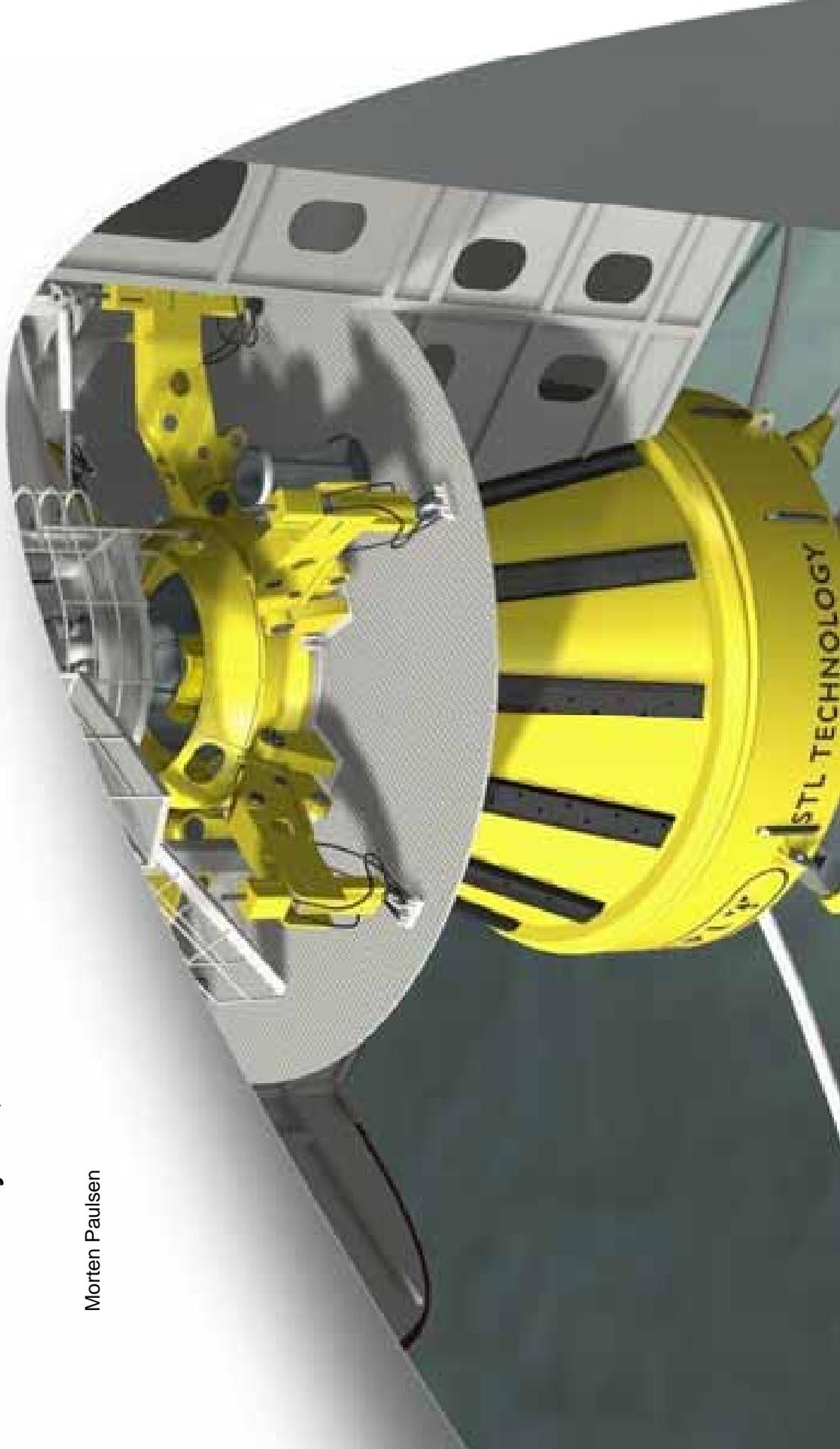


APL – Subsea Mooring Connector

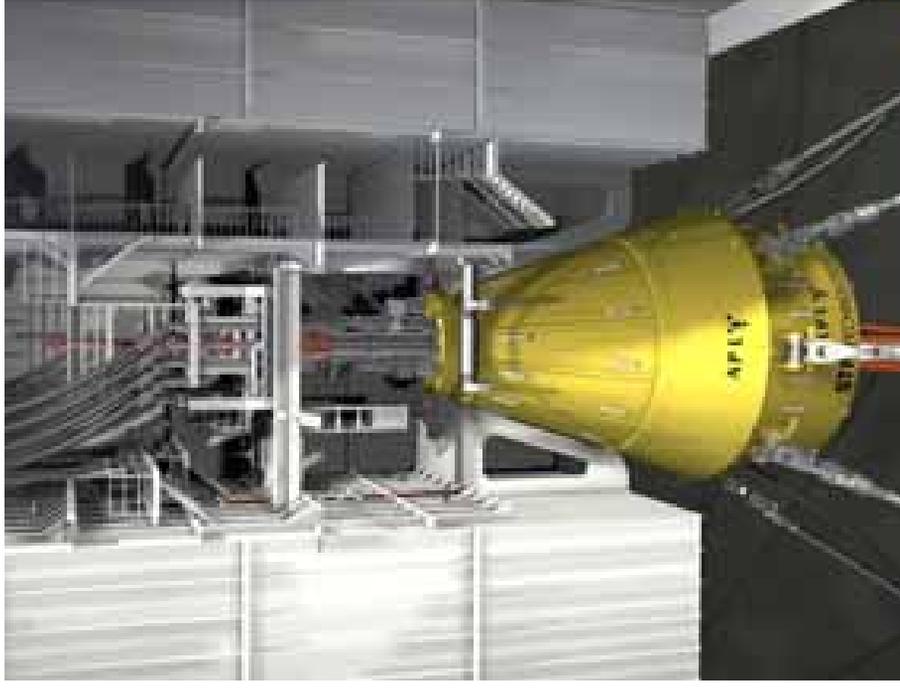
January 28, 2010.

Morten Paulsen



APL Introduction:

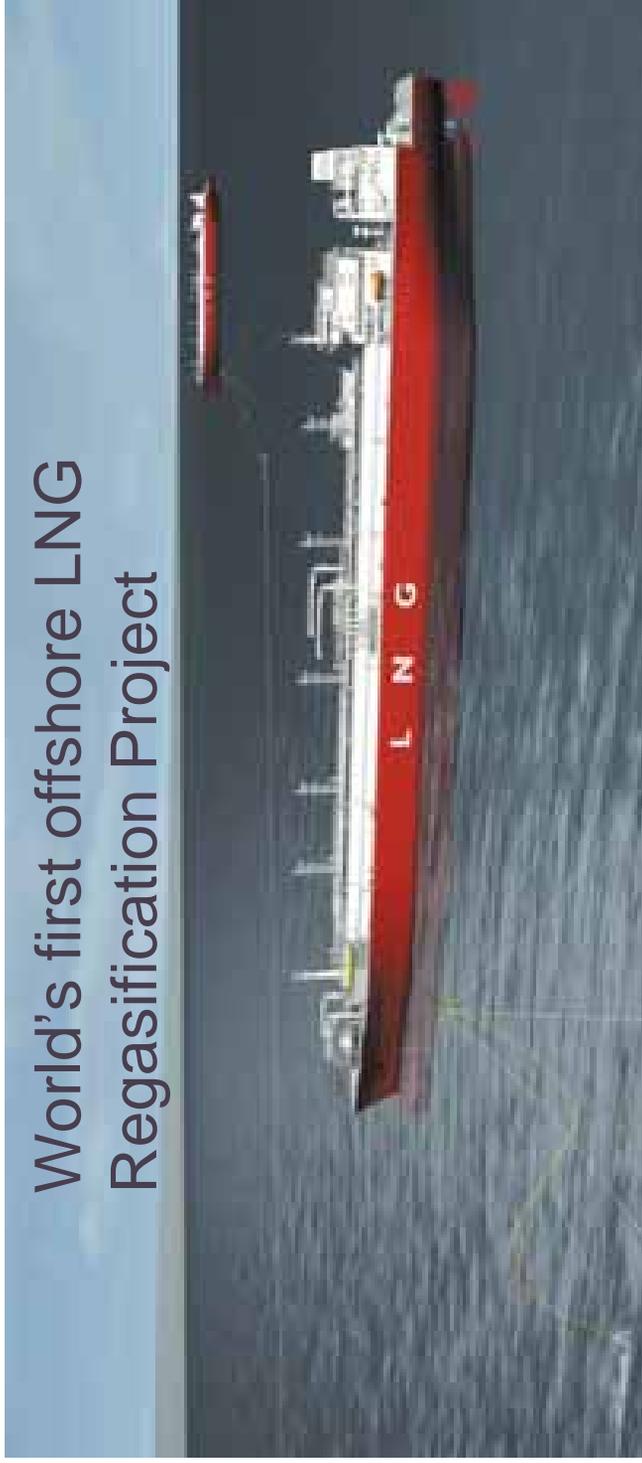
- **Advanced Production and Loading AS (APL) was founded in 1993 to develop and commercialize the STL and STP systems.**
- **APL is a market leader in development, fabrication and sale of turret mooring systems and related technologies for the oil and gas industry.**
- **The main development/technology office is in Arendal, Norway. APL also has offices in Brazil, USA, France, Malaysia, China, Singapore and UK.**
- **APL is owned 100% by BW Offshore and is part of the BW organization.**



APL Introduction:

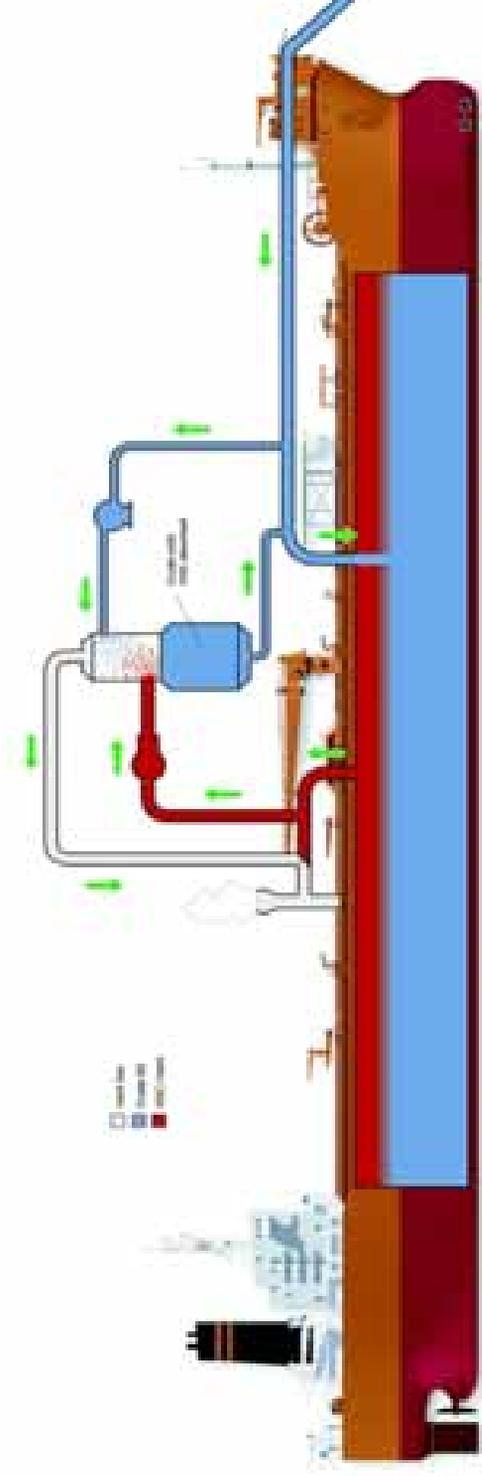


- APL has grown from about 10 employees in the start to close to 200 today.
- The development of the STL technology was a result of a demand in the market for loading systems with high availability in harsh environments. Today both STL and STP systems are well established as the world's first standardized turret systems.

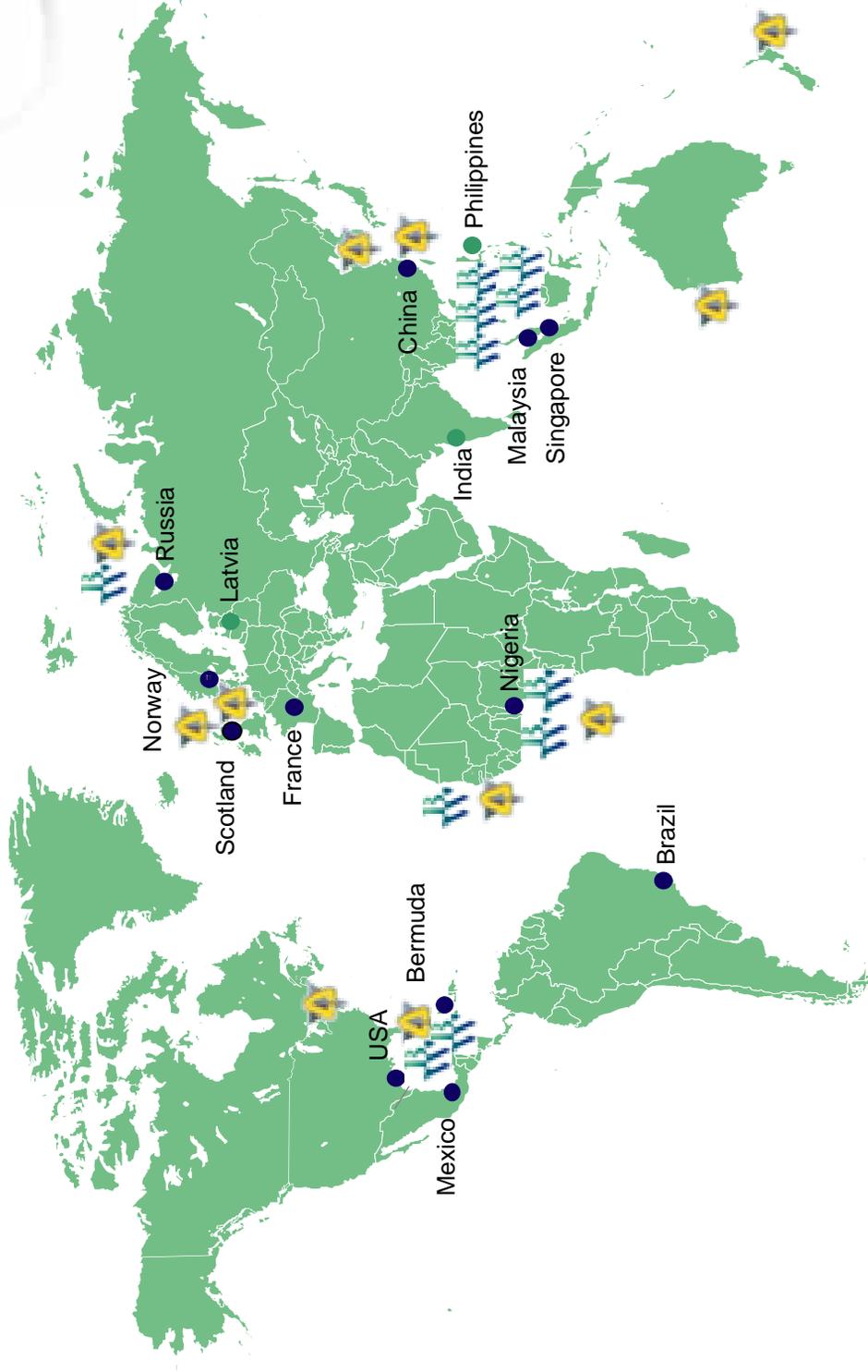


APL Introduction:

- Derived from this technology, APL developed the Single Anchor Loading (SAL) system, Single Anchor Production (SAP) system, the SAL Yoke (SYS) system, the Buoy Turret Loading (BTL) system, the External Turret Production (ETP) system, and Spread Moored Tandem (SMT) system.
- Our current product range also includes the Bow Loading System (BLS), the Stern Discharge System (SDS), the Volatile Organic Compounds Recovery (VOC rec.) system, the Volatile Organic Compounds Return (VOC ret.) system, Sequential Transfer of Tank Atmosphere (STTA) system and Gas to liquid (GTL).



APL global presence:



- BW Offshore units
- APL Technology
- BW Offshore offices
- Recruitment centers



Turn key solutions:

Production systems



Submerged Turret Production (STP) for FPSO



Submerged Turret Loading (STL) for FSO



External Turret Production (ETP) for FPSO



SAL Yoke System (SYS) for FPSO



Harsh environment FPSO

Terminal systems



Submerged Turret Loading (STL) for LNG and Shuttle Tankers



Single Anchor Loading (SAL) for Shuttle Tankers



Buoy Turret Loading (BTL) for Shuttle Tankers



BLS and SDS systems for Shuttle Tankers

STL™ - Submerged Turret Loading



References:

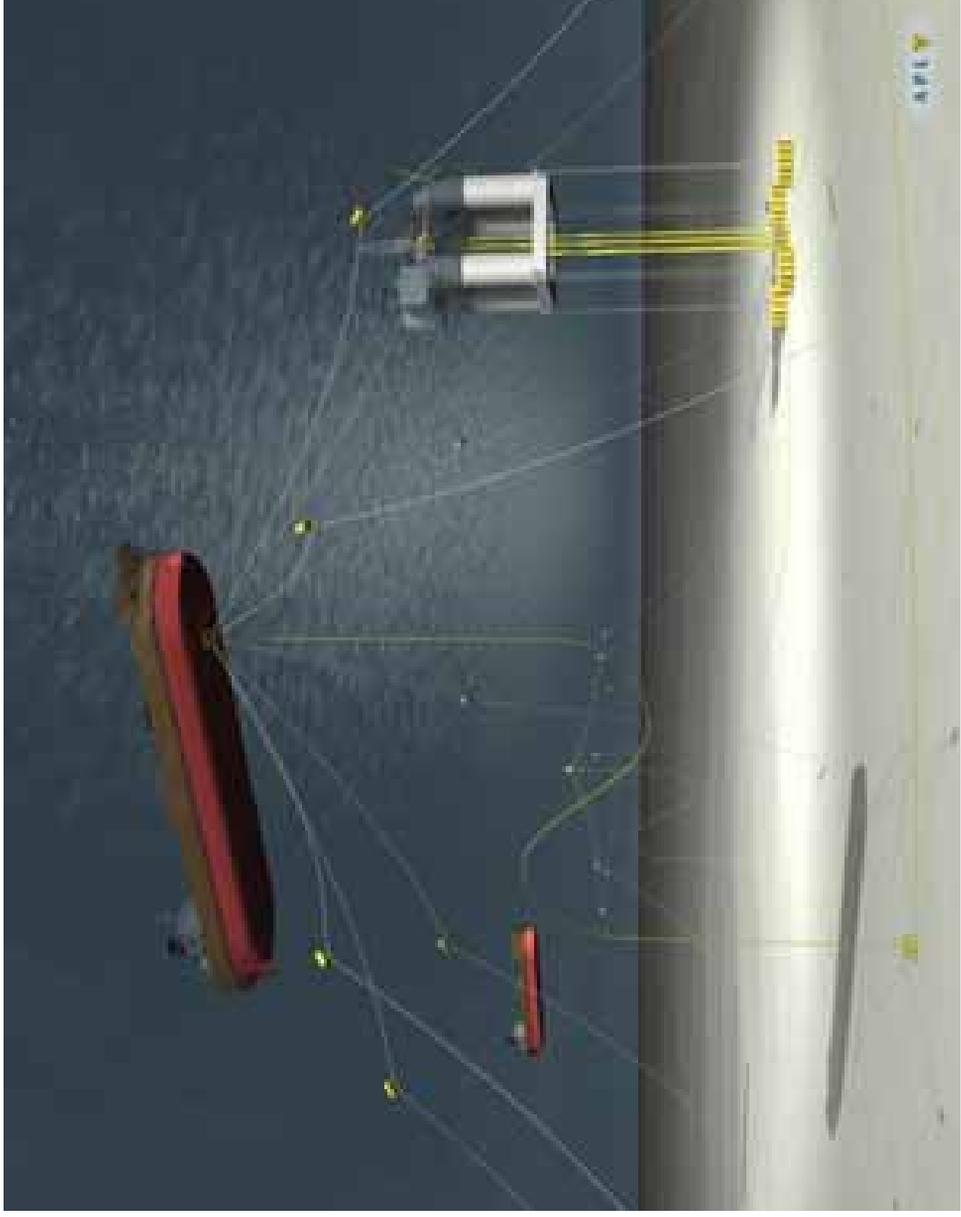
Shell, Fulmar
Statoil, Heidrun

BP, Harding
Statoil, Yme
Hydro, Njord B
Statoil, Åsgard C

ConocoPhillips, Banff
ConocoPhillips, Bayu Undan
Excelerate, Gulf Gateway
Statoil, Volve,
Excelerate, North East Gateway
Suez LNG NA, Neptune



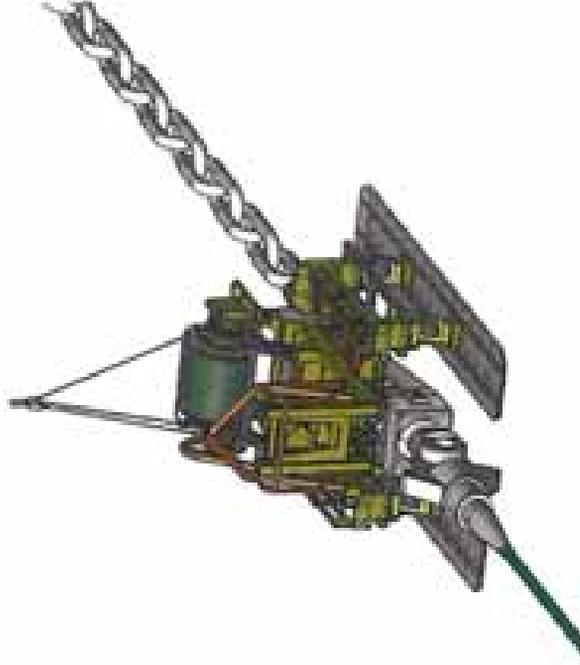
STL™ - Submerged Turret Loading (Heidrun)



Subsea Mooring Connector



- Reason for development
 - Easier and safer connection of STL/STP mooring lines.
 - Avoid expensive diver installation.
 - Connect all lines using ROV.
 - Develop a standard connection that can be used for most of APL installations / systems.



Subsea Mooring Connector



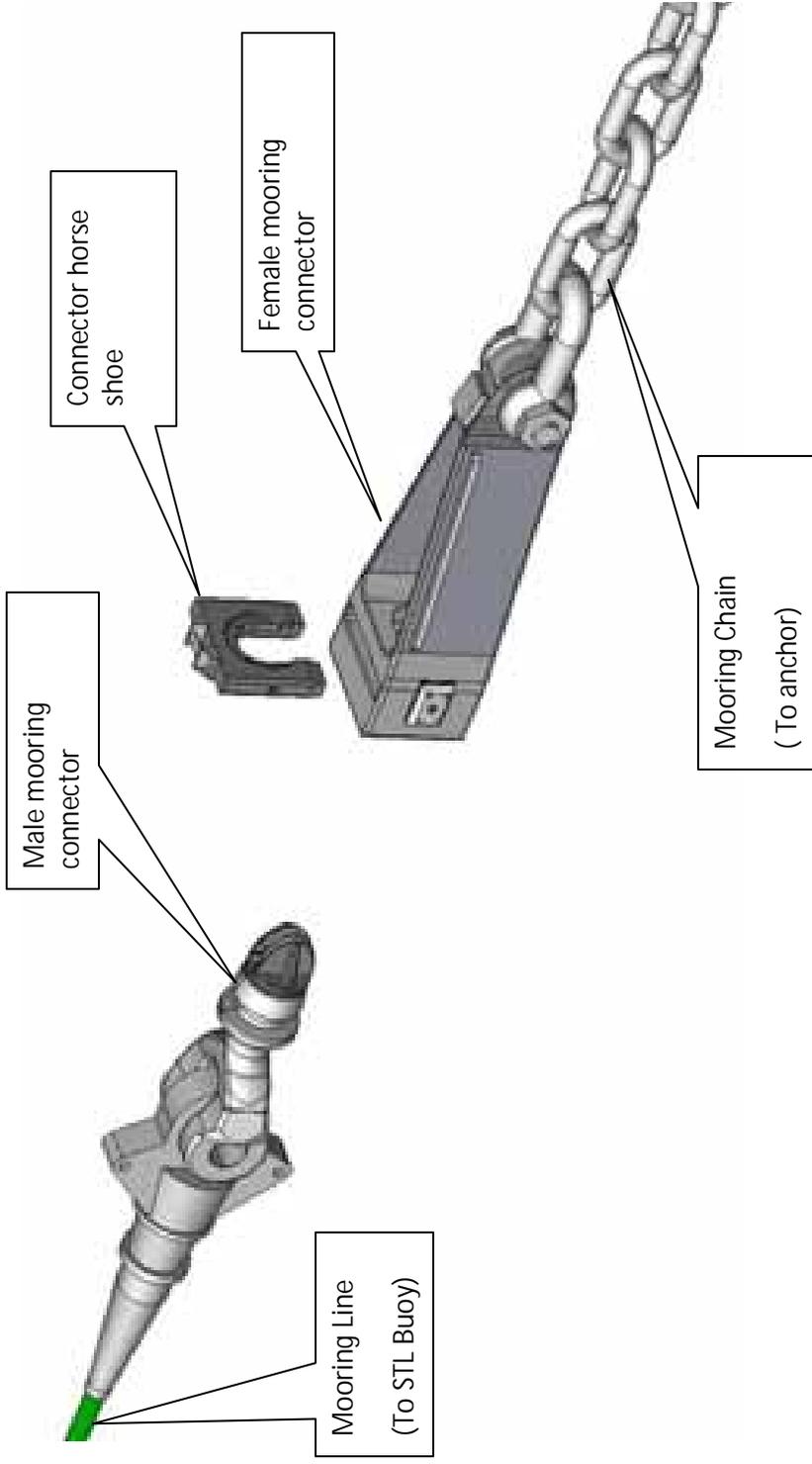
■ General Description

- The Subsea Mooring Connector comprises a male and a female connector that are pulled together and locked with a horse shoe lock.
- Total weight is 3.4 tonnes (dry) and it is 3.4m long.
- The connector forms a permanent part of the mooring line and is designed and qualified for the full MBL of the lines and the total lifetime of the mooring system.
- Offers ROV assisted subsea mating with a limited tension in the mooring line.
- Connection / mating is done using a specially designed winch tool. This tool is operated by ROV.
- The winch tool can also do the reverse operation, meaning disconnect the mooring line if needed.
- Connectors are developed for an MBL up to 15000 kN.
- Connector for MBL from 15000 – 20000kN is being developed (equal design, but different material).
- The connector has been through a qualification program specified by DNV.

Subsea Mooring Connector

■ Technical Description

- The Mooring Connector consists of three main components, male connector, female connector and horse shoe lock.



Subsea Mooring Connector

- **Male Connector**
 - Has a double padeye for connection towards mooring wire closed socket. (Can be changed so it can fit other interfaces)
 - Has a guide cone with circular shape that fits into the female connector. The circular shape ensures that the male/female is independent of their relative orientation.
 - It is equipped with a recess for the horse shoe lock.
 - At the end towards the female, the male has a claw for connection of winch wire.



Subsea Mooring Connector

- **Female Connector**
 - Has a single padeye for connection towards mooring chain joining shackle.
 - Has a guide cone for entering of the male connector.
 - Equipped with mechanical locking for the horse shoe lock.
 - Includes anodes and support points for the subsea winch tool.

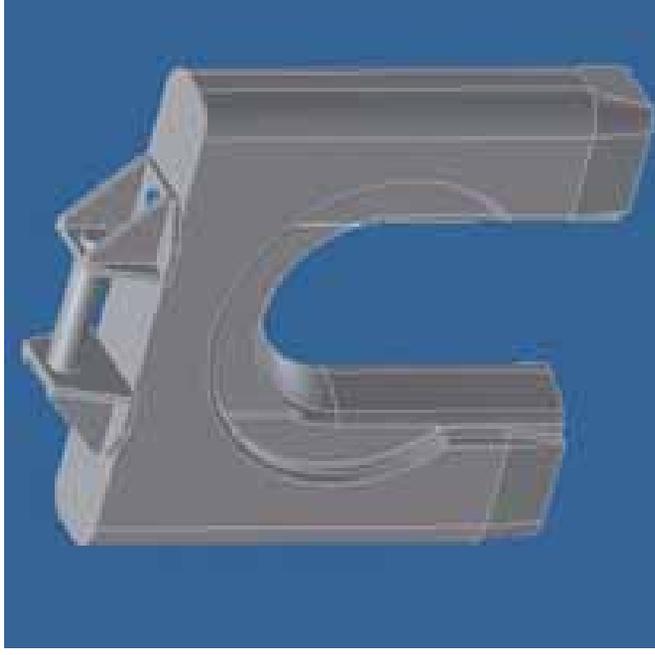


Subsea Mooring Connector



■ Horse Shoe Lock

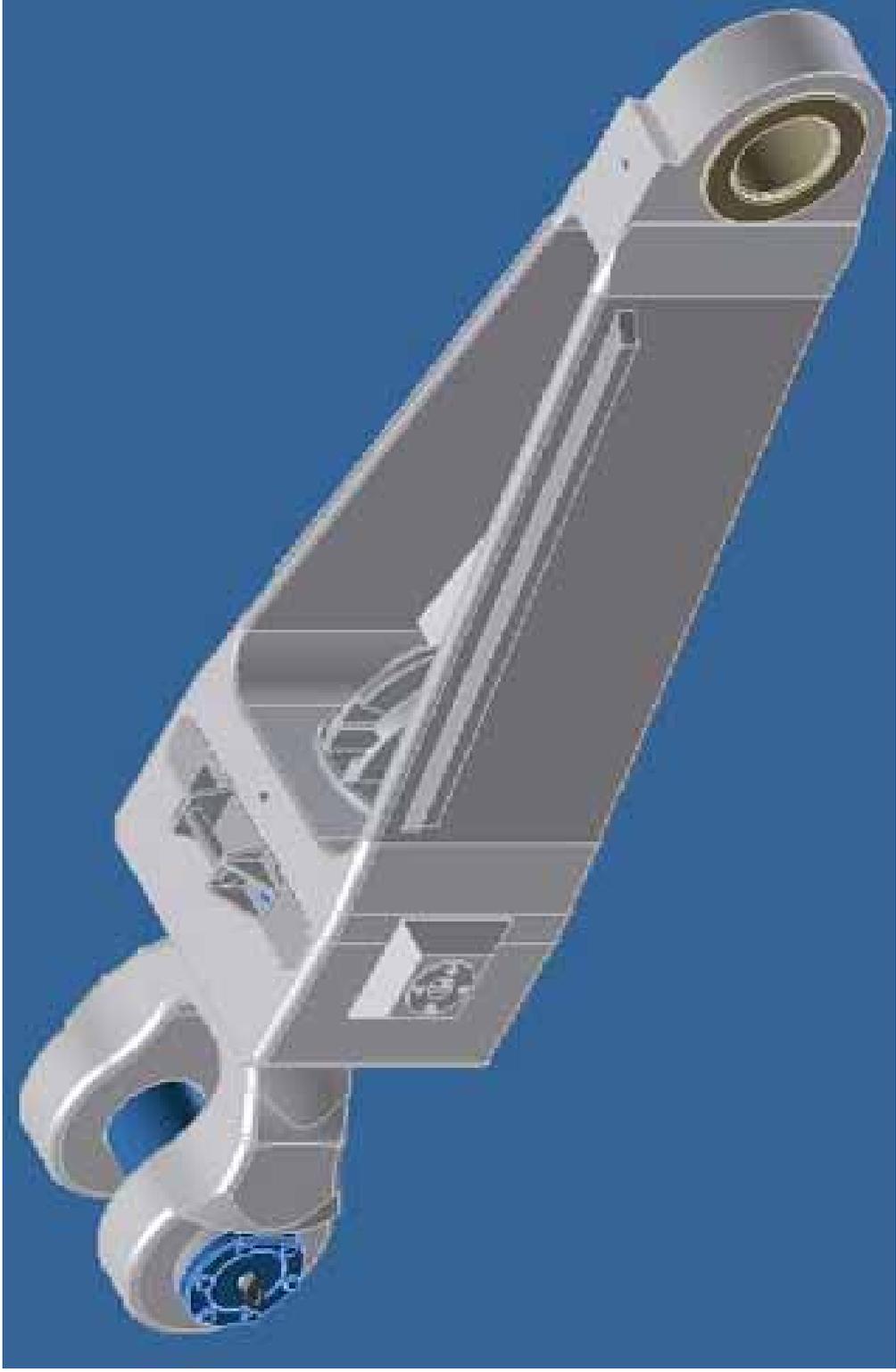
- When installed in the machined track in the female connector, it locks the male inside the female connector. It is self locked as long as there is tension in the line. In addition, it is mechanically locked with two locking bolts.
- Shaped like a horse shoe with machined track for self locking.



APL - Subsea Mooring Connector

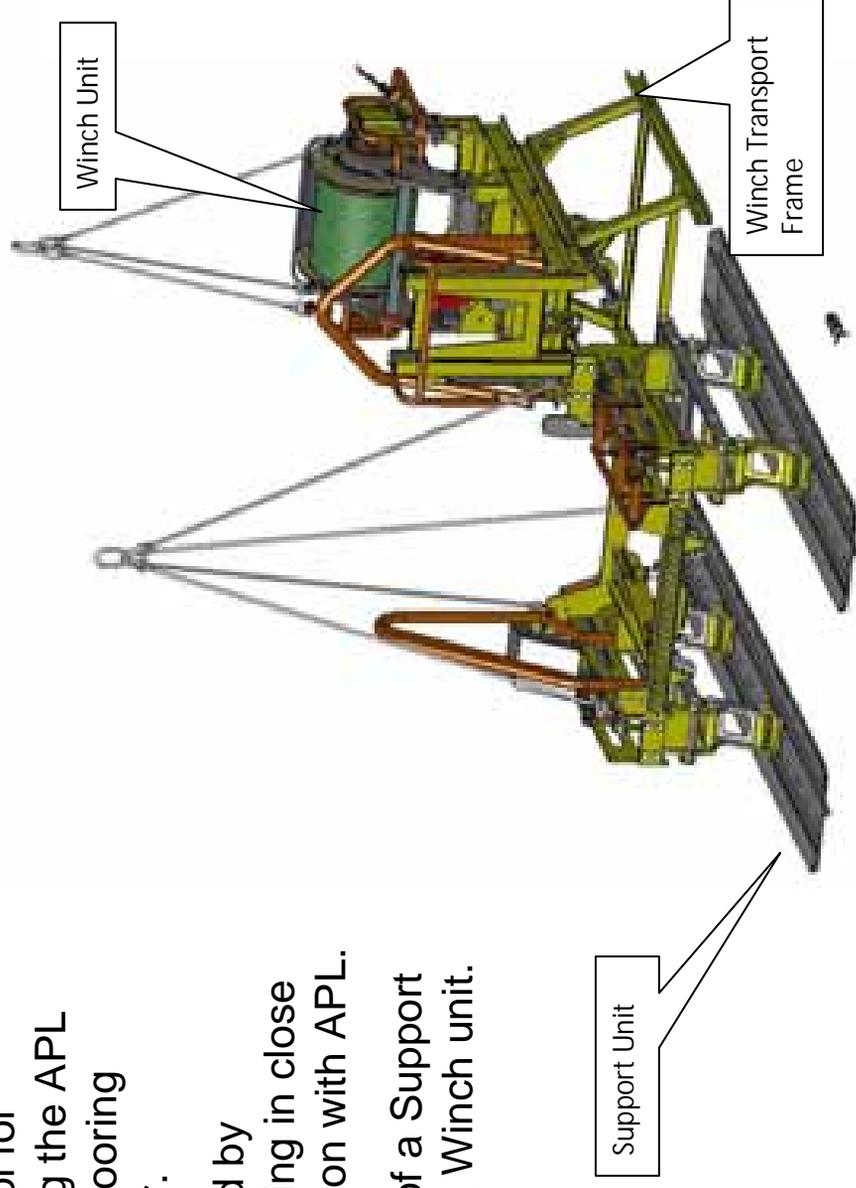


A BW Offshore company



Subsea Mooring Connector

- **Mooring Winch system**
 - A ROV tool for connecting the APL Subsea Mooring Connector.
 - Developed by Oceaneering in close collaboration with APL.
 - Consists of a Support Unit and a Winch unit.



Subsea Mooring Connector

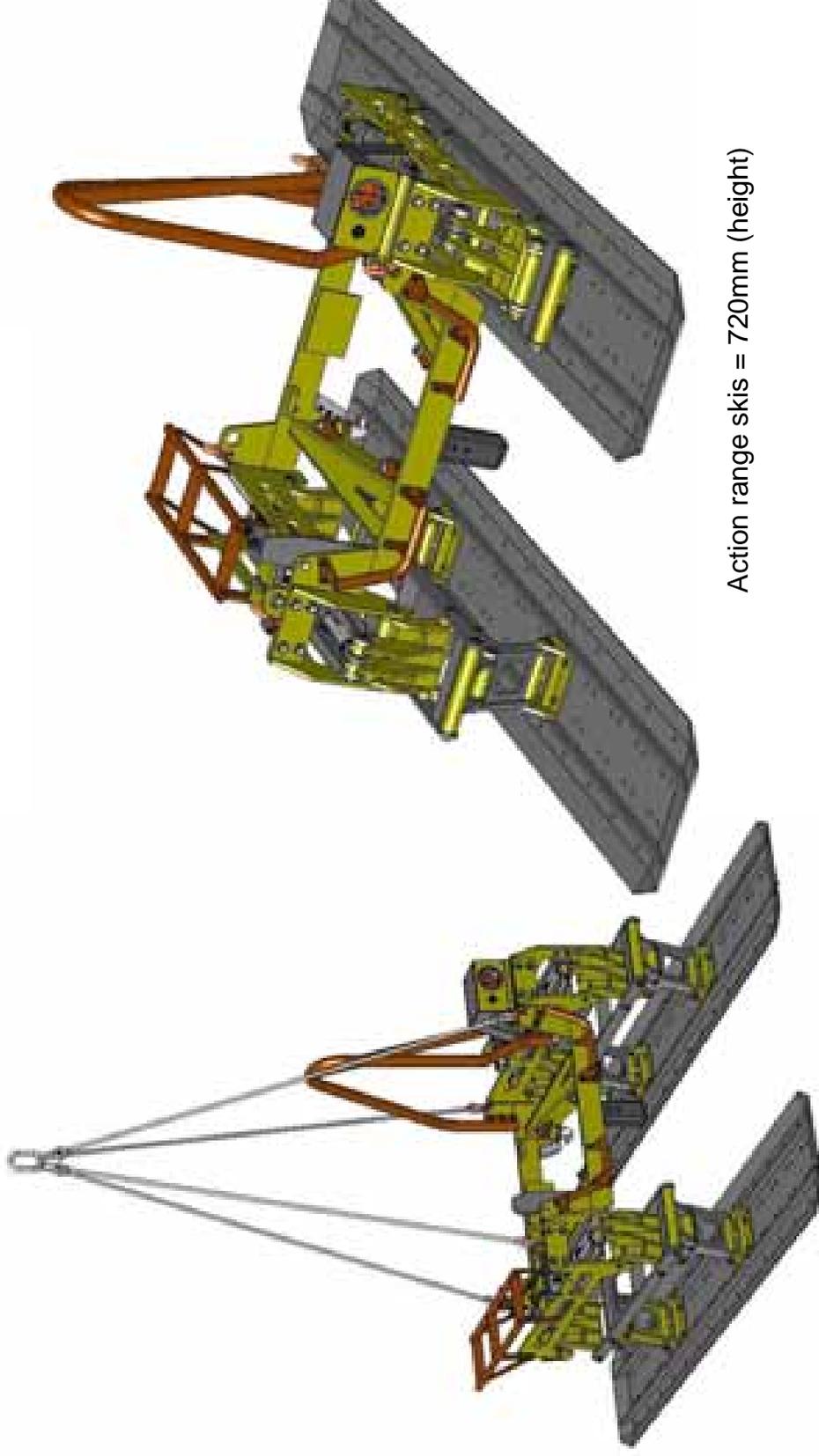


■ Support Unit

- The purpose of the Support Unit is to secure and stabilize the female mooring connector during tie-in. It is also the interface adaptor between the female connector and the Winch Unit.
- The female connector can be tilted or partly buried in mud after launching, and still be picked up by the Support Unit and lifted/tilted to horizontal position ready for mating with male connector.
- The two adjustable stabilizer skis are operated hydraulically by a 35mm QP hot-stab. They are adjusted separately by operating a three way valve for choosing left or right ski.
- For extreme soft soil conditions, where it is likely that the whole connector is totally buried, it is recommended to use mats underneath. Also the size of the skis can be increased.
- The Support Unit has guides for interfacing with connector and for interfacing with Winch Unit.
- Operating pressure: 50 to 210 bar.
- Weight in water is 2130 kg.

Subsea Mooring Connector

- Pictures of Support Unit



Action range skis = 720mm (height)

Subsea Mooring Connector



Subsea Mooring Connector



Subsea Mooring Connector



Subsea Mooring Connector

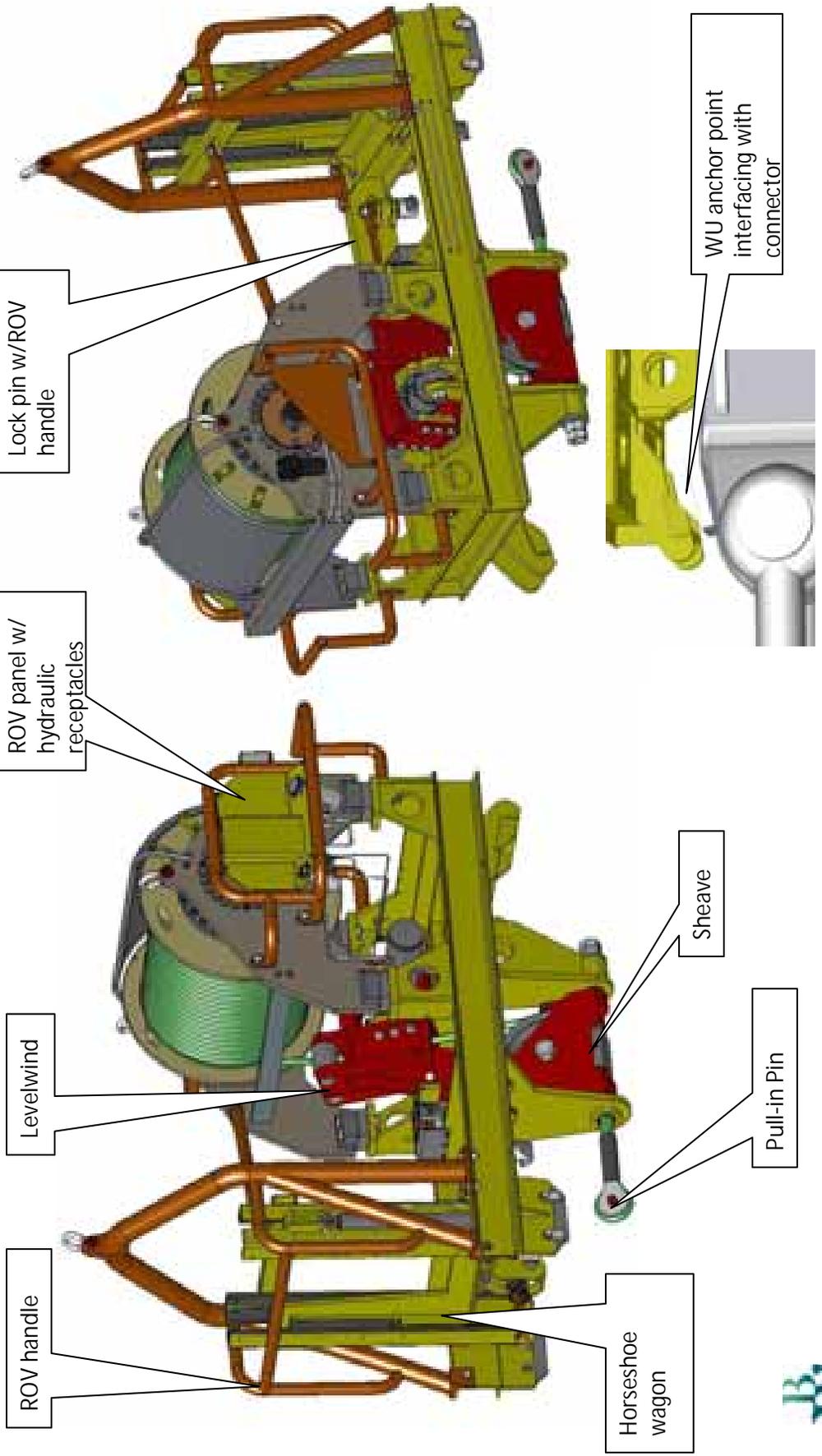


■ Winch Unit

- The purpose of the winch unit is to pull the male connector into the female connector and install the horse shoe in locked position.
- The unit has three hydraulic functions, all operated by ROV. Winch pay in/out, level-wind and horse shoe up/down.
- The winch pay in/out is operated through a 43mm highflow hotstab. The level-wind and horse shoe functions are operated through the same 35mm QP hot stab as used for the Support Unit.
- The winch has a pull capacity of 35 tonnes.
- The winch is fitted with a Dynema fiber rope.
- Weight in water is 2230 kg.
- Size: 2551x1538x2210mm

Subsea Mooring Connector

■ Pictures of Winch Unit



Subsea Mooring Connector



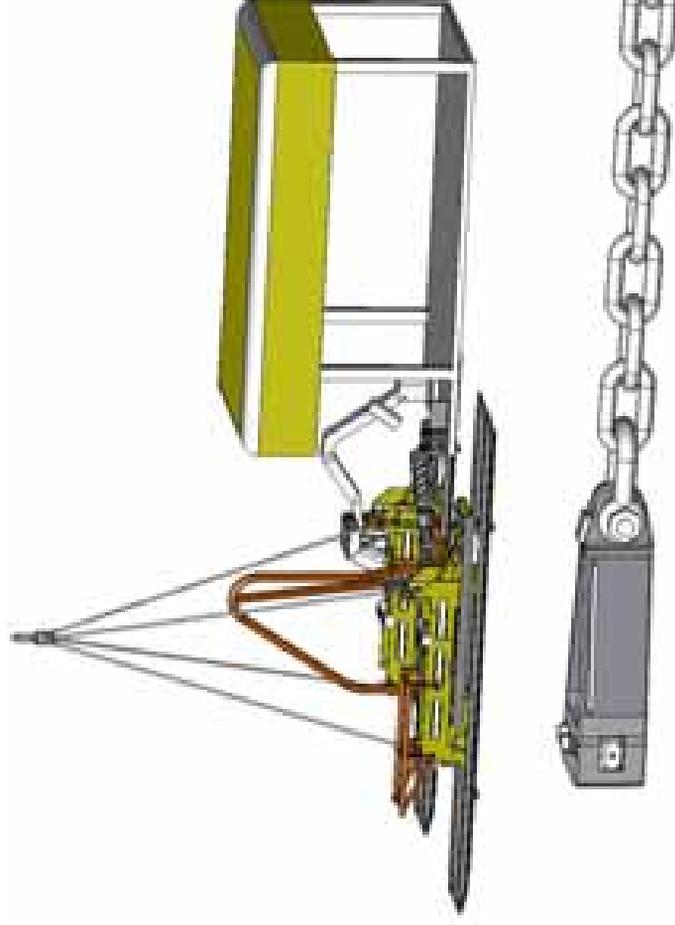
Subsea Mooring Connector



Subsea Mooring Connector

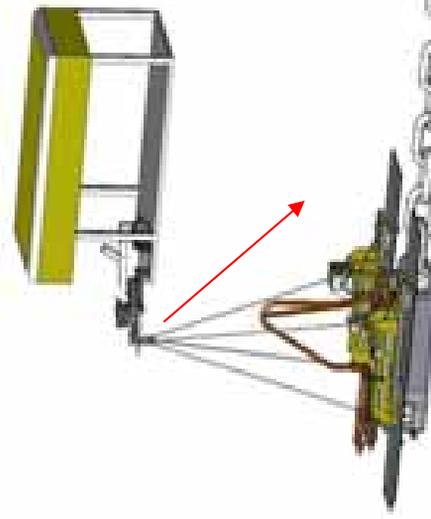
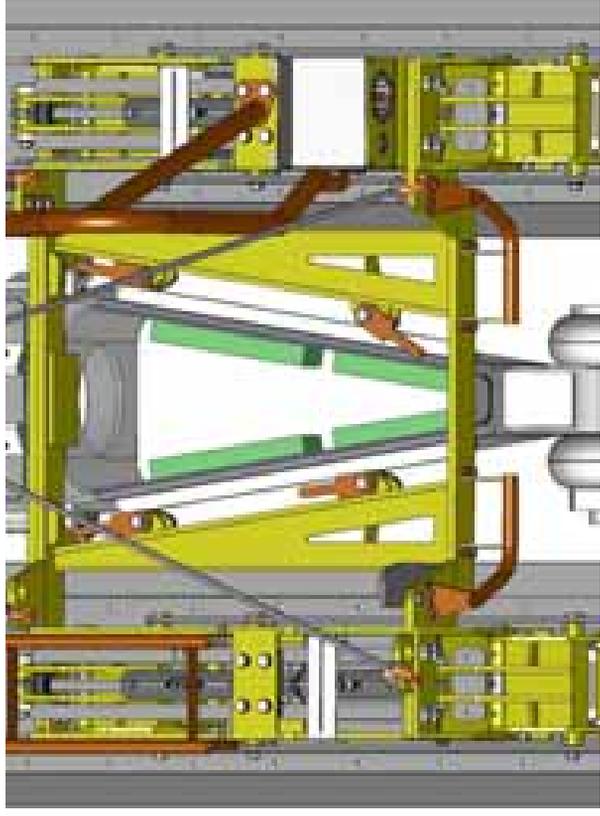
Outline Installation Method (STL/STP systems):

1. Install Anchors with chain and the female connector.
2. Pretension mooring.
3. Deploy Support Unit and guide it down to interface with the female connector.



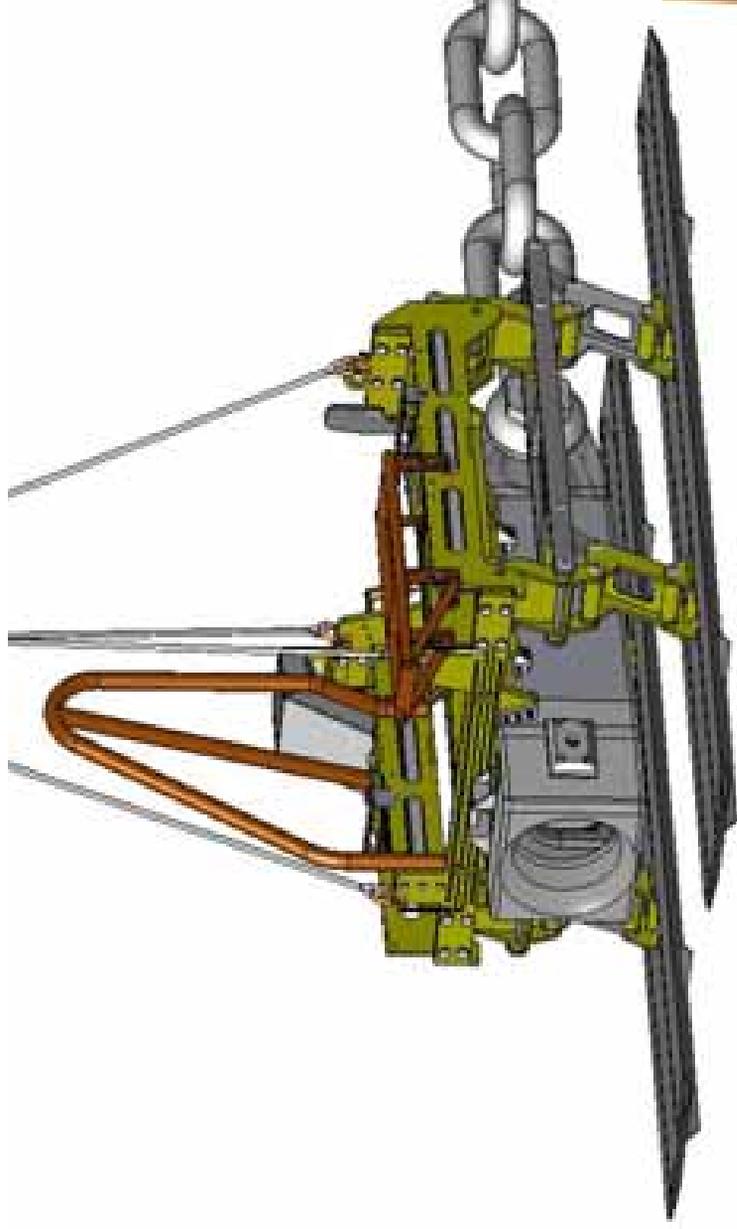
Subsea Mooring Connector

4. When in position on the female Connector, use ROV handles to turn the 4 lock handles into locked position.



5. Disconnect lift rigging and keep rigging outside all interface points to avoid interference with Winch Unit docking.

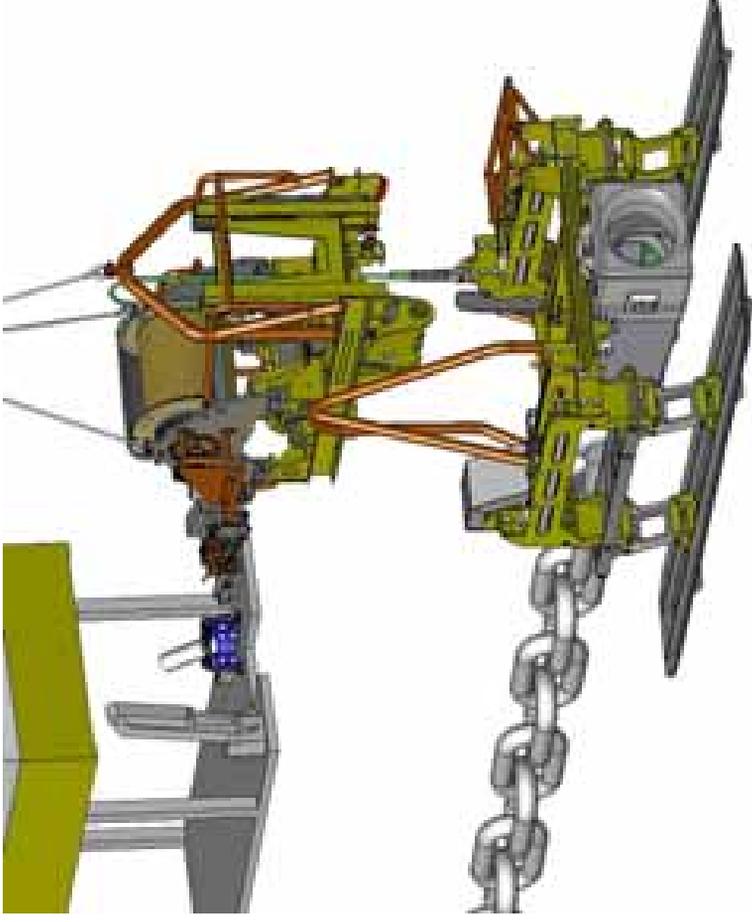
Subsea Mooring Connector



6. The female connector can now be lifted from the soil and tilted so it is ready for connection with male. This is done with the ROV using hotstab and turning the ball valve with the ROV arm.



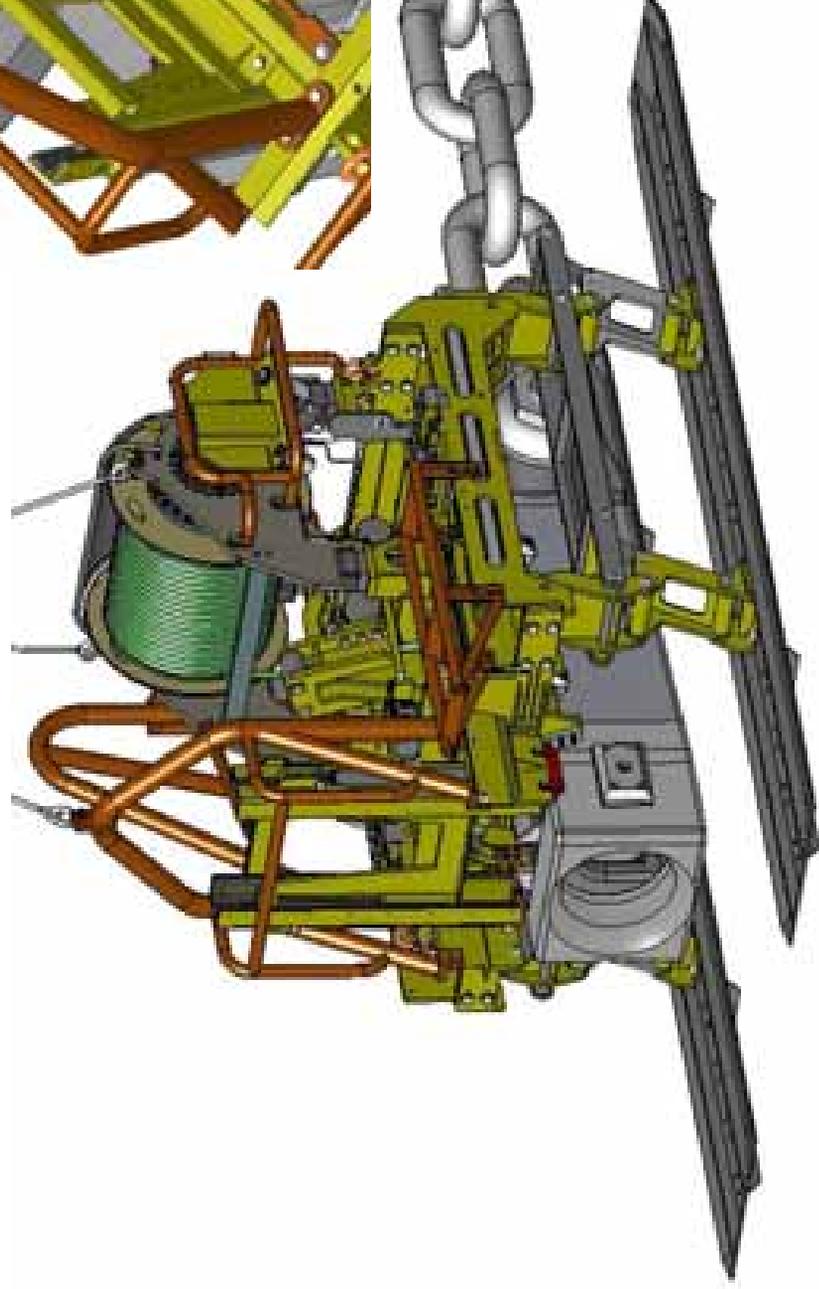
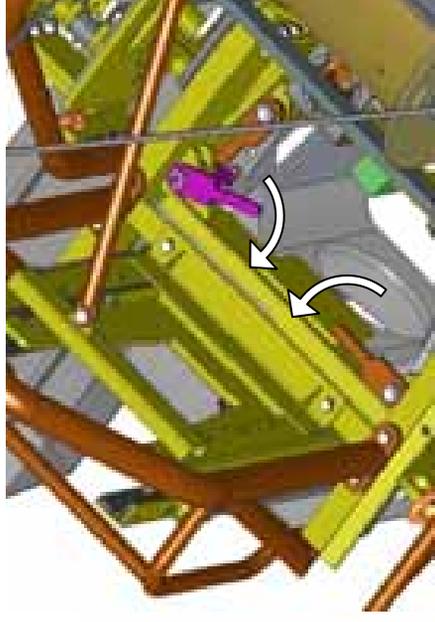
Subsea Mooring Connector



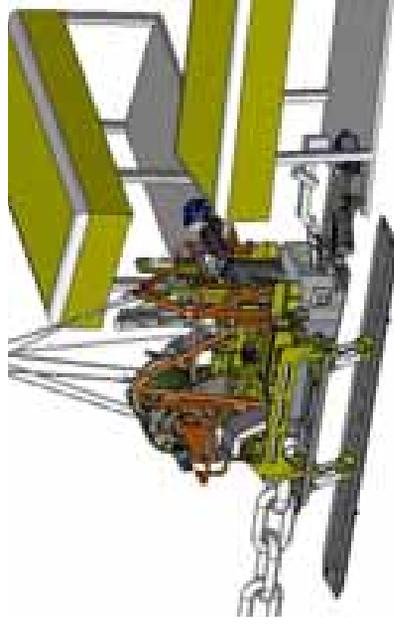
7. Install the Horse Shoe in the Winch Unit. Deploy the Winch Unit and guide it with the ROV until connected with the Support Frame. The units are fitted with several guides that makes the connection easy.

Subsea Mooring Connector

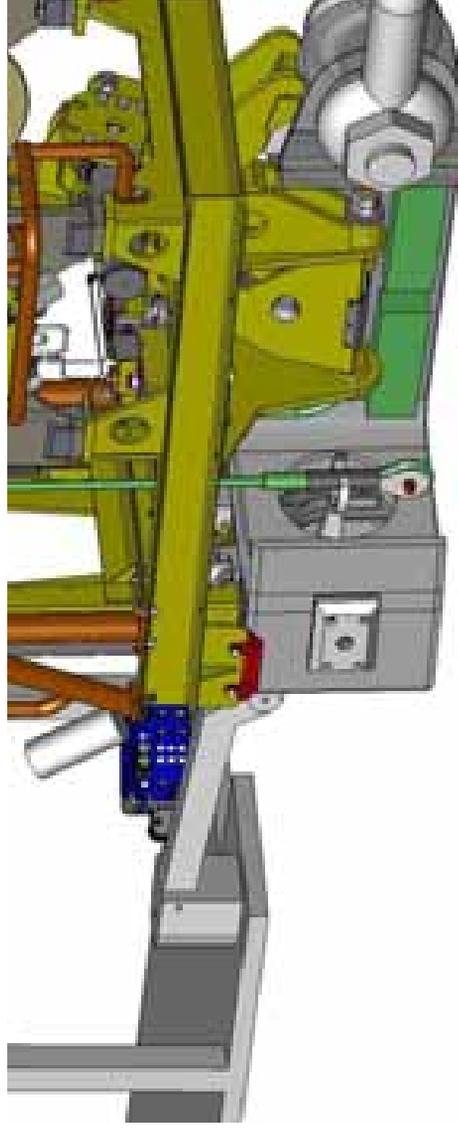
8. When fully docked onto the Support Unit, turn the locking handles to locked position by the ROV arm.



Subsea Mooring Connector



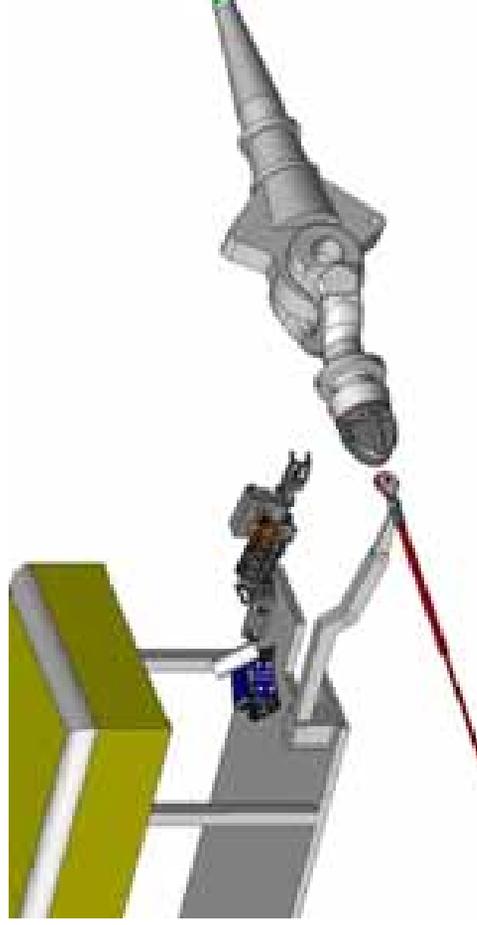
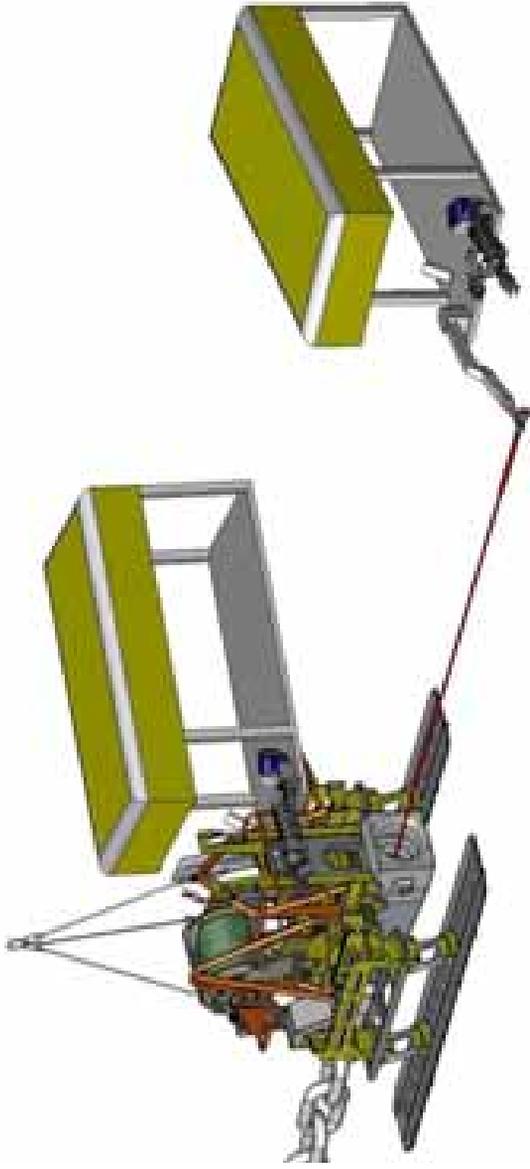
9. One ROV docked to Winch Unit while second ROV grabs fiber rope. Grab over shrink fitted protective sleeve. Operation can be performed with one ROV only, but two is recommended.



Subsea Mooring Connector

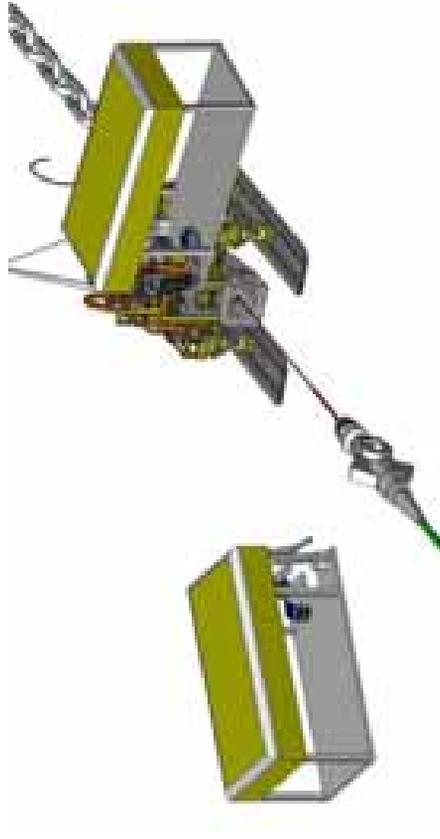


10. One ROV pays out on winch while second ROV guides rope to male connector.

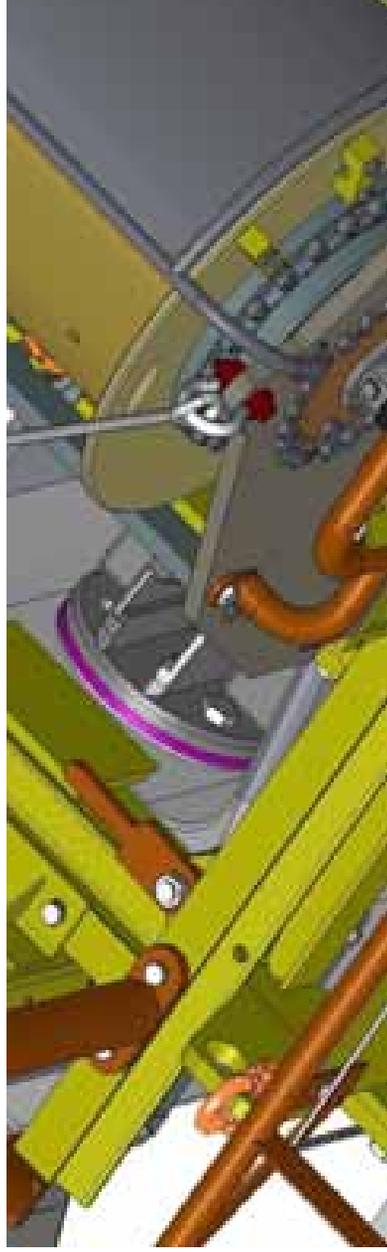


Subsea Mooring Connector

11. One ROV pulling in male connector while second ROV is observing.

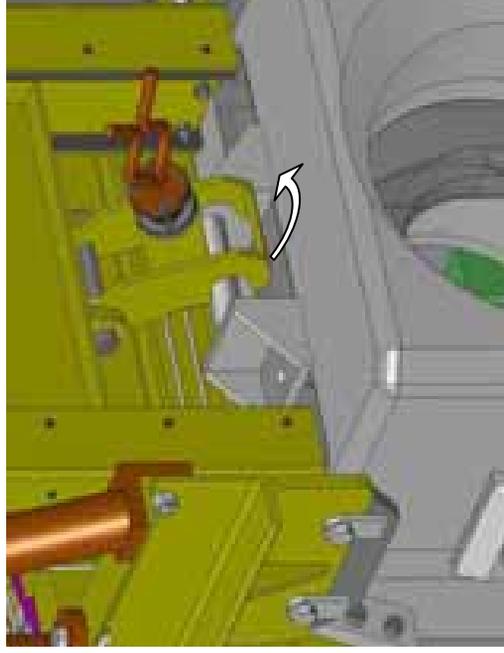
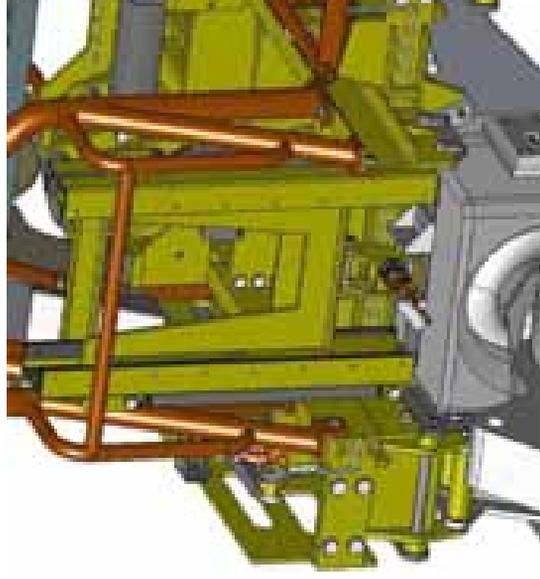


12. Pull in male connector until fully docked. Indication ring on male to be visible.



Subsea Mooring Connector

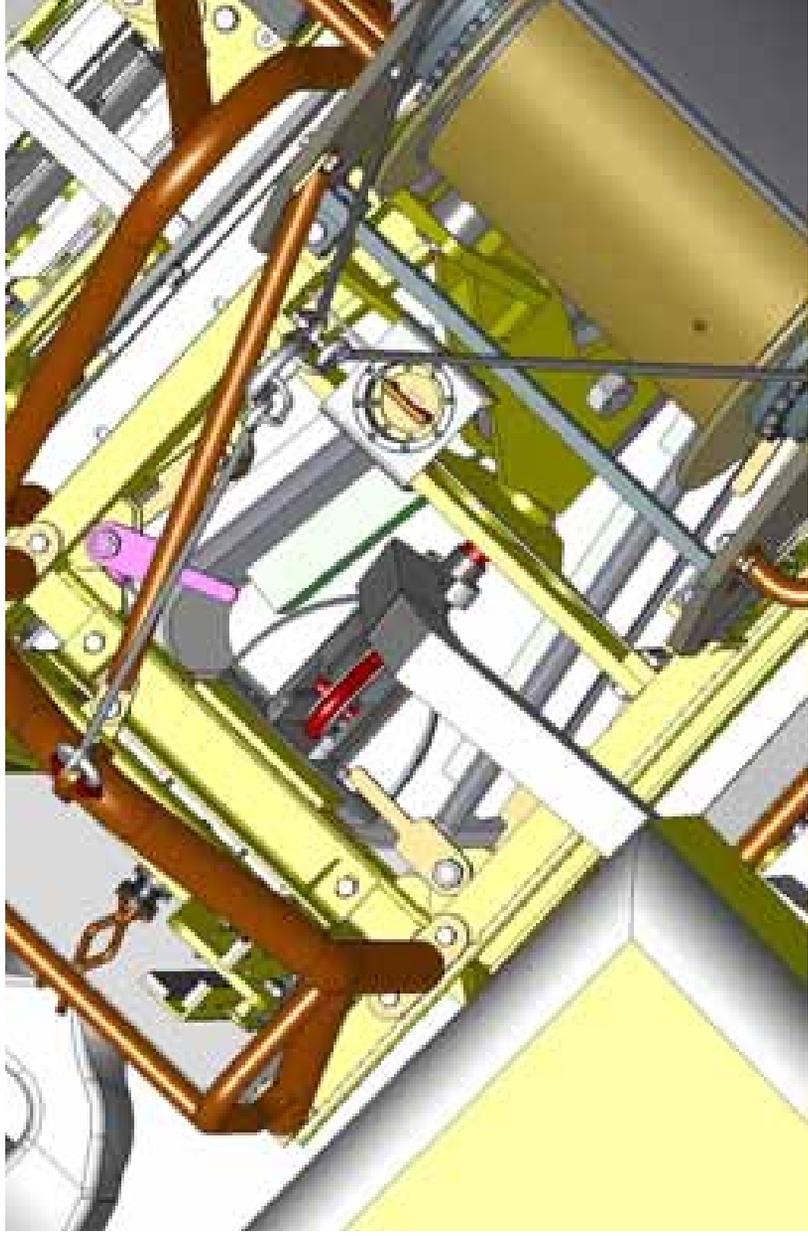
13. Lower the horse shoe into locked position by using ROV hotstab.



14. Use the ROV arm to release the horse shoe hinge arm.

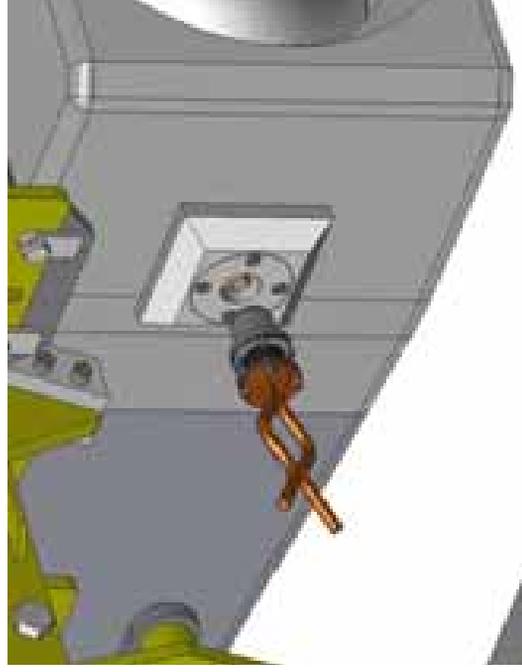
Subsea Mooring Connector

15. Pay out on winch to release tension and release rope from male connector claw.



Subsea Mooring Connector

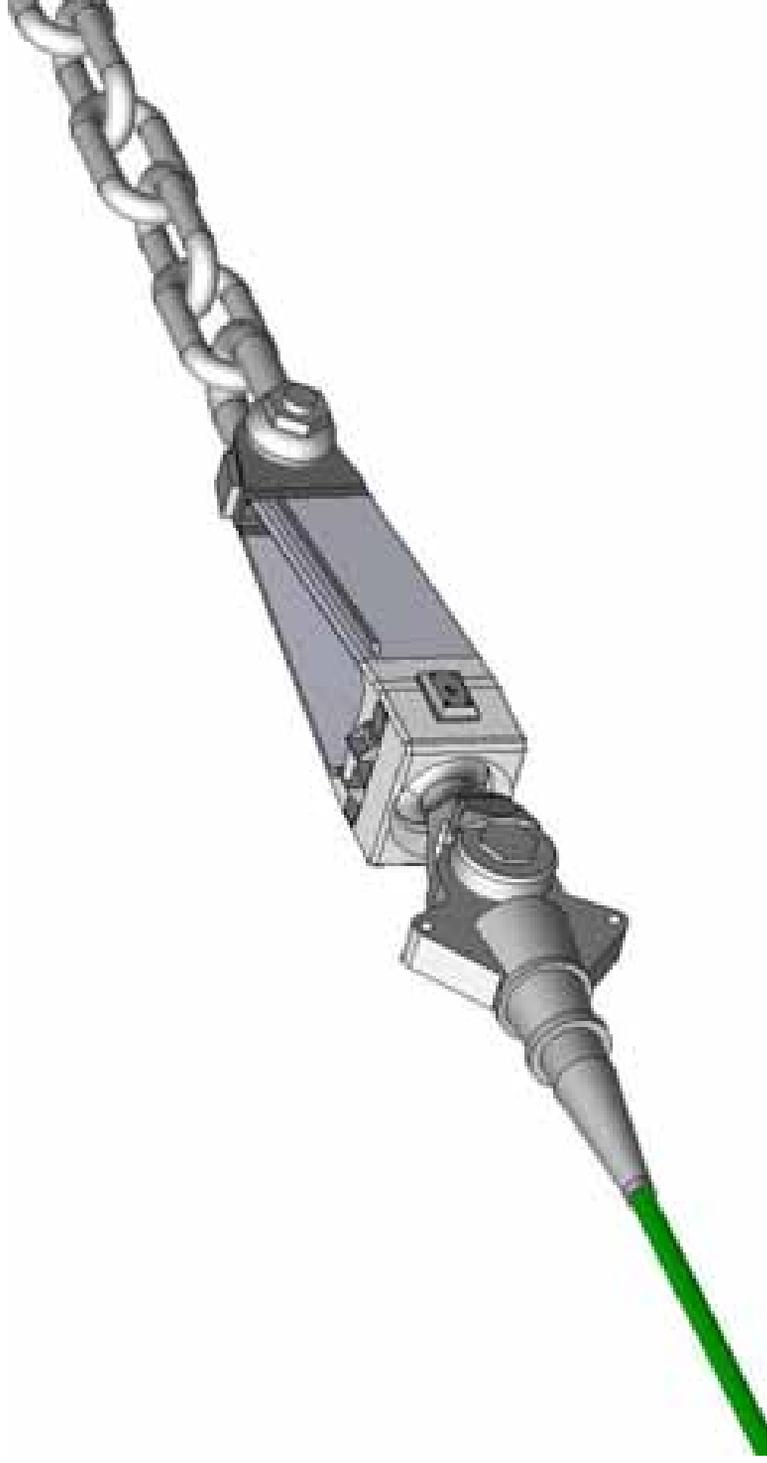
16. Use the ROV arm to mechanically lock the Horse Shoe in place using a lock key. Note that the horse shoe is self locked, and this mechanical lock is only for extra safety.



Subsea Mooring Connector



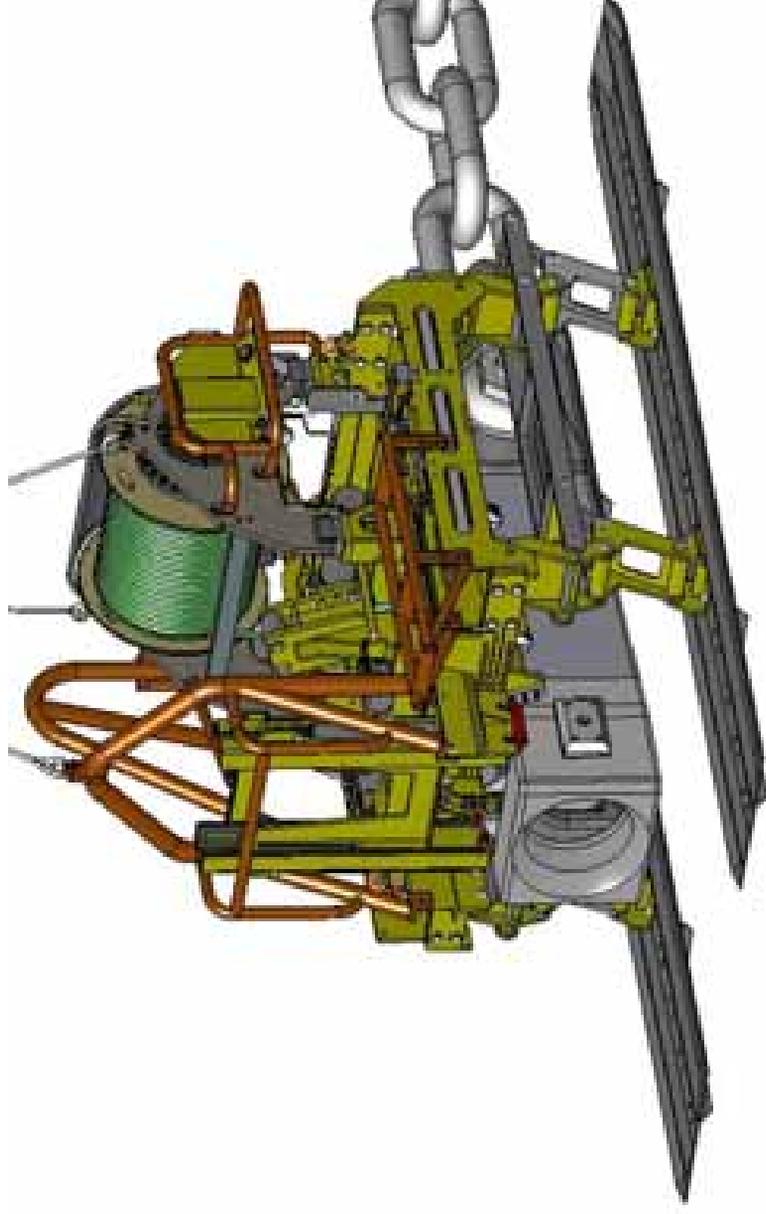
17. The APL Subsea Mooring Connector is now fully connected. The Winch unit and Support unit can now be removed and be ready for another connection. Note that the operation is reversible. Meaning the connector can be disconnected using the same tool and technology.



Subsea Mooring Connector

Alternative installation procedure:

The described installation method is the basic method installing everything separately. It is also possible to install the Support Unit and Winch Unit on the Female connector before lay-down of connector. The installation vessel must then pick up the chain and bring the end to the deck for connecting of connector and tool. This method will save time.



Subsea Mooring Connector



Testing and History:

- A qualification program has been performed in collaboration with DNV. The connector has gone through full scale strength and fatigue testing in addition to small specimen fatigue testing. All testing was performed at DNV lab's in Oslo and Bergen.
- Connection testing using the tool and a full scale connector was done dry at the Oceaneering facility in Jättåvågen. Interface testing between Support unit, winch unit and connector performed at the same time.
- In addition to the above full scale testing, the connector and tools were modeled in the simulation program Mimic. Simulation was then performed of the complete installation procedure to check access for ROV, visibility and so on. This work was done by Oceaneering.
- Two STL buoys was installed this summer (2009) outside Boston on the Neptune field. Water depth was 80m and the soil was very soft. 9 off connectors was installed with great success. Design approval was received from DNV on the connectors.

Subsea Mooring Connector



Advantages of the Subsea Mooring Connector:

- Allow subsea connection with low tension in mooringlines (typically 10-25 tonnes).
- No operations involving personnel working with wires under high tension.
- No diver assistance needed.
- Compared to a conventional deck connection, the Subsea Mooring Connector significantly reduce risk for damage to mooringline during installation.
- Allow connection using standard anchor handler. Dynamic positioning is not required.
- No heavy purpose made installation equipment required on the installation vessel.
- No heavy lift or A-frame required. Typically a SWL 20-30 tonnes crane required for overboarding of female connector.
- Allow installation in seastates up to Hs 3m. Sea state limitation is mainly limited by ROV launch/recovery operations and overboarding of tools.



Subsea Mooring Connector



**Thank you for your attention,
any questions?**

