The Aegir is equipped with a full Class III Dynamic Positioning system.

**Thrusters**
2 x 6,500 kW fixed pitch, variable speed azimuth thrusters for main propulsion and for DP 4 x 3,200 kW fixed pitch, variable speed, retractable azimuth thrusters and 1 x 2,500 kW fixed pitch, variable speed tunnel thruster for DP and manoeuvring.

**Power supply**
The Aegir is equipped with a 48 mW total main power plant comprising of 6 diesel generators rated at 8,000 kW each and 1 emergency diesel generator set rated at 1,731 kW.



**General Description**

| | |
|---|---|
| Design | Ulstein Sea of Solutions customized SOC 5000 design |
| Dimensions | Length 211 m x width 46 m |
| Operating draft | 9 – 11 m |
| Transit draft | 8 m |

**Pipelay Equipment**

| | |
|---|---|
| Type | Multilay system suitable for J-lay and Reeling |
| J-lay | Quad joints, max 32" OD, top tension 2,000 mT |
| Reel-lay | Reel capacity 2x 2,000 mT 800 mT top tension, max 16" OD |
| A&R system | 2,000 mT max 3,500 m water depth |

**Heavy lift crane**

| | |
|---|---|
| Type | Revolving mast type crane |
| Boom length | 125 m |
| Capacity revolving | 4,000 mT between 17 – 40 m radius 1,500 mT at 78m radius |
| Lifting Height main hoist | 96 m above main deck |
| Maximum radius | 79 m |
| Auxiliary Hoist | 750 mT between 23 – 92 m radius |
| Whip hoist | 110 mT between 31 – 123 m radius |

**Auxiliary Cranes**

| | |
|---|---|
| Deck cranes | Two (2) knuckle boom cranes, each 40 mT SWL at 20 m radius and 5 mT at 40 m radius. Man riding certified |

**Deep water lowering system**

| | |
|---|---|
| Capacity | 3,500 m waterdepth, active and passive heave compensation up to 750 mT |

**ROVs and LARS**

| | |
|---|---|
| ROV | Two (2) ROV work class systems, launched from ROV hangars at starboard and portside |
| LARS | Two (2) launch and recovery systems inside the ROV hangars suitable for 3,500m waterdepth |

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August 2017

# SAIPEM 7000

SEMISUBMERSIBLE CRANE AND PIPELAYING (J-LAY) DP VESSEL

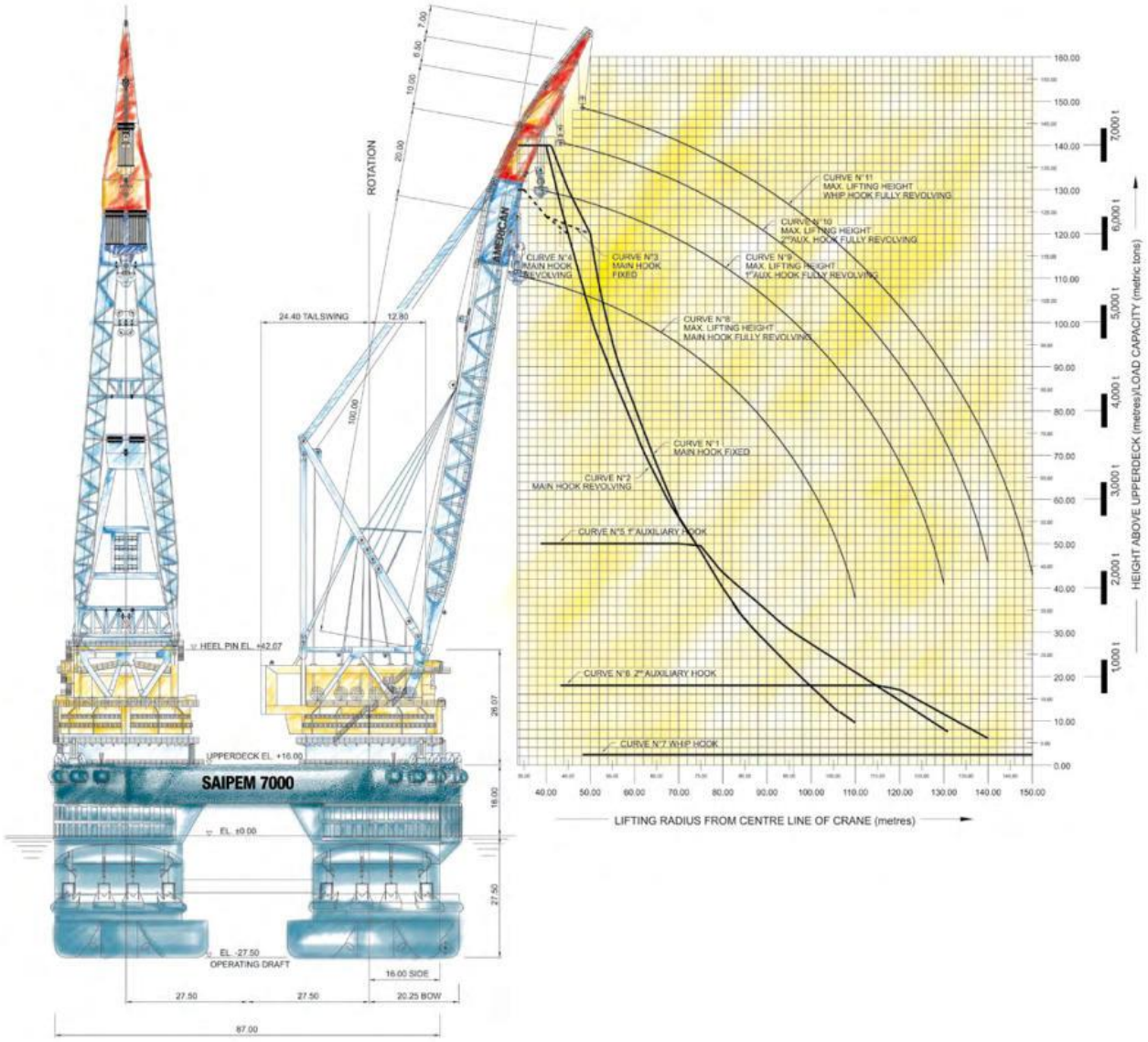

2


With its state-of-the-art J-lay tower, upgraded dynamic positioning capability and fast ballasting system, the Saipem 7000 semisubmersible crane vessel has the capacity to handle the entire workscope of offshore construction developments worldwide, encompassing pipelaying in water depths greater than 2,000 metres and heavy lift operations up to 14,000 tonnes.

The vessel's Class 3 DP system of 12 thrusters ensures that the vessel maintains good station keeping in the most difficult of weather conditions. Additionally, because the Saipem 7000 has accommodation facilities up to 725 people, the vessel can assist hook-up and commissioning as well as initial platform life support activities.

Altogether, this high specification means that the Saipem 7000 can be counted on to provide the highest level of reliability for conventional, deep and ultradeep water development projects.

In support of its underwater works, the Saipem 7000 operates two state-of-the-art Innovator type of working rov's, which are an essential part of the vessel's equipment that complement and integrate surface and subsea operations of the Saipem 7000.




**HULL TYPE**

Self propelled dynamically positioned semisubmersible

**VESSEL FEATURES**

Length overall
197.95 m
Upper platform
175 m x 87 m x 8.5 m
Lower pontoons
165 m x 33 m x 11.25/15.25 m
Depth to main deck
43.5 m
Free deck area
9,000 sq.m

Deck load
15,000 tonnes
Operating draft
27.5 m
Survival draft
18.5 m
Transit draft
10.5 m
Transit speed
9.5 knots

5

**MOORING SYSTEM**

14 x 1,350 kw single drum winches, each 3,350 m x 3¾" mooring line and 40 tonnes high holding power anchor
Fully redundant SDPM system
2 anchor windlasses, each 550 m x 5 ⅛" chain and 34.5 tonnes anchor

**PROPULSION AND THRUSTERS**

All fixed pitch and variable rpm
4 aft x 4,500 kw propulsion azimuthing units
4 fore x 3,000 kw retractable azimuthing units
2 fore x 5,500 kw retractable azimuthing units
2 bow x 2,500 kw tunnel thrusters


6


**BALLAST SYSTEM**

Computer controlled system with simulation capabilities comprising
4 x 6,000 tonnes/h ballast pumps
40 ballast tanks - Total 83,700 cu.m
14 rapid ballast tanks - Total 26,000 cu.m

**LIFTING FACILITIES MAIN CRANE**

2 twin Saipem 7000 model fully revolving bow mounted Amhoist cranes.
Main blocks tandem lift: 14,000 tonnes
Main block single lift: 7,000 tonnes
6,000 tonnes revolving at 45 m rad./50 m tieback
Aux. 1 block: 2,500 tonnes
Aux. 2 block: 900 tonnes
Lowering capability to 450 m below sea level
Whip hook: 120 tonnes

**PILE DRIVING/HANDLING EQUIPMENT AVAILABILITY**

2 Menck MHU 3,000 hydraulic hammers
2 Menck MHU 1,700 hydraulic hammers
2 Menck MHU 1,000 hydraulic hammers
2 Menck MHU 600 hydraulic hammers
1 Menck MHU 220 hydraulic hammer
1 Menck MHU 195 hydraulic hammer
2 underwater/surface power packs
1 hydraulic hammer compensator
"Slim" and "Free" riding mode capability
Full spread of internal/external lifting clamps ranging from 20" to 102" i./o. dia.
2 levelling systems range 66" - 72" dia. - 900 t. capacity
2 external levelling systems 1,000 tonnes

**HANDLING DECK EQUIPMENT**

1 x 70 tonnes Kobelco Crawler crane
1 x 35 tonnes hydraulic wheeled deck crane
2 x 5 tonnes fork lifts

**POWER PLANT**

Total power plant 70,000 kw, 10,000 Volt
12 diesel generators on heavy fuels divided in 6 fire segregated engine rooms

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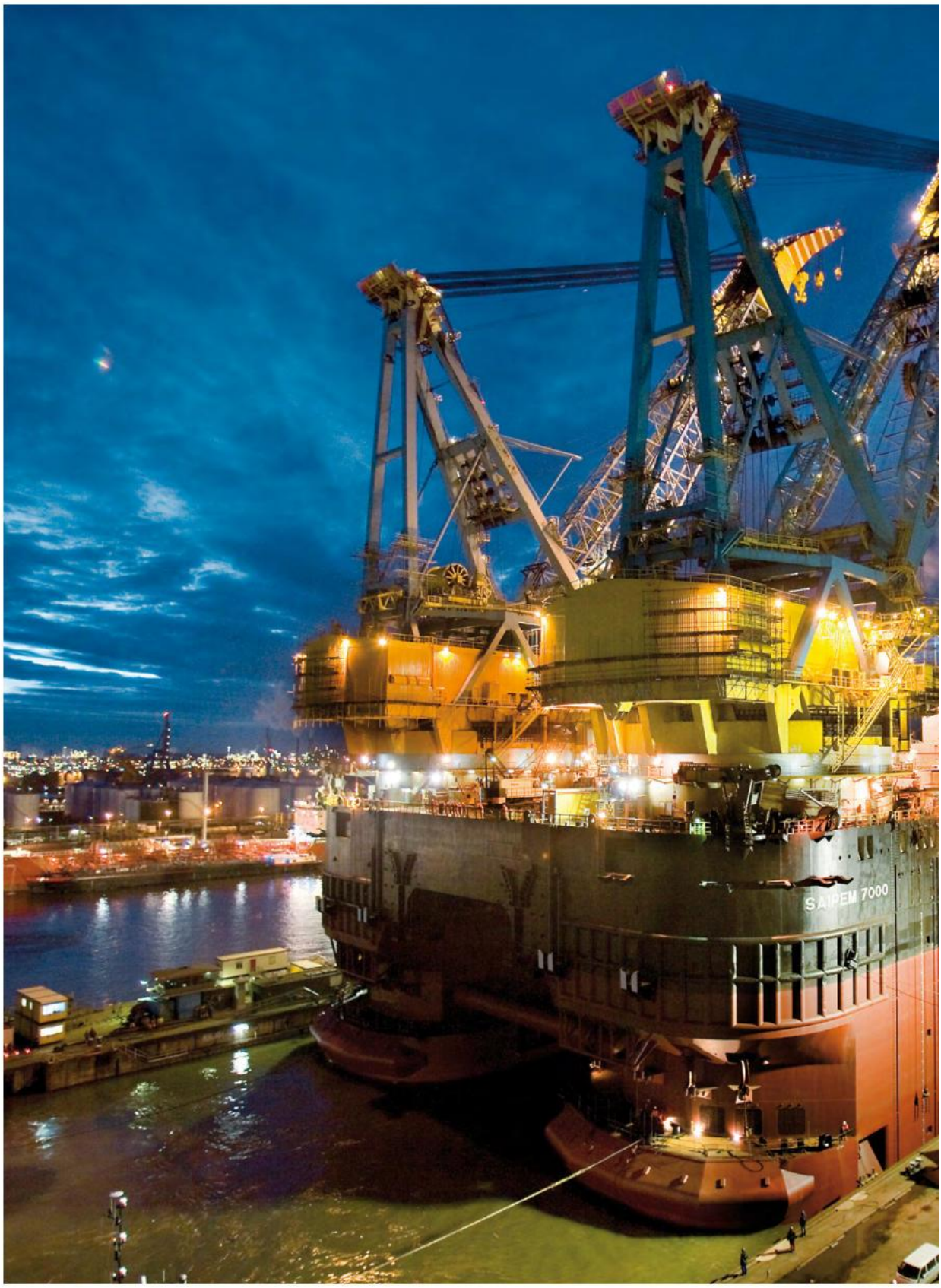


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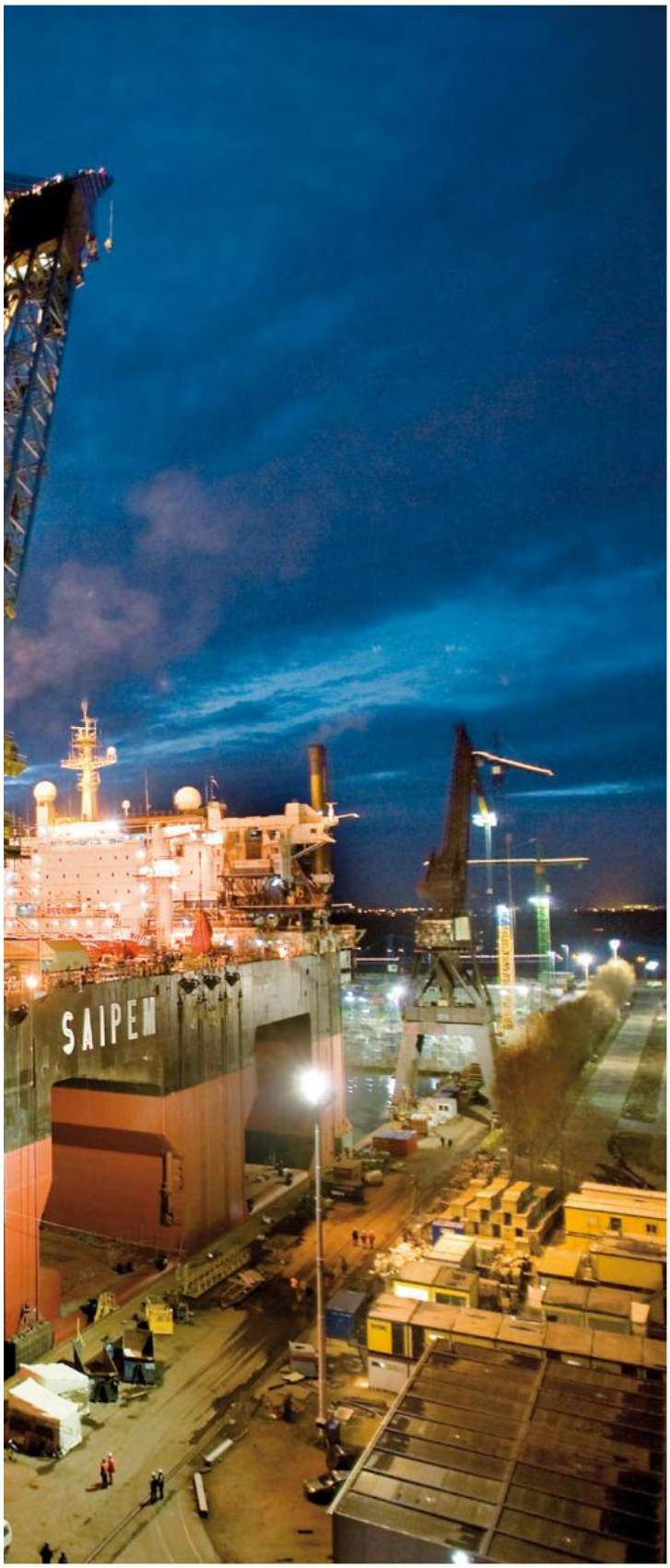


**CREW FACILITIES**
388 fully AC single or double cabins for 725 persons
Gym, cinema, internal radio/TV,
400 seat main messroom
70 seat officers messroom, recreation room, bar-cafeterias

**HELIDECK**
Suitable for two BV234 LR Chinook helicopters (one parked)
Classified helicopter refueling system

**J-LAY SYSTEM**
Pipe diameter range from 4° to 32°
Main laying tension system 750 tonnes with tensioners, up to 2,000 tonnes with friction clamps
Laying tower angle 90° - 110°
Abandonment/Recovery system double capstan winch with 750 tonnes capacity (up to 2,000 tonnes with clamps)
1 welding station
1 NDT and field joint station
Pipe string quadruple joint
Pipe storage capacity up to 6,000 tonnes
The tower is self erecting and removable by the Saipem 7000 own cranes

Seaway Strashnov

seaway 7

## General Information

| | |
|---|---|
| Type | **Heavy Lift** |
| Classification | **DNV 1A1 crane vessel clean DK (+) HELDK-SH DYNPOS AUTRO EO BIS** |
| Flag | **Cyprus** |

## Principal Dimensions

| | |
|---|---|
| Length overall | **183m** |
| Breadth | **47m** |
| Depth from deck | **18.2m** |
| Draft | **8.5 - 13.5m** |
| Displacement | **77,210m³** |

## Power and Propulsion

| | |
|---|---|
| Main engines (six) | **6x 4,500kW** |
| Main thrusters (two) | **2x 5,500kW** |
| DP thrusters (two) | **2x 3,500kW** |
| Bow thrusters (two) | **2x 1,150kW** |
| Transit speed | **12 knots** |

## DP System

| | |
|---|---|
| DP3 positioning system | |
| Eight-point anchor mooring system | **15t** |

## Cranes

| | |
|---|---|
| **Main hoist** | |
| Maximum revolving capacity | **5,000t at 32m** |
| Maximum lift height above water level | **102m** |
| **Auxiliary hoist I** | |
| Maximum capacity | **800t at 72m** |
| Maximum lift height above water level | **134m** |
| **Auxiliary hoist II** | |
| Maximum capacity | **200t** |
| Maximum lift height above water level | **109.5m** |
| **Whip hoist** | |
| Maximum capacity | **110t** |
| Maximum lift height above water level | **136m** |

## Helideck

| | |
|---|---|
| Equipped for | **S-61 and S-92** |

## Accommodation

| | |
|---|---|
| People | **220** |

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The Subsea 7 fleet comprises of vessels that have exceptional versatility, capable of operations worldwide including; pipelay, construction, survey, remote intervention, diving support, heavy lifting operations, renewables and decommissioning.

Our Differentiators

Culture · Creativity · Relationships · Reliability · Solutions

VESSELS

Heavy Lift

Our Values

Safety · Integrity · Sustainability · Performance · Collaboration · Innovation


# Seaway Strashnov

## Vessel Info

*Full specification overleaf*

***Seaway Strashnov* is a state-of-the-art crane vessel, equipped with the latest technology.**

A unique feature of the vessel is the innovative and patented hull shape. This, together with fuel efficient engines, enables a transit speed of 12 knots. In combination with the working characteristics for a monohull crane vessel, this is a highly effective installation vessel and will contribute to the successful execution of projects.

Lift heights of approximately 100m for the 5,000t main hook and 130m for the 800t auxiliary hook enables the vessel to undertake an impressive range of projects from dual hook upending of large jackets, to heavy topside installations. The installed DP3 system also enables the vessel to be employed for the installation of large and heavy subsea structures, TLP/Spar foundations and topsides. Moreover, the vessel's lift capacity, in combination with high sailing speed and DP3 capabilities, makes it the a great candidate to install modules on FPSO's in the field, all over the world.