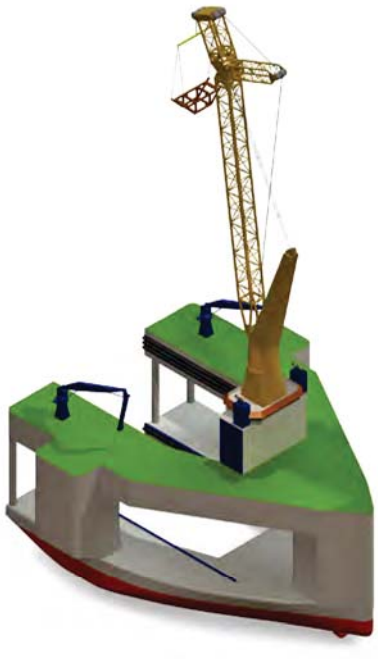
LEENAARS BV

MARINE & OFFSHORE DESIGN

SWIV - Semi-submersible Wind turbine Installation Vessel



3 Column Semi with large recess

The design of a semi-submersible wind turbine installation vessel by Leenaars BV is an innovative solution to the existing installation problems and methods. Flat seas are no longer required for the transportation and installation of offshore support structures and wind turbines, meaning that installation work can be done year-round.

LOA: 108m

Breadth: 75m

Depth: 36m

Transit draught: 6m

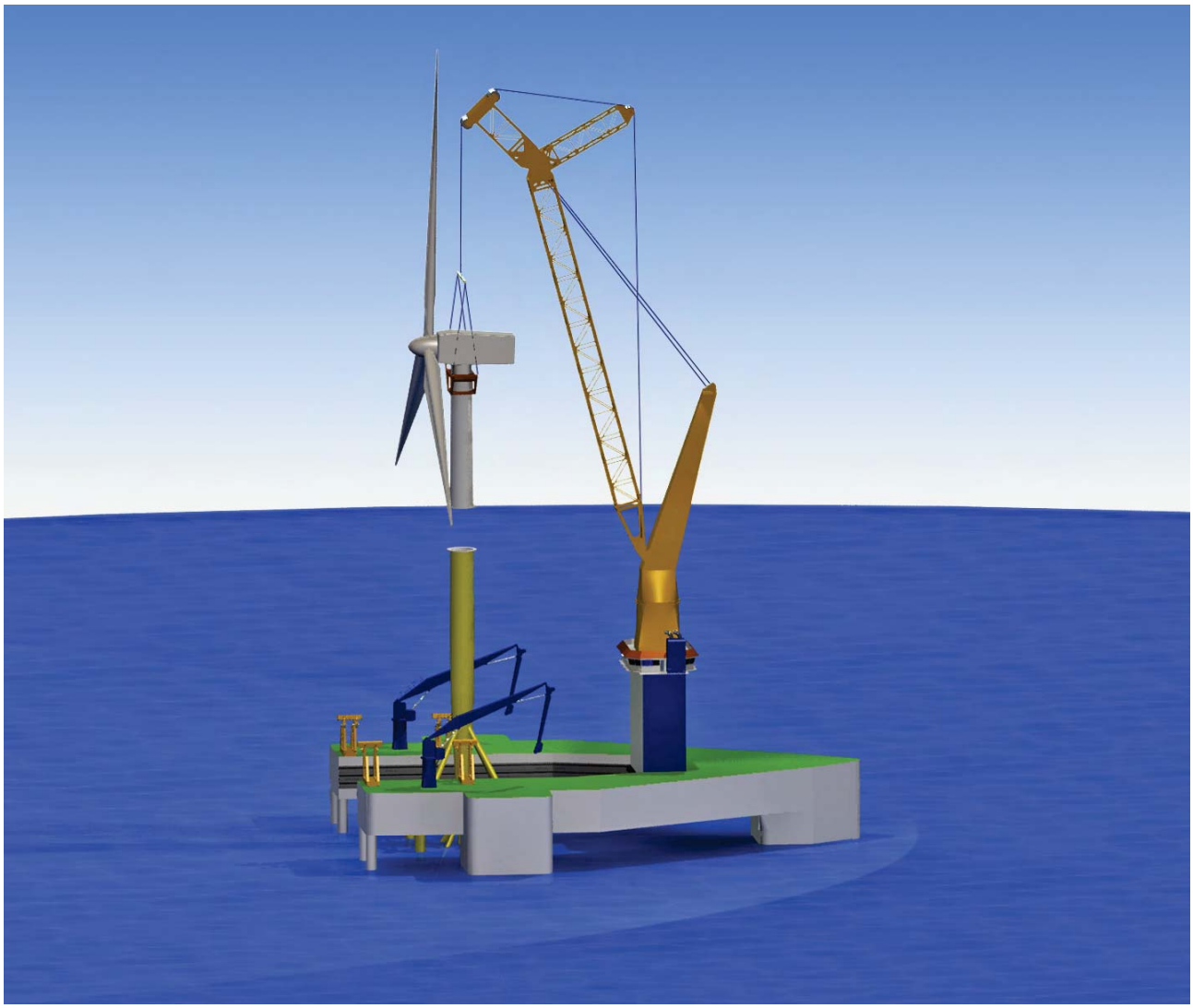
Operational draught: 20.5m

Service speed: 10 knots

Propulsions: 3x 3.5MW azimuth, 1x 2.7MW tunnel

Crane capacity: 1200tons @ 30m

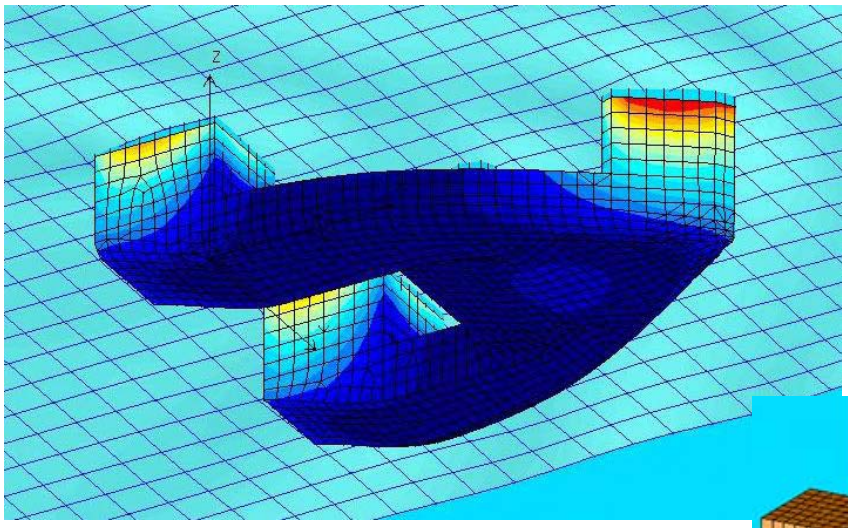
Slot opening: 36x60.75m

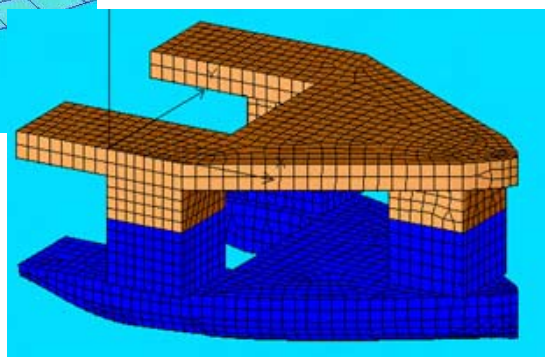


A deep water wind farm installation vessel

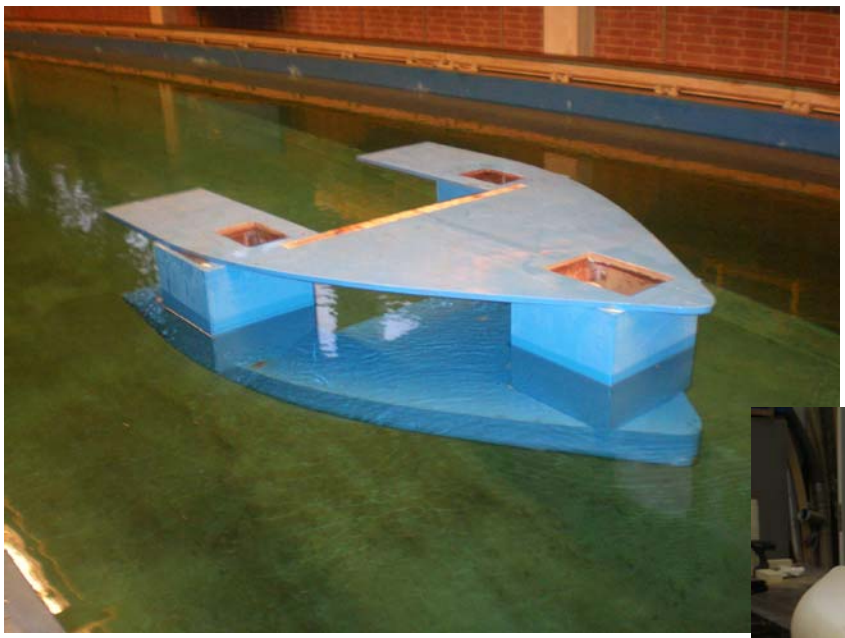
For water depths between 12 meter onwards a semi is the perfect installation vessel. Optimalisation studies have resulted in a semi with 3 columns. The 3 column solution has made it possible to develop a large recess, good transit speed and minimum motions.

The significant vertical motions in the recess do not exceed 20 to 30 cm in Hs=2m.





Optimalisation by 3d diffraction



Verification by tank testing

Transport & Installation

Mast, nacelle and blades are assembled and commissioned onshore . The mast is provided with a quick coupling for fast and efficient installation. The vessel is able to transport the wind turbine in vertical position and is fitted with a 1200 tonnes crane to handle + 5MW wind turbines. The jacket can weigh up to 4500 tons and is handled by davits.

The SWIV can support 3 different campaigns:

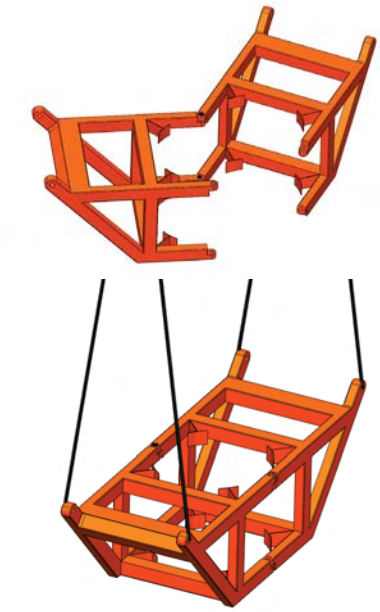
1 Installation of wind turbine and jacket in 2 day round trip cycle.

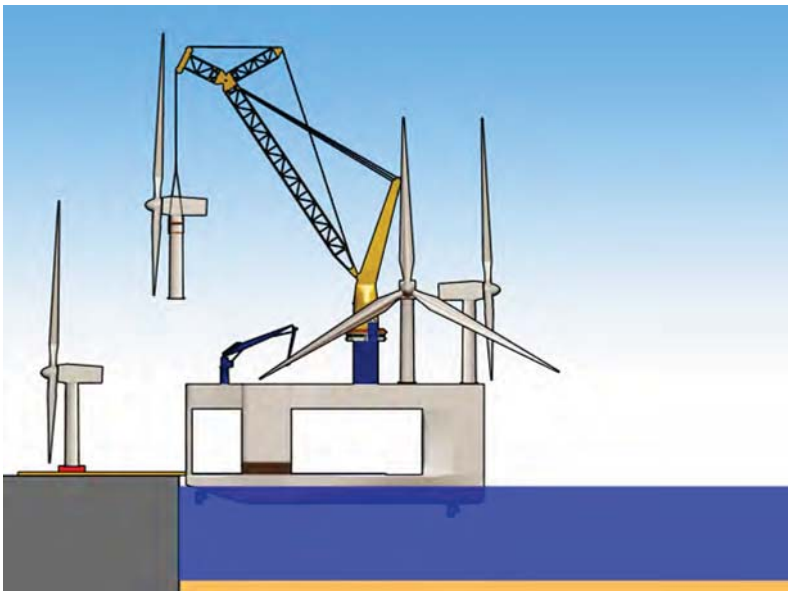
2 Installation of foundations separately.

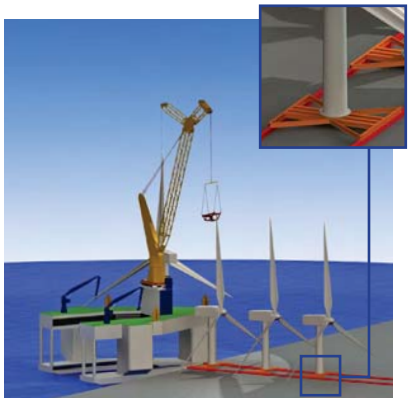
Depending on size 1 to 12 foundations can be handled per round trip.

3 Installation of wind turbine topsides.

4 to 5 topsides can be handled per round trip.





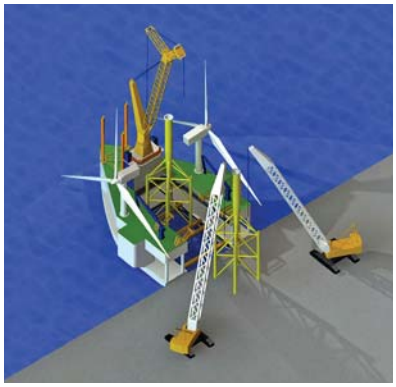


Stage 1

A fully assembled wind turbine stands on beams which can be skidded towards the vessel, within the crane's reach.

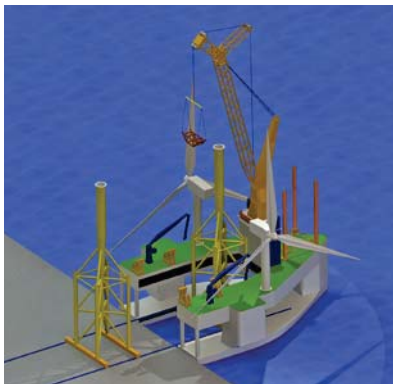
Stage 2

The wind turbine is lifted onboard. An aft recess accommodates the base of the mast and a number of clamps provide a secure connection during transit.



Stage 3 alternative 1

The jacket is lifted onto skid beams on board the vessel by onshore crane(s).

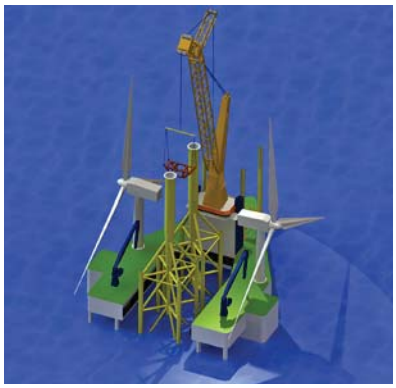


Stage 3 alternative 2

The jacket stands in cups on skidding beams which allows the structure to be skidded into the vessel.

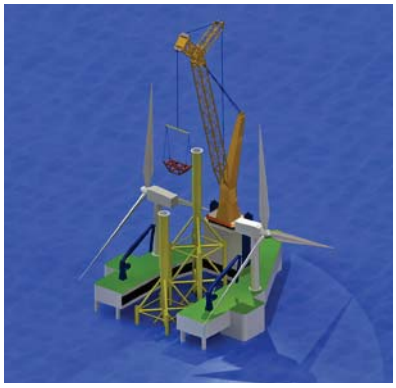
Stage 4

The vessel sails to the installation site.



Stage 5

The vessel partially submerges to the operational draft.

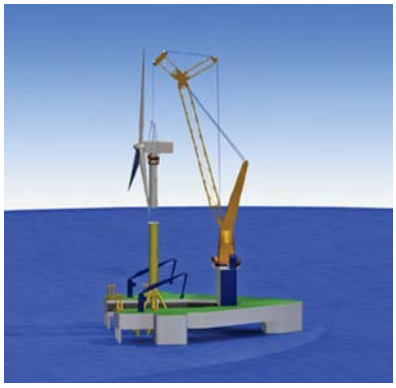


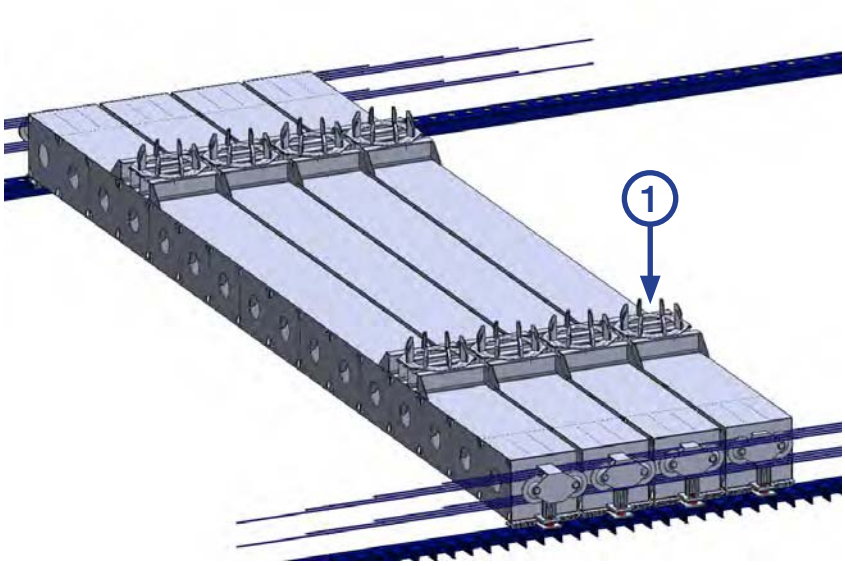
Stage 6

The jacket is lowered onto the sea bottom and the piles are driven into the sea bed.

Stage 7

A final step to completion is lifting of the wind turbine onto the jacket substructure.



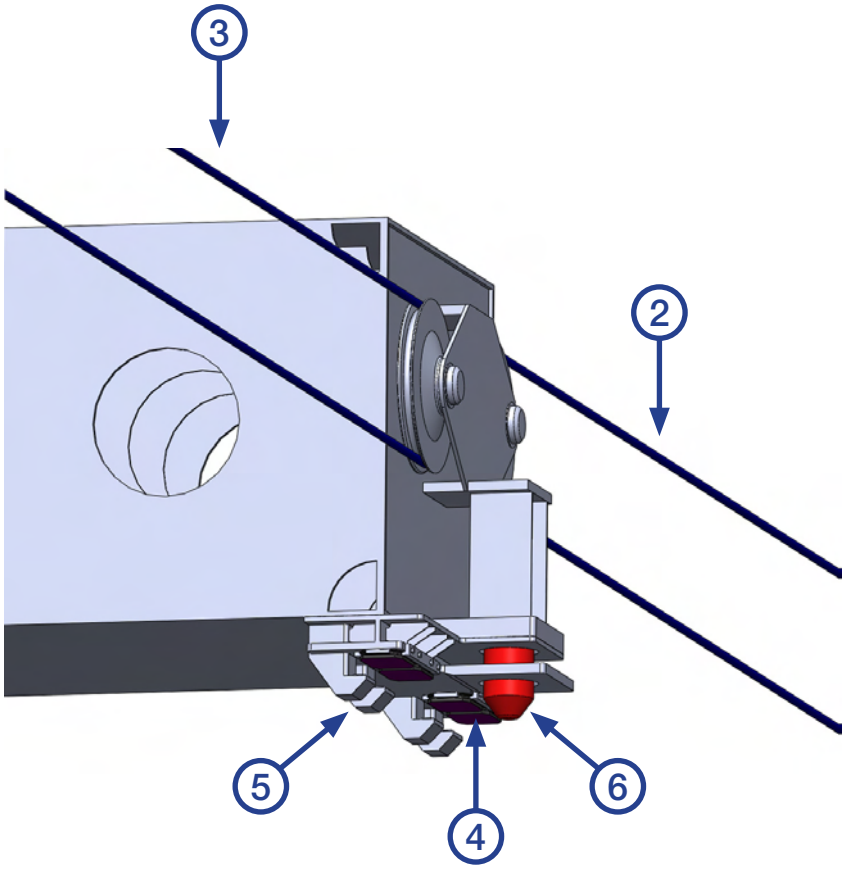


Skid Beams

1 Load spreaders designed for 850 tons corner load.

2 Pullingwire for individual positioning of each beam.

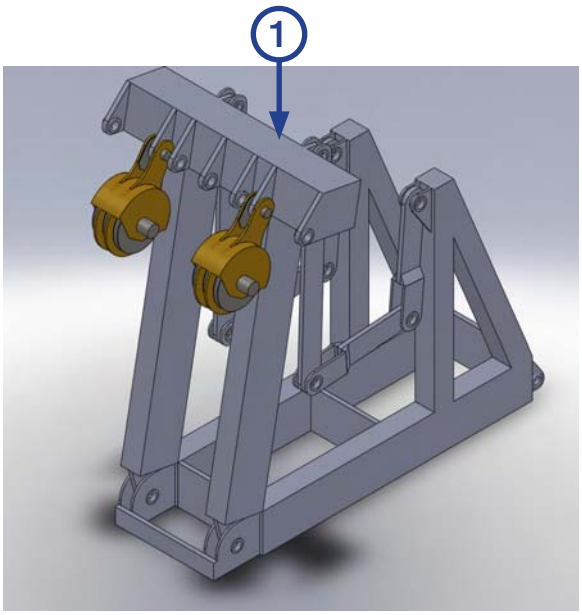
3 Hold-back wire for running to transom or ashore.

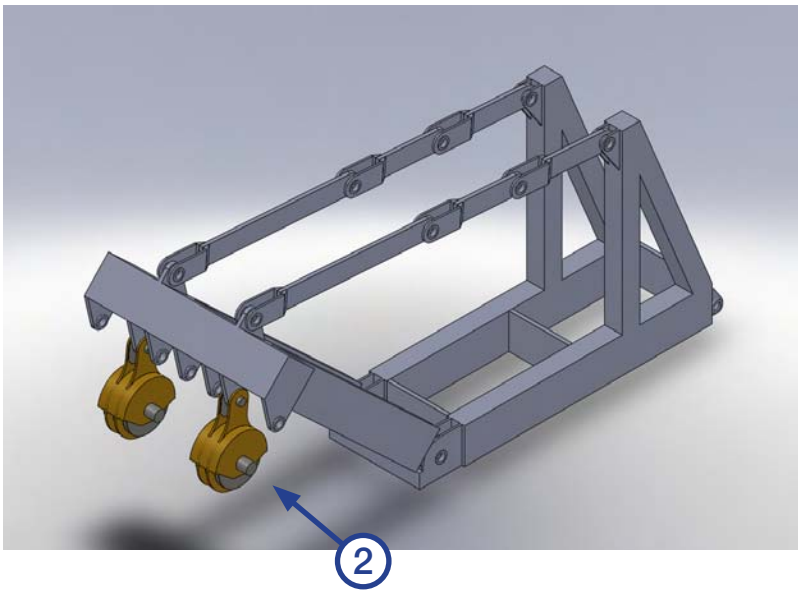


4 Skid pads sliding on stainless steel strips. Design load each beam 2x 600 tons skidding.

5 Horizontal guides with uplift fingers & orkot strips.

6 Locking pin.





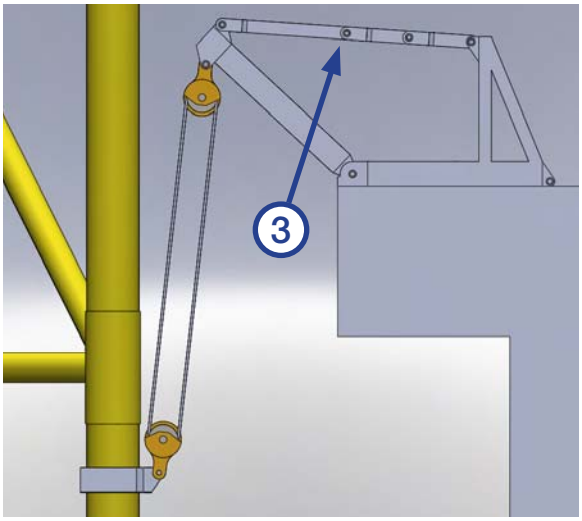
Each davit is designed for 3” wire, 12 falls 500 tons capacity

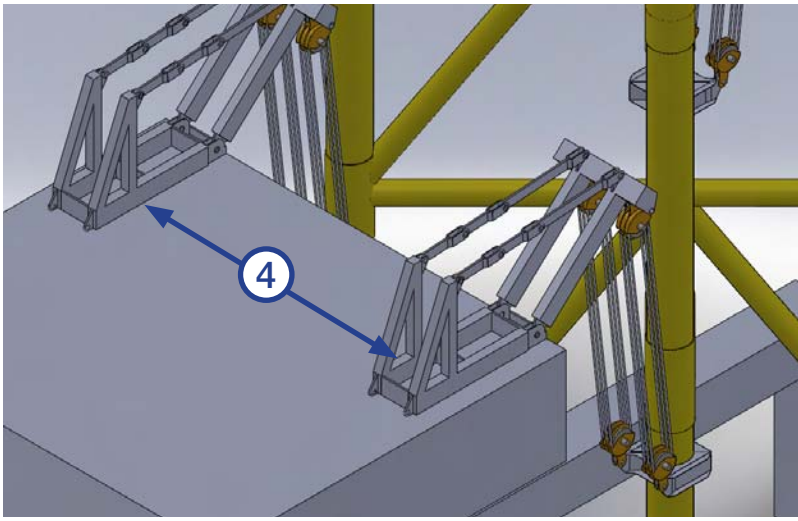
1 Davit can be stored on deck

2 Position of blocks can be adjusted on top girder to suit lifting points

3 Outreach can be adjusted by modifying (removing or adding) links

4 Davit position can be moved along the main deck to suit jacket or topside size





Multi Purpose Vessel Caters to a Wide Market

The 36m recess in the aft of the hull is designed to accommodate various projects:

1 Standard campaign 2 wind turbines & 2 jackets

2 Monopiles

3 3 or 4 legged support(jacket) campaign

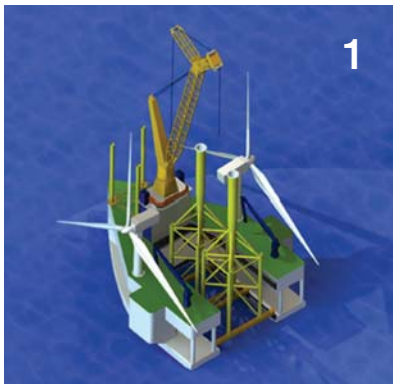
4 Preassembled wind turbine topside

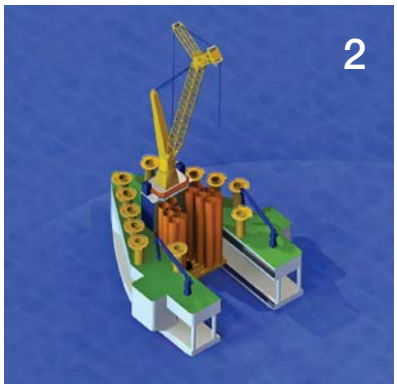
5 Installation of high voltage stations and accomodation,

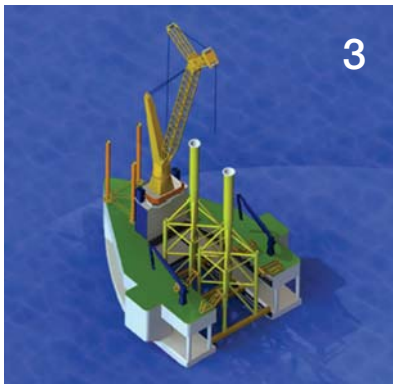
offshore installation and decommissioning for the oil industry (fork lift method).

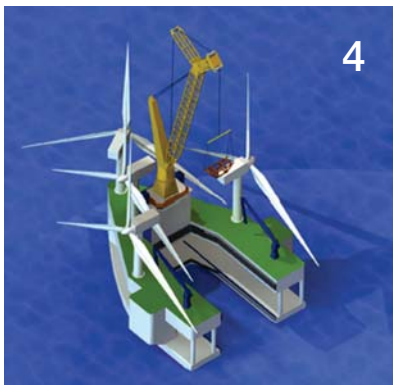
6 Deepwater installation

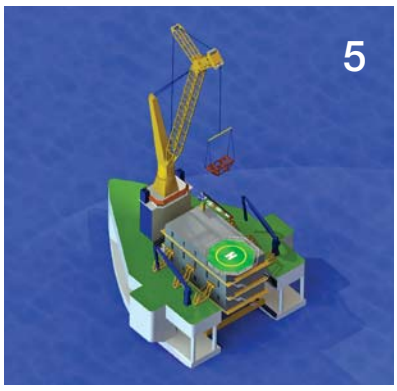
7 Wind farm maintenance

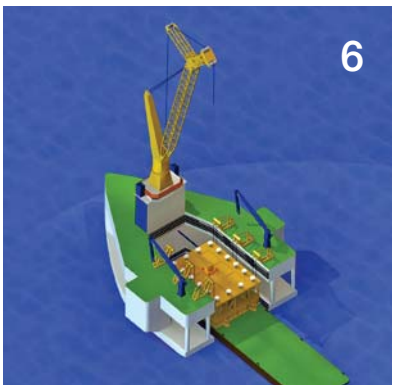


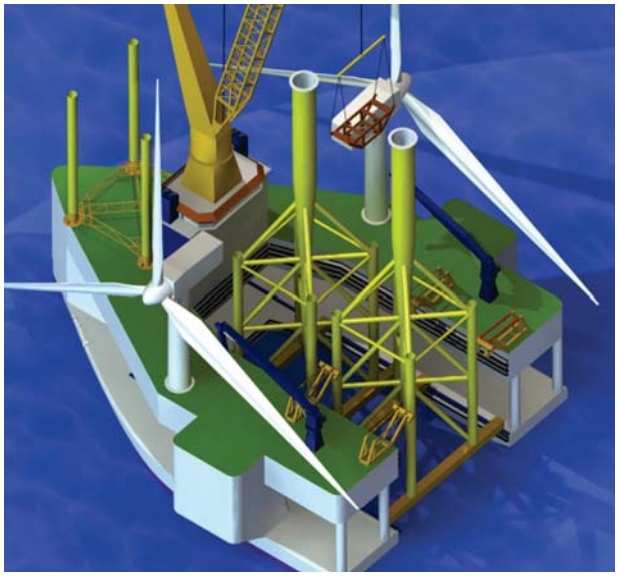






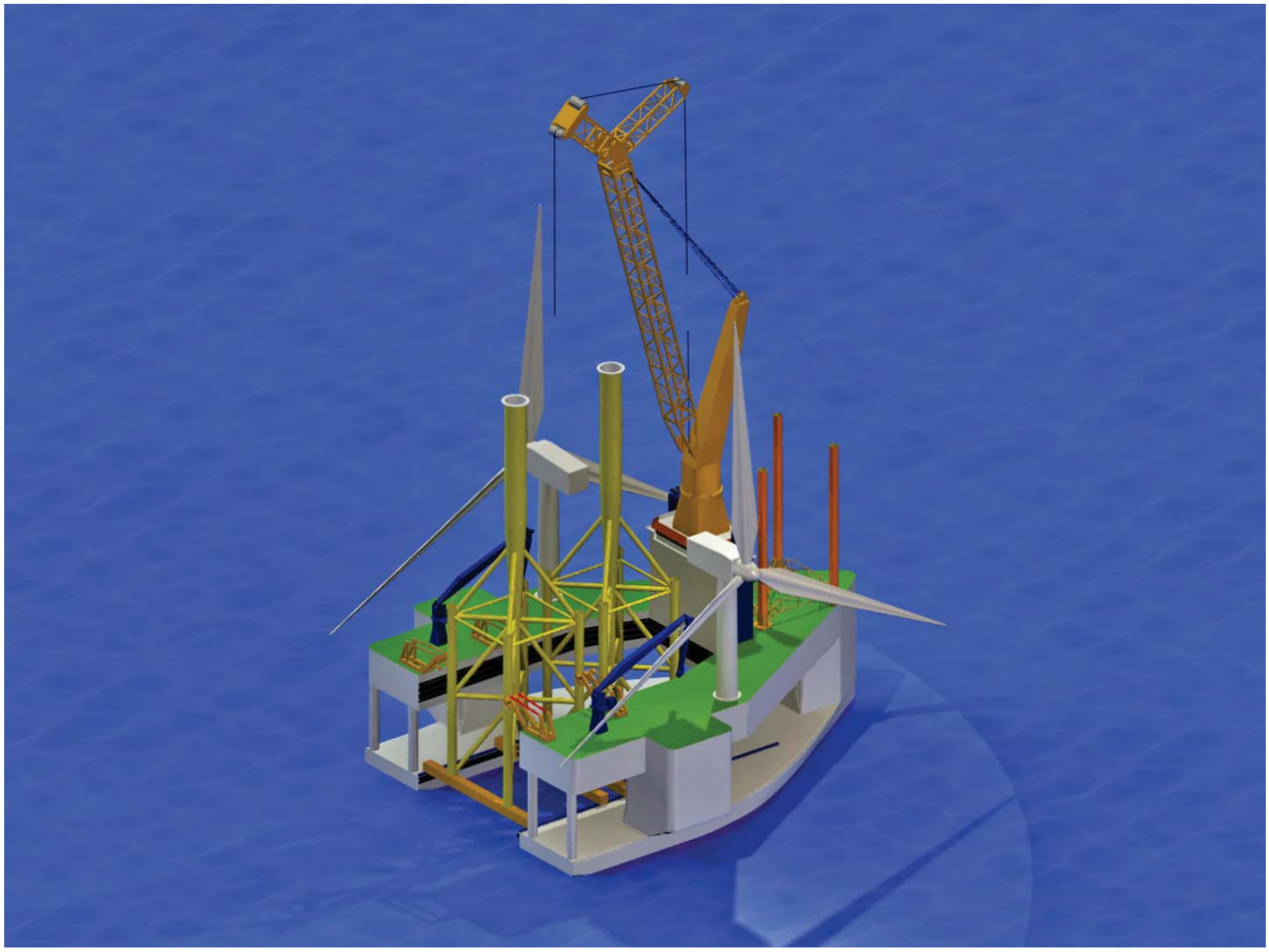


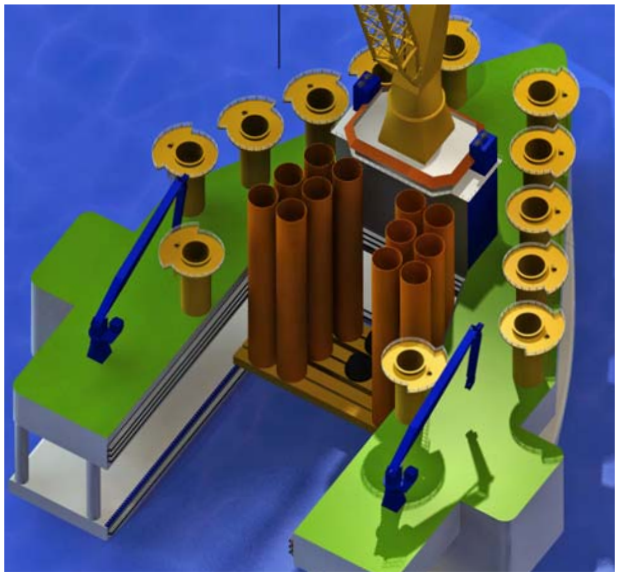




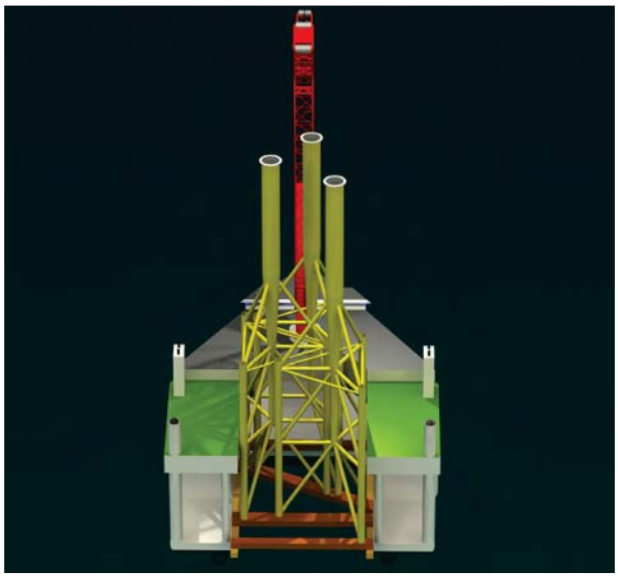
Standard Campaign of 2 Wind turbines and 2 Jackets

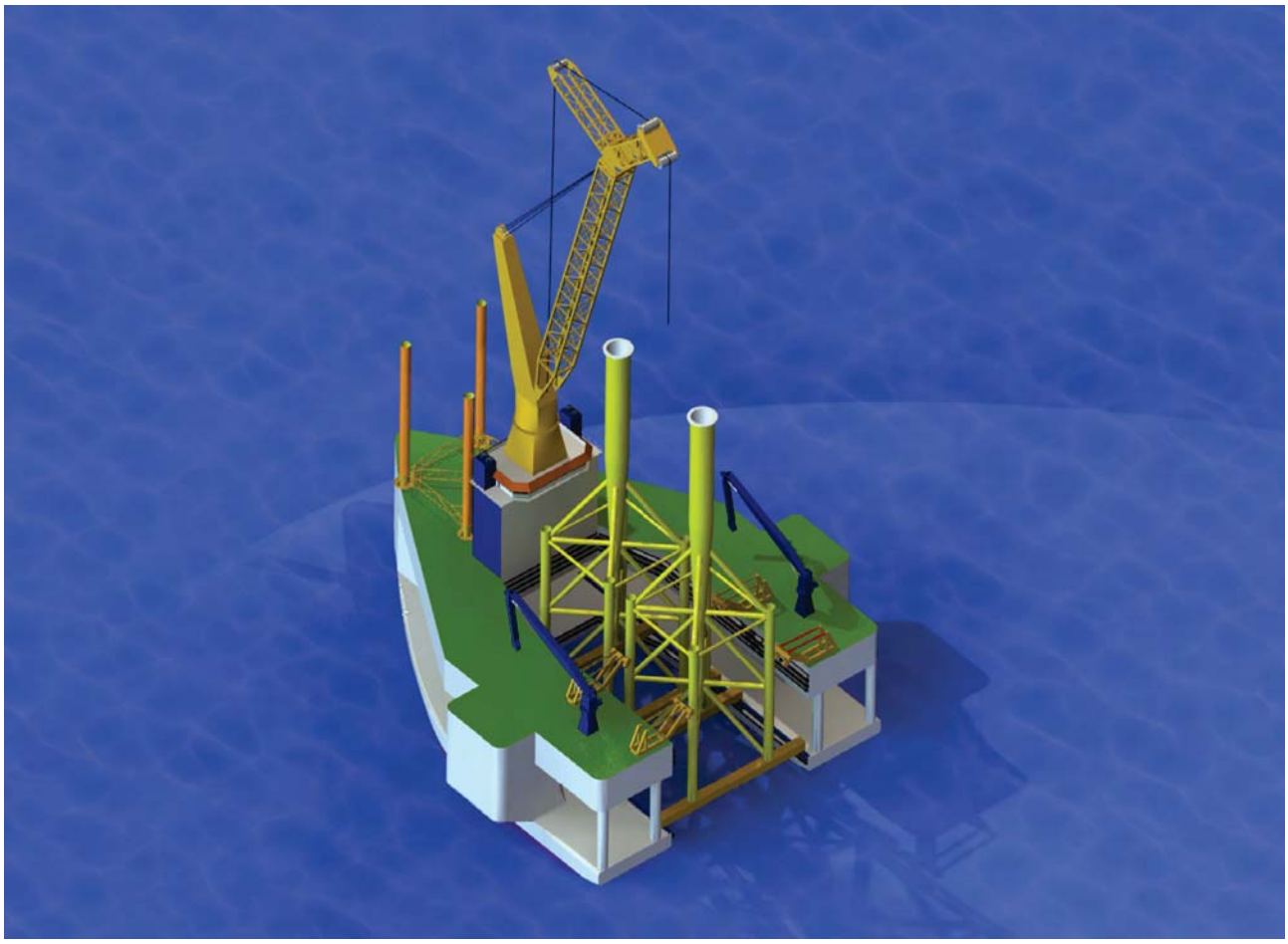
Two complete wind turbines campaign in a two day round trip.

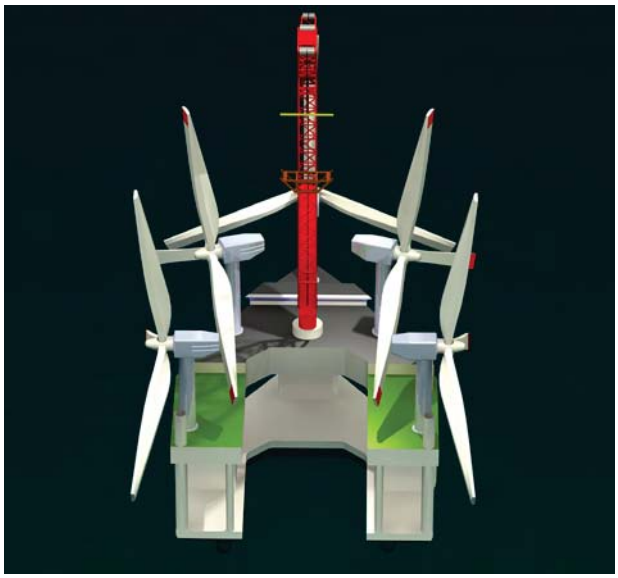




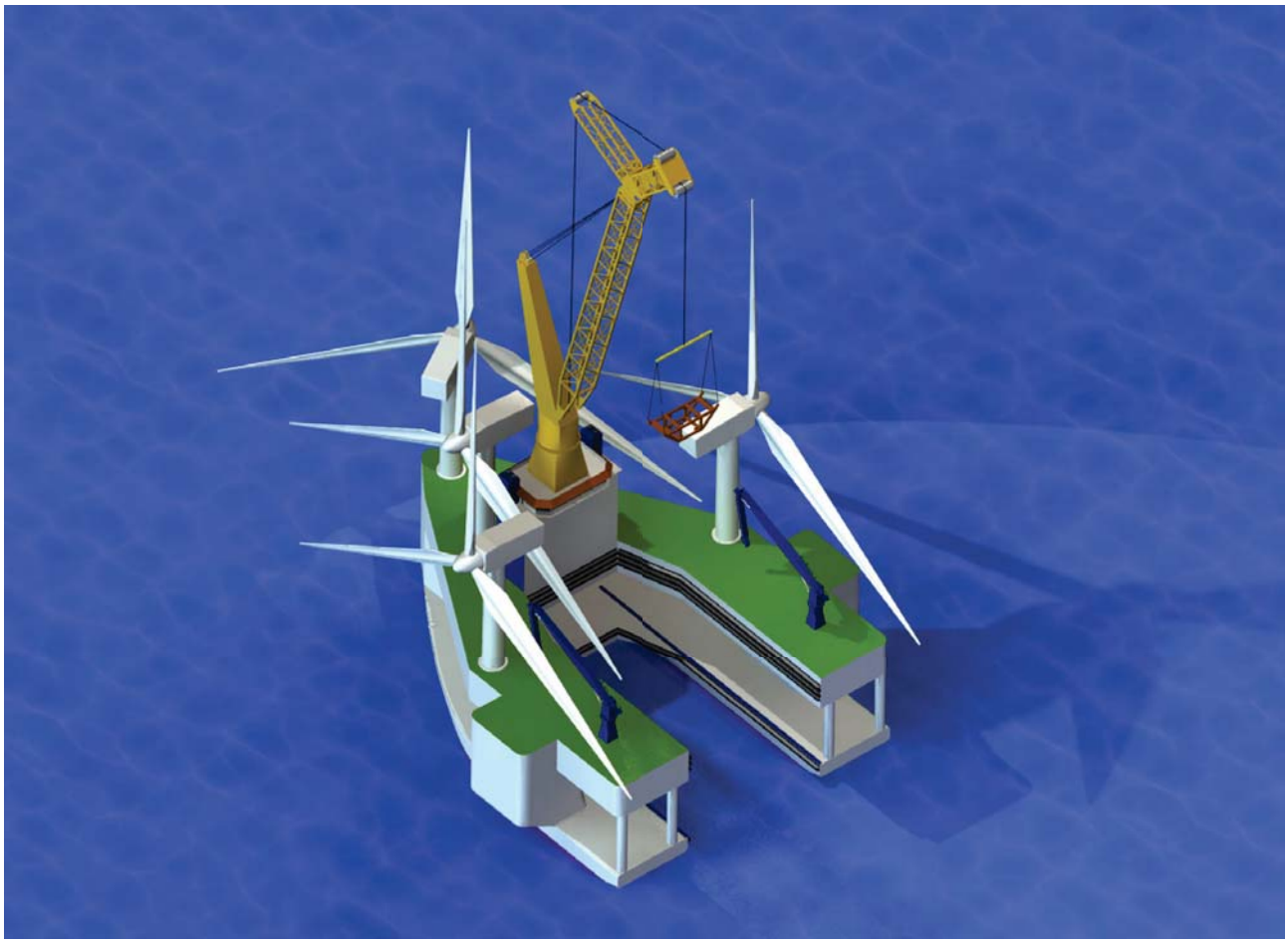
Example of stowage arrangement with 12 monopiles.

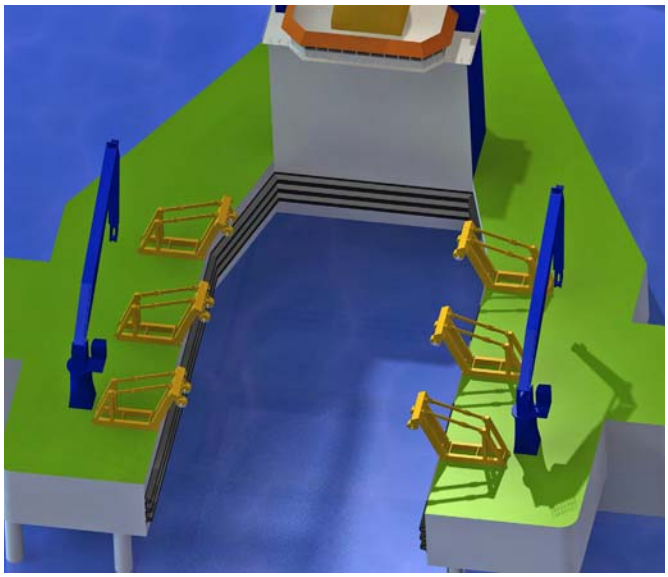




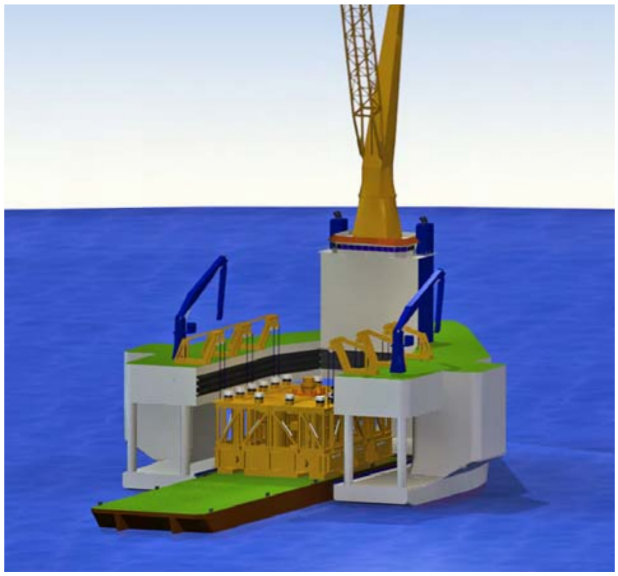


The SWIV has sufficient deck area to accomodate up to 5 wind turbines with ample clearance for all turbine blades.

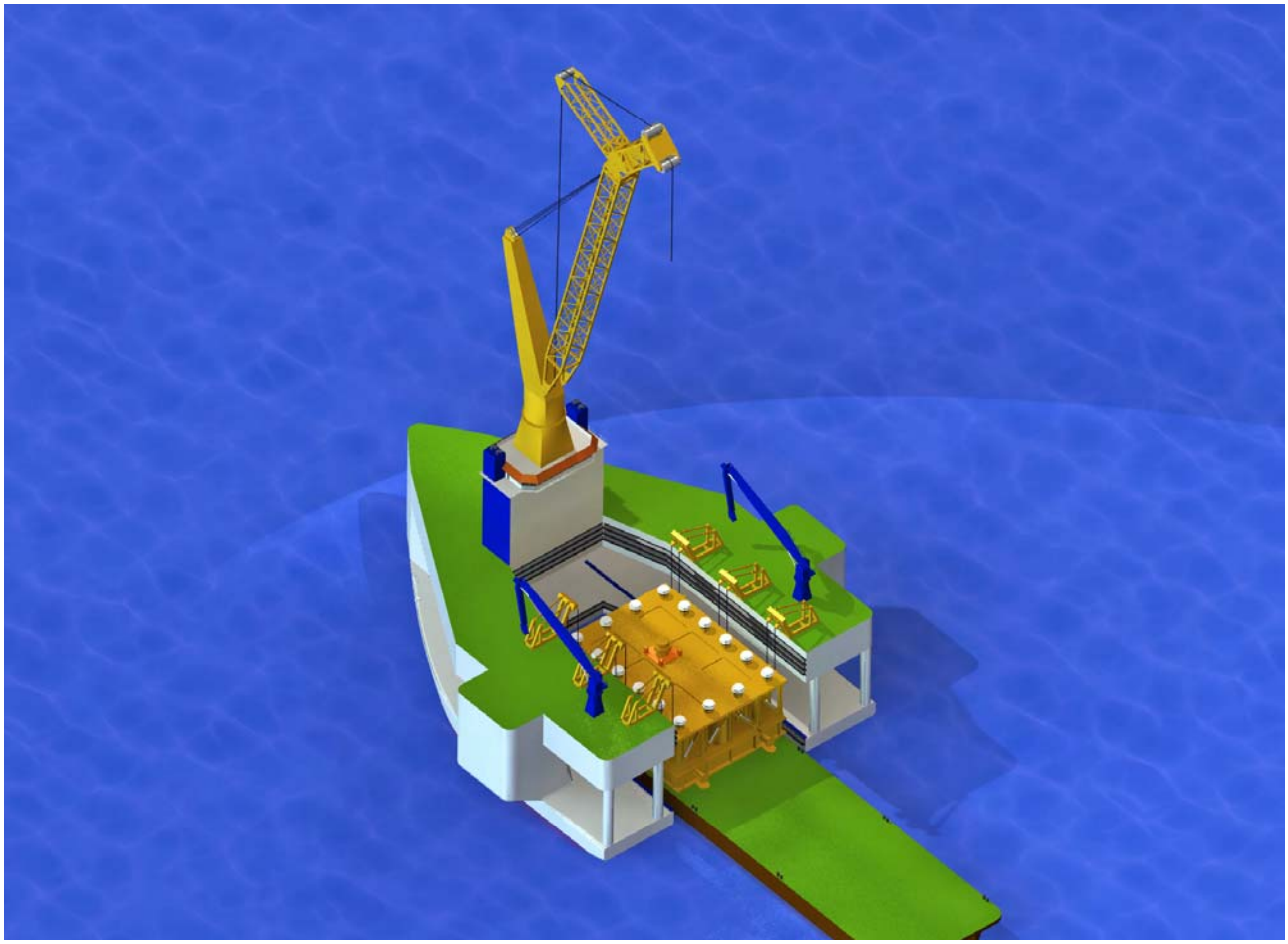


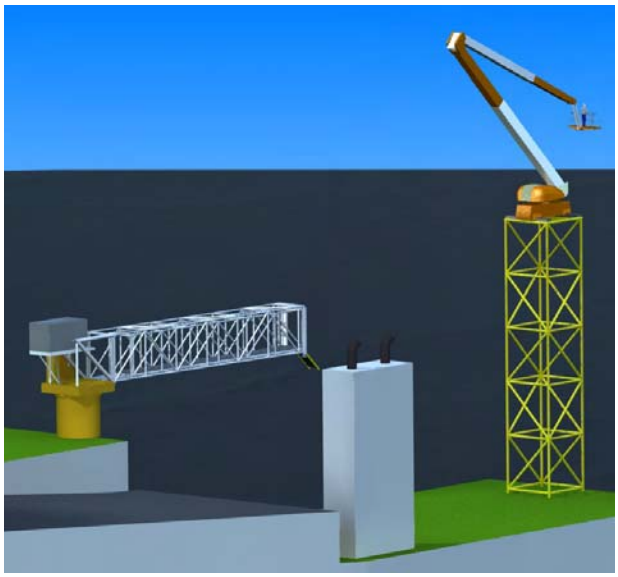


The recess enables the SWIV to perform the installation and decommissioning of various topsides.



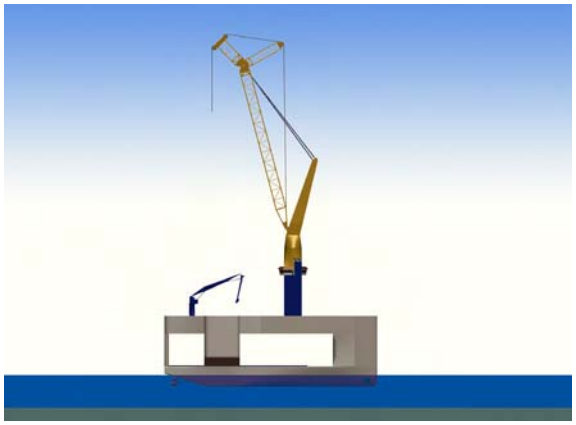
The recess can accomodate the world´s currently largest deepsea manifolds.



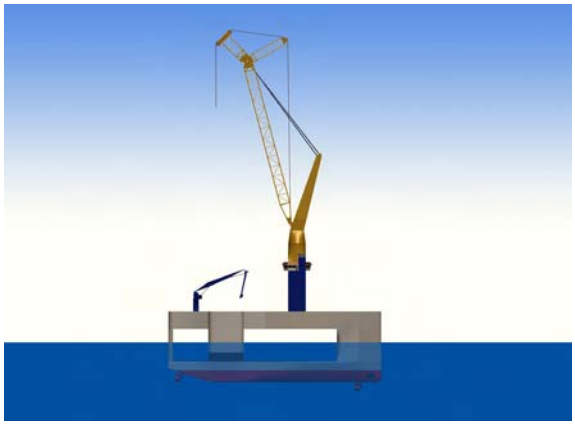


The SWIV can be specially equipped for wind farm maintenance.

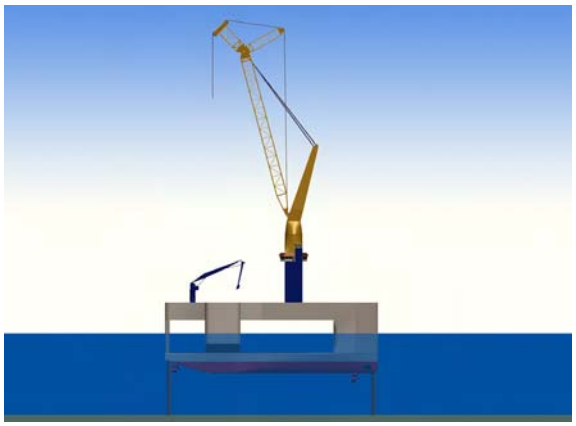
- The SWIV can be used to bring the complete topside ashore to do serious maintenance or upgrading of the unit.
- The vessel has a high standard accommodation for 80 men with ample recreation rooms, meeting rooms and messroom.
- An offshore bridge is available for safe connection and access to the jacket/wind turbine
- For very precise operations with wave periods under 8 seconds the motions of the SWIV can be completely stopped by clamping the spuds and preloading the spuds with open air driven ballast tanks.
- A tower with man riding articulated boom lift can be provided for detailed investigation of blades, hubs etc.



6 - 12m Waterdepth, unit at transit draft

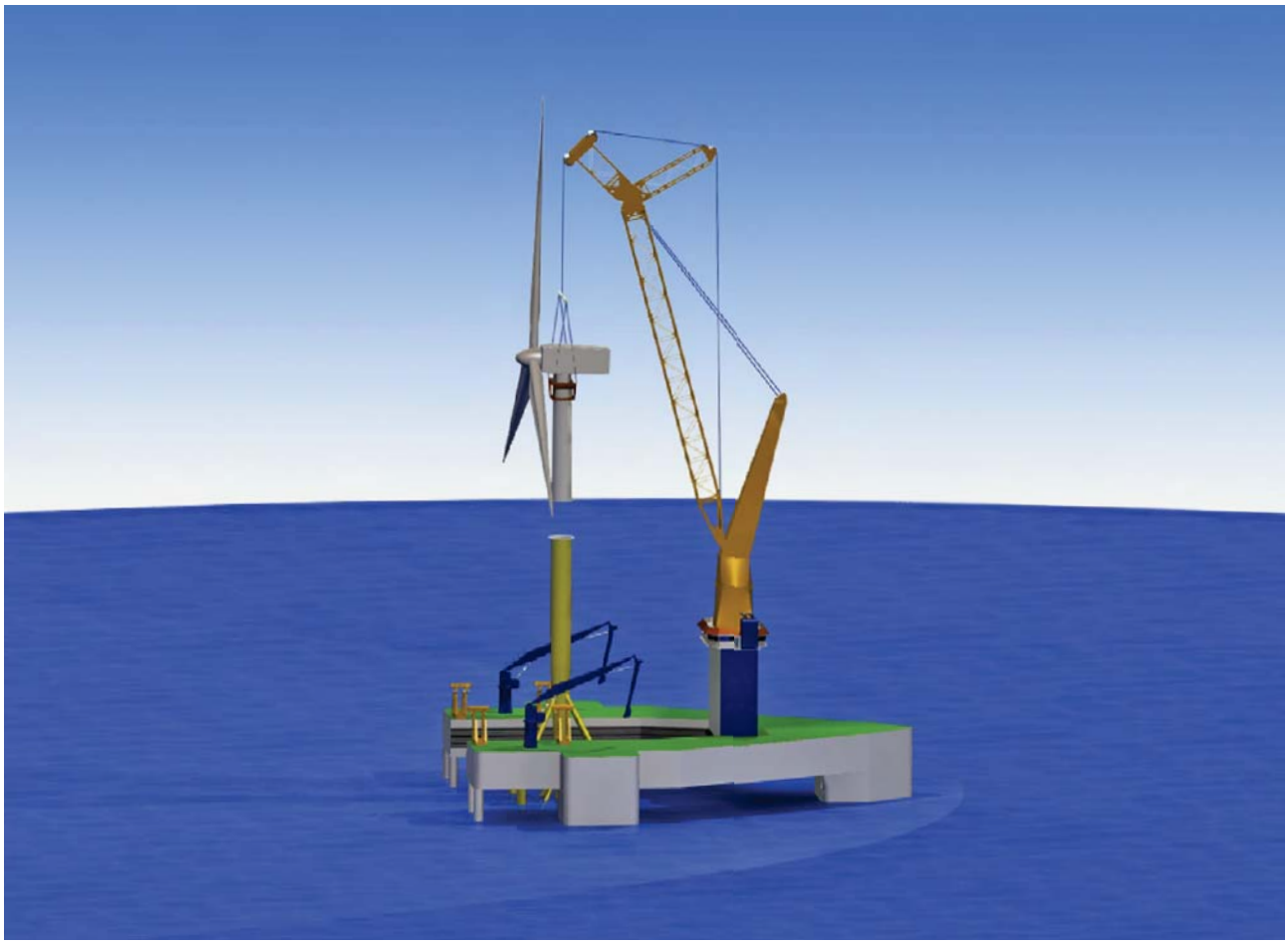


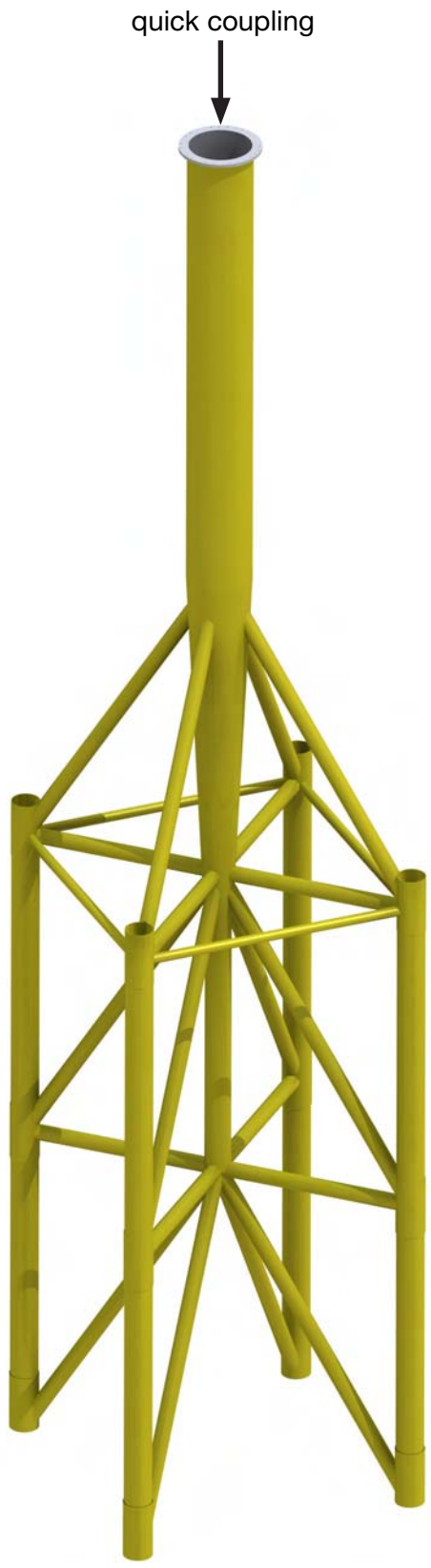
unlimited waterdepth semi-submerged



Spud Poles Engaged for maintenance work

- High workability
- Excellent free-floating motions
- High transit speed
- Low spud loads
- Low investment
- Flexible on various markets

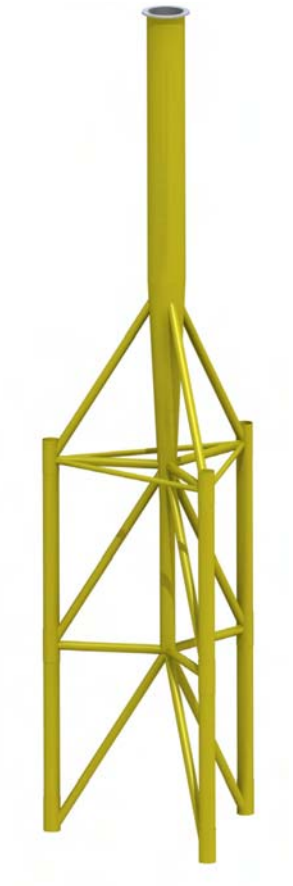




The Submersible Wind turbine Installation vessel SWIV can handle: monopiles, 3 legged jackets and 4 legged jackets depending on topside weight and water depth. As future wind farms are being pushed into increasing water depths, larger foundations will be required to support wind turbines above the sea surface.

To meet this requirement Leenaars has developed a jacket design which is characterised by its vertical legs and the high position at which the mast is supported and the wind turbine is attached. This results in lowest possible steel weight combined with simple fabrication. The vertical legs rise high above the water level after which diagonal bracings support a circular pipe. This pipe forms the base of the remaining wind turbine tower. Two main advantages emerge from this configuration: A smaller overturningmoment on the jacket results in lower structural weight and as a large part of the tower is incorporated with the jacket, and less weight needs to be lifted by the crane. This improves handling, transportation and installation of the structures.

Further, the nacelle blades and mast are combined and are handled as one topside module.This topside can be installed quickly but also it can be taken back ashore for maintenance or serious upgrading.



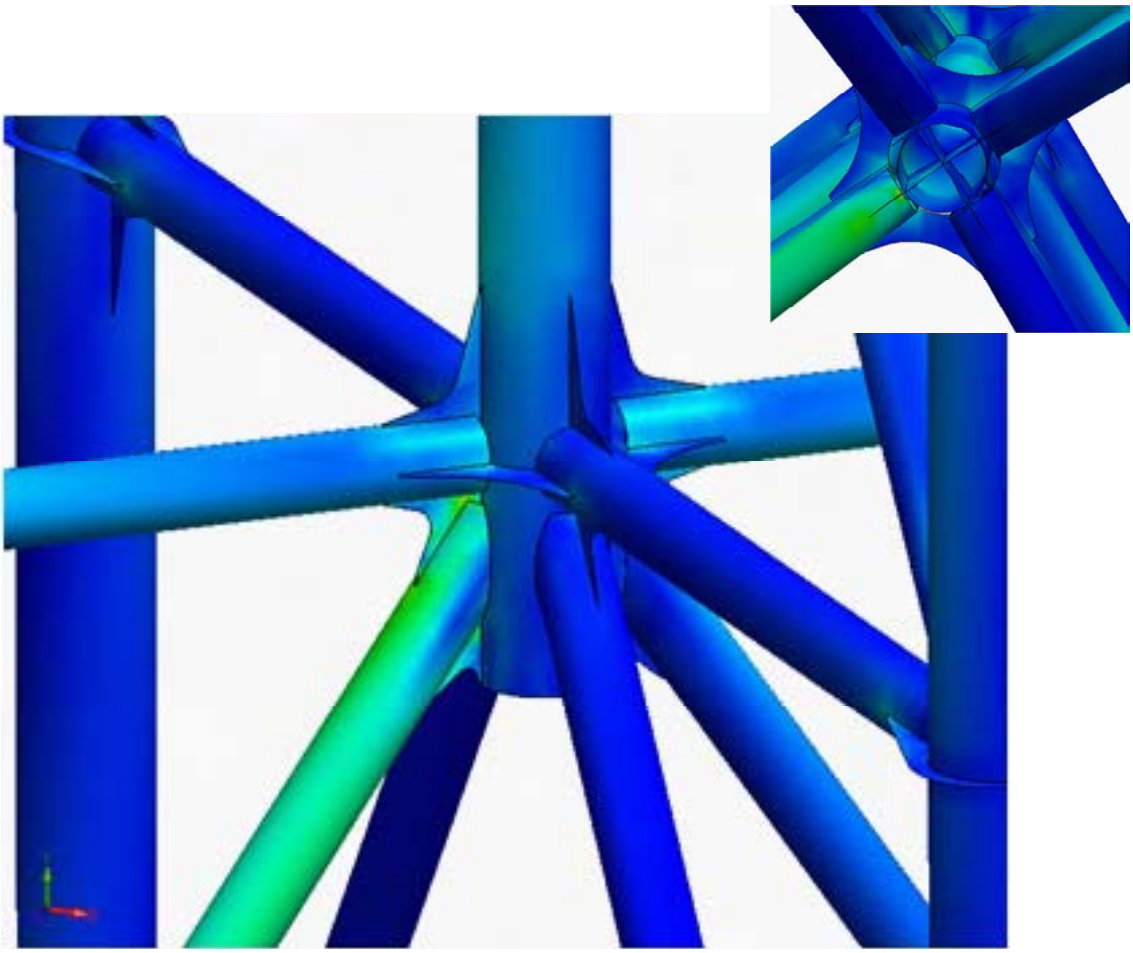
three legged version

monopile alternative

To make this possible the following features were developed.

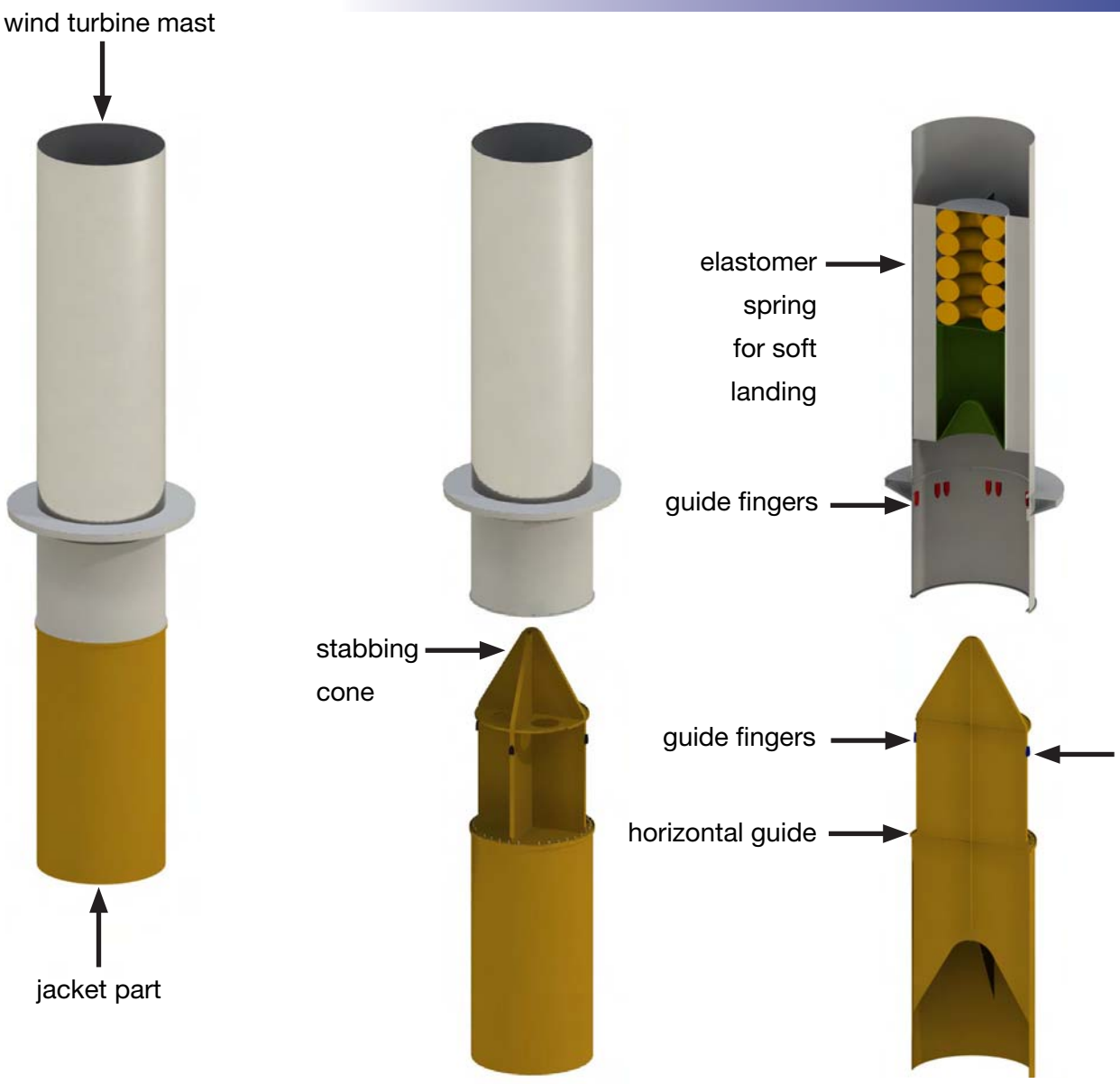
- The mast is shortened with the 2 lower blades just clearing the ground level to simplify erection and reduce accelerations during transport by lowering total cog.
- The central mast is supported at a much higher level than was common practice up to now.
- The corner legs of the jacket are kept vertical leading to lower bracing forces and a considerable reduction of overall weight.
- The piles are installed by a template in line with the jacket legs avoiding moments in the jacket legs due to the foundation loads.
- A quick pile- coupling is designed between the piles and the jacket legs. This coupling is used to connect the piles to the jackets and to level the jacket.
- This pile coupling can also be disconnected and the jacket can be simply removed at the end of the wind turbine lifecycle.
- A quick mast-coupling between jacket and topside has been developed for fast offshore installation and removal of the complete topside. The coupling has 2 horizontal guides therefore eliminating assistance of people during stabbing and landing. The coupling has internal elastomeric puffers that ensure a soft landing. (Similar to offshore platform float-over operations.) Further special guides take care of rotating the topside in the right position for landing. No people are initially involved, thereby reducing risks to workers during the landing phase. After landing some securing bolts can be safely installed by the crew.

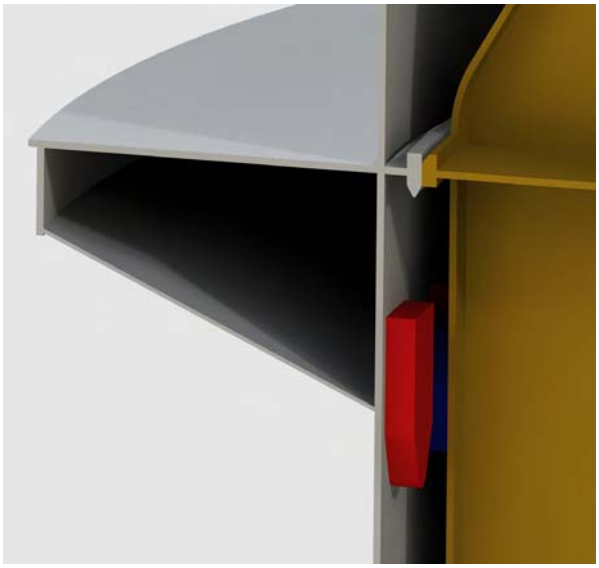
A light construction is made possible by the fact that the structure is connected to the turbine's mast high above the water level. Additionally, joints are designed with steel plate connections for a stronger joint. These characteristics allow the wall thicknesses of the legs and bracings to be kept to a minimum to reduce structural weight.



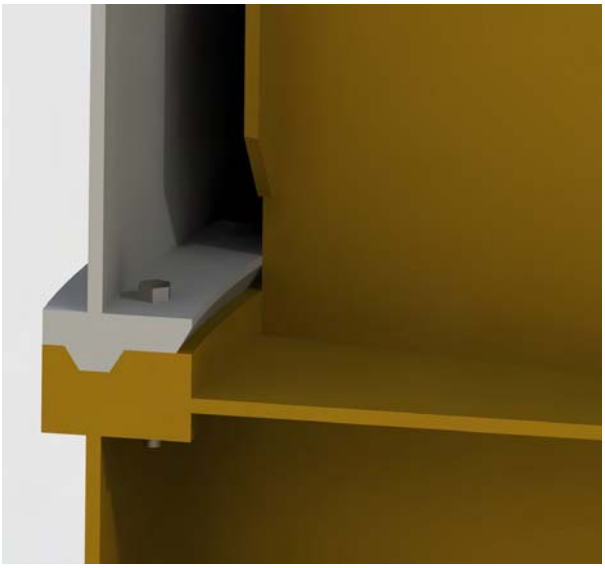
Summary

- Water depths up to 50m
- Swift installation
- Low weight
- High connection of topside





connection flange with horizontal guide



horizontal guide

Soft landing of topside

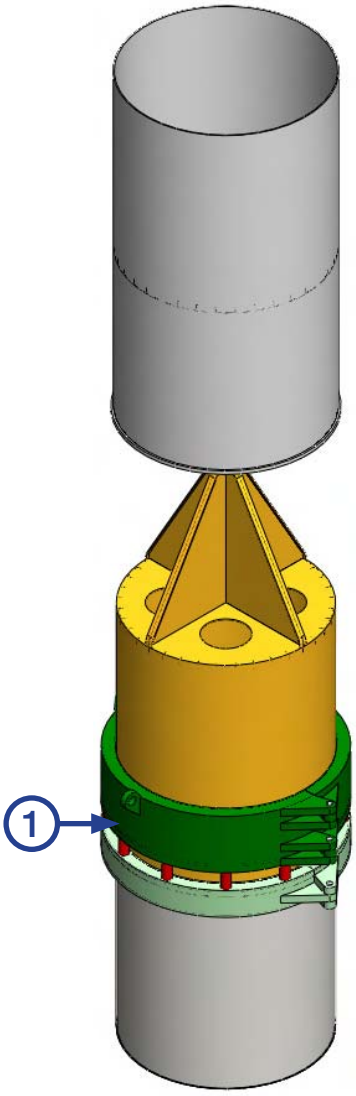
By reducing the torque of the winch drives the weight of the topside is gradually transferred to the mast through the mating unit. The mating unit can be fitted on the inside or outside of the wind turbine.

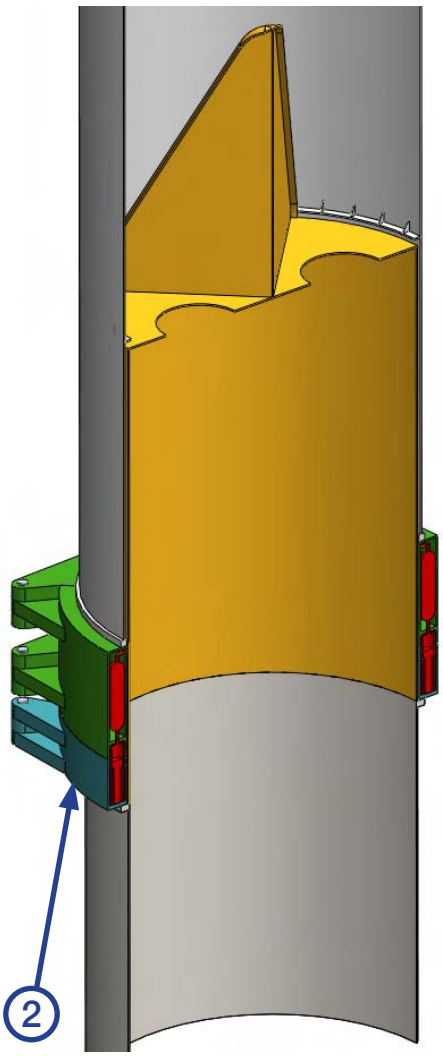
1 Mating unit out

2 Mating unit in support in topside

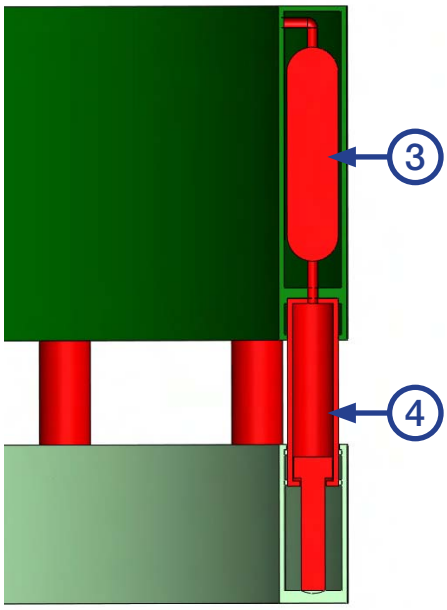
3 Accumulator

4 12x 7,5tons cilinders

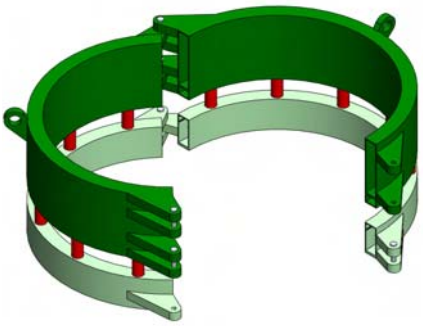




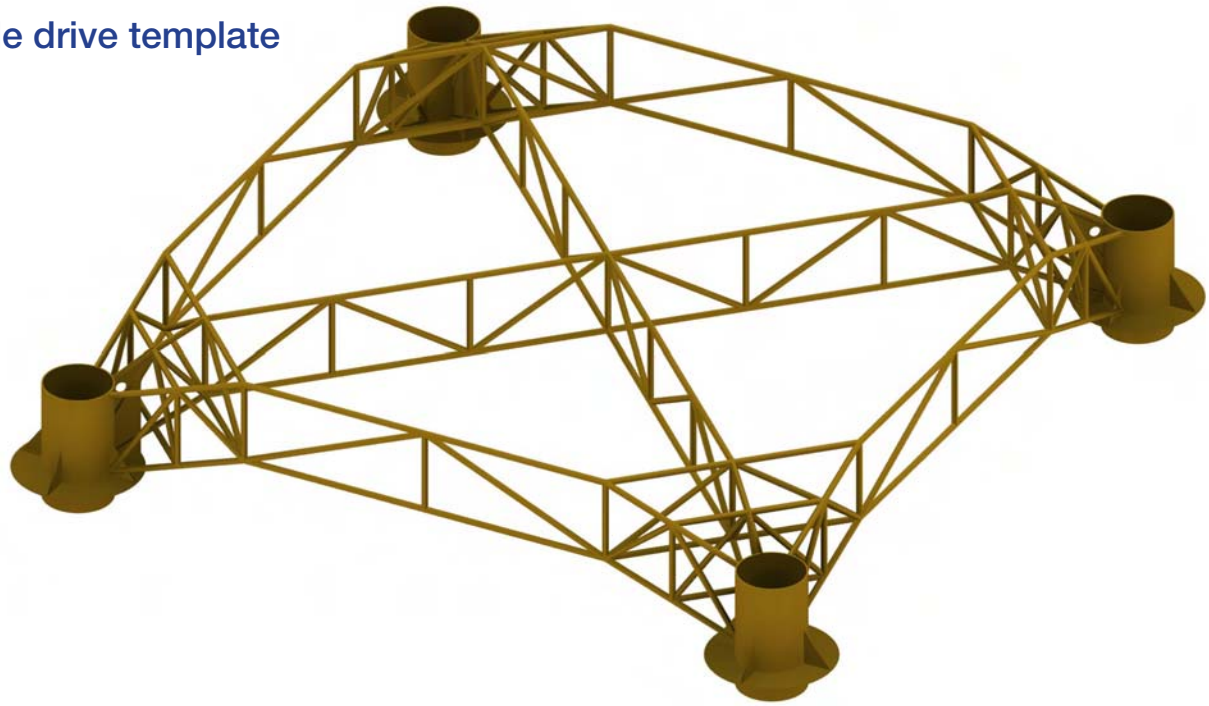
Section over cilinder



Open for removal



Pile drive template



Prepiling with template

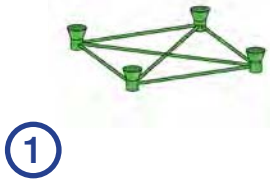
1 Pile drive template placed on seabottom.

2 Piles driven through template sleeves.

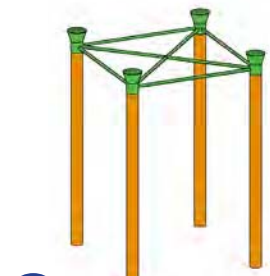
3 Jacket placed on piles and swaged.

4 Level top of piles by adjusting pile heads relative to template.

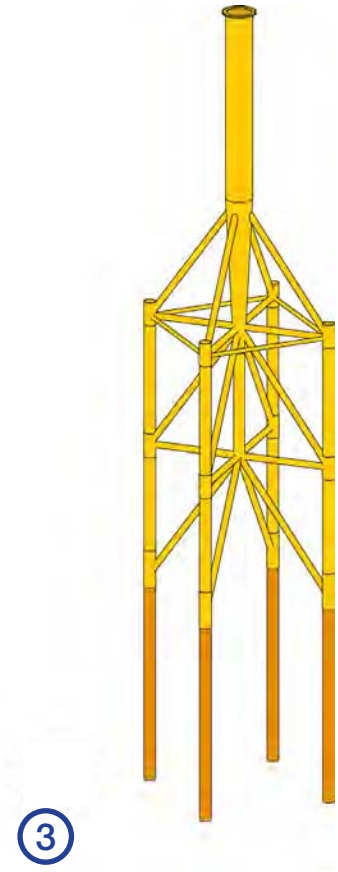
5 Pile connection by quick coupling, swaging or grouting.



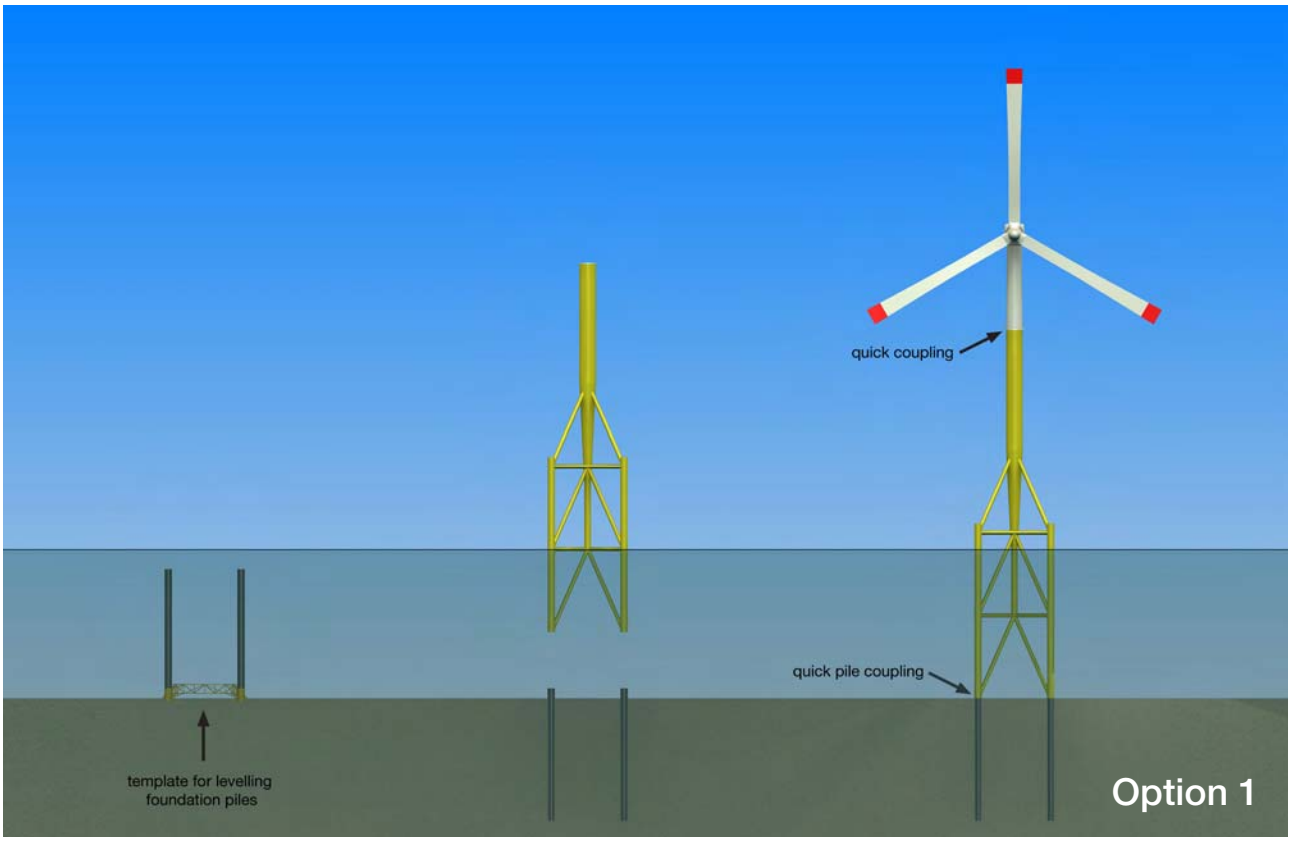
1



2



3



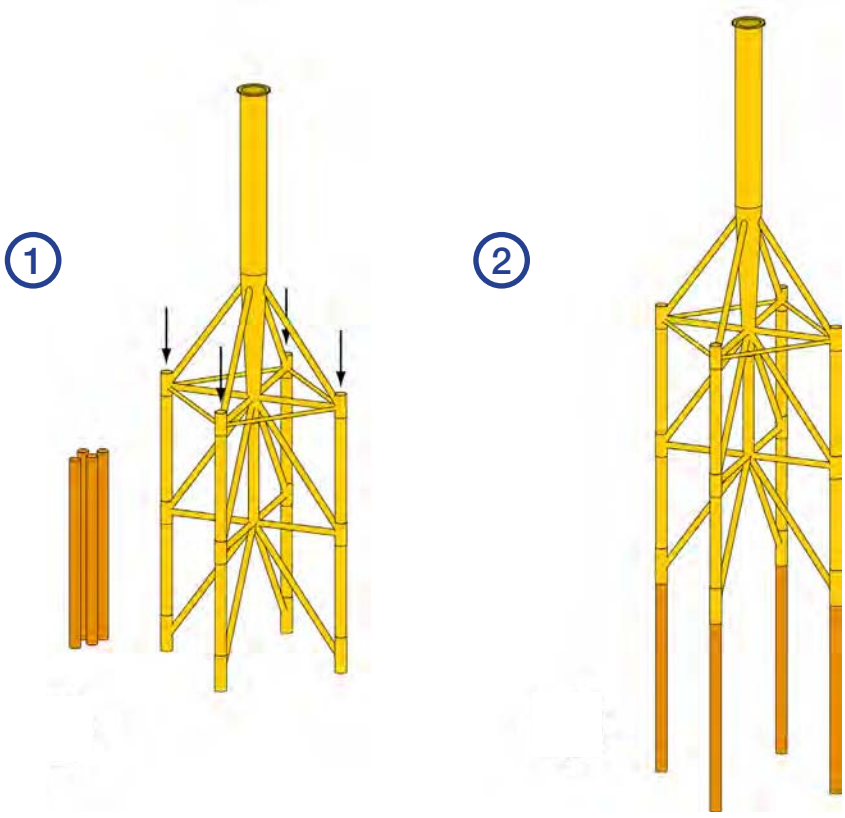
Piling through legs with follower

1 Jacket placed on seabottom.

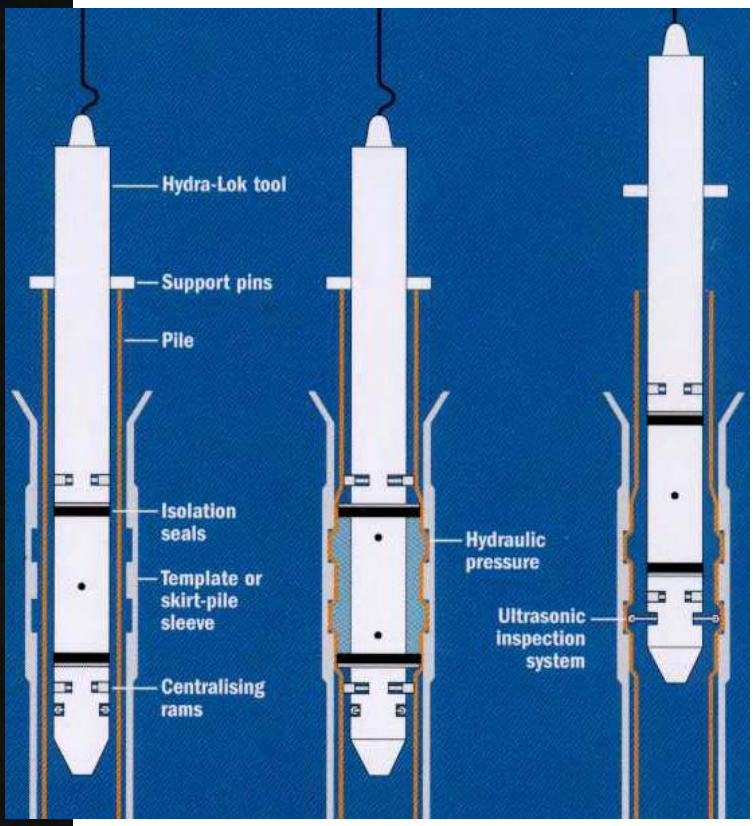
2 Piles driven through outer jacket pipes with follower.

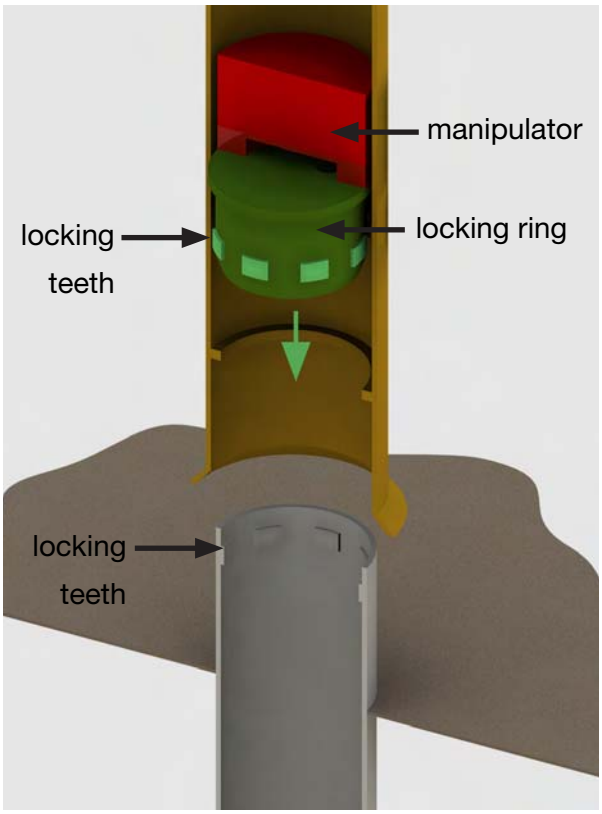
3 Connection by quick coupling or swaging

4 Leveling with followers.

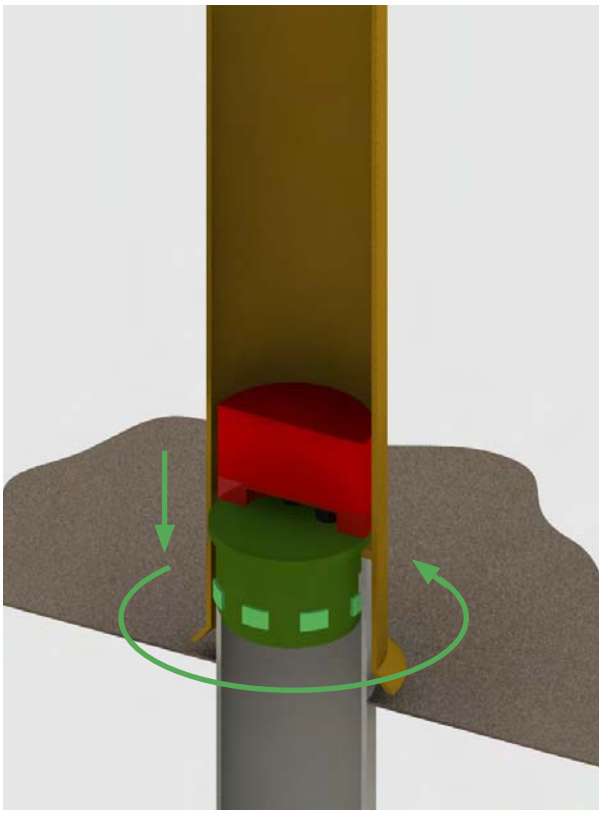


Swaging

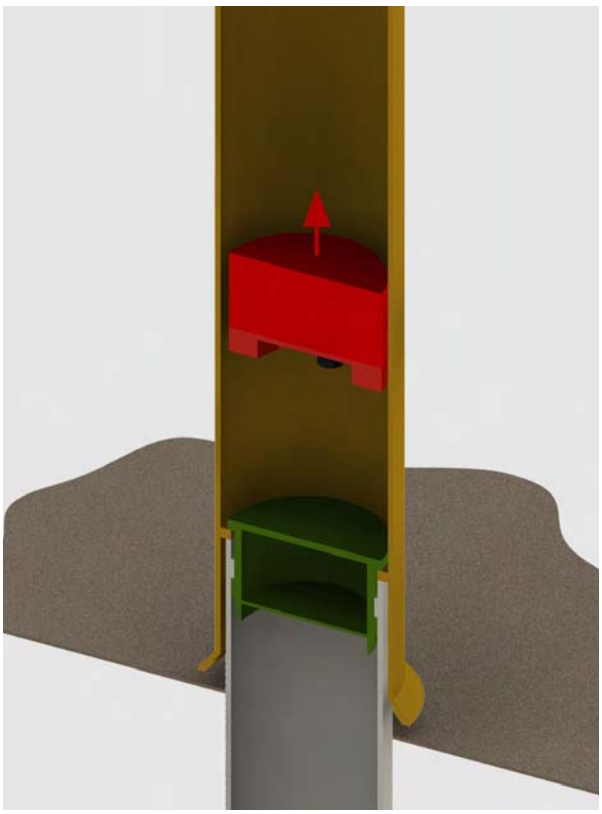

Hydra-Lok tool
Support pins
Pile
Isolation seals
Template or skirt-pile sleeve
Centralising rams
Hydraulic pressure
Ultrasonic inspection system



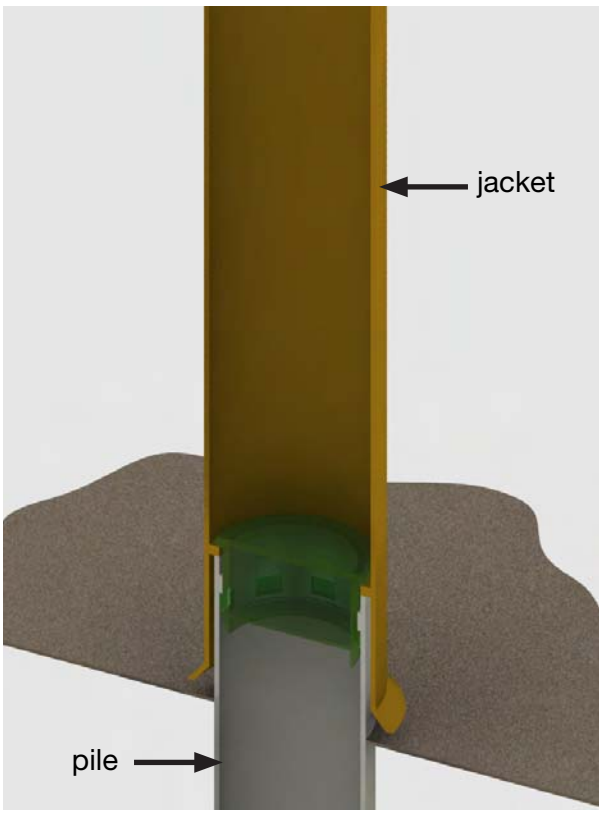
This quick pile coupling is designed to connect the piles to the jacket legs and simultlevel the jacket.



The manipulator lowers and twists the locking ring into place.



The manipulator is withdrawn when the locking ring is properly positioned.



Jacket is connected to the pile.

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LEENAARS BV
MARINE & OFFSHORE DESIGN

Pascalweg 19
3225 LE Hellevoetsluis
The Netherlands
t +31 (0) 181-316305
w www.leenaars-bv.nl

LEENAARS - LONGWAYS Ltd.
MARINE & OFFSHORE DESIGN CHINA

Xinggang Street 207-10
Zhifu District, Yantai
Shandong Province China
t +86 535 6743910
@ lzd76529@163.com