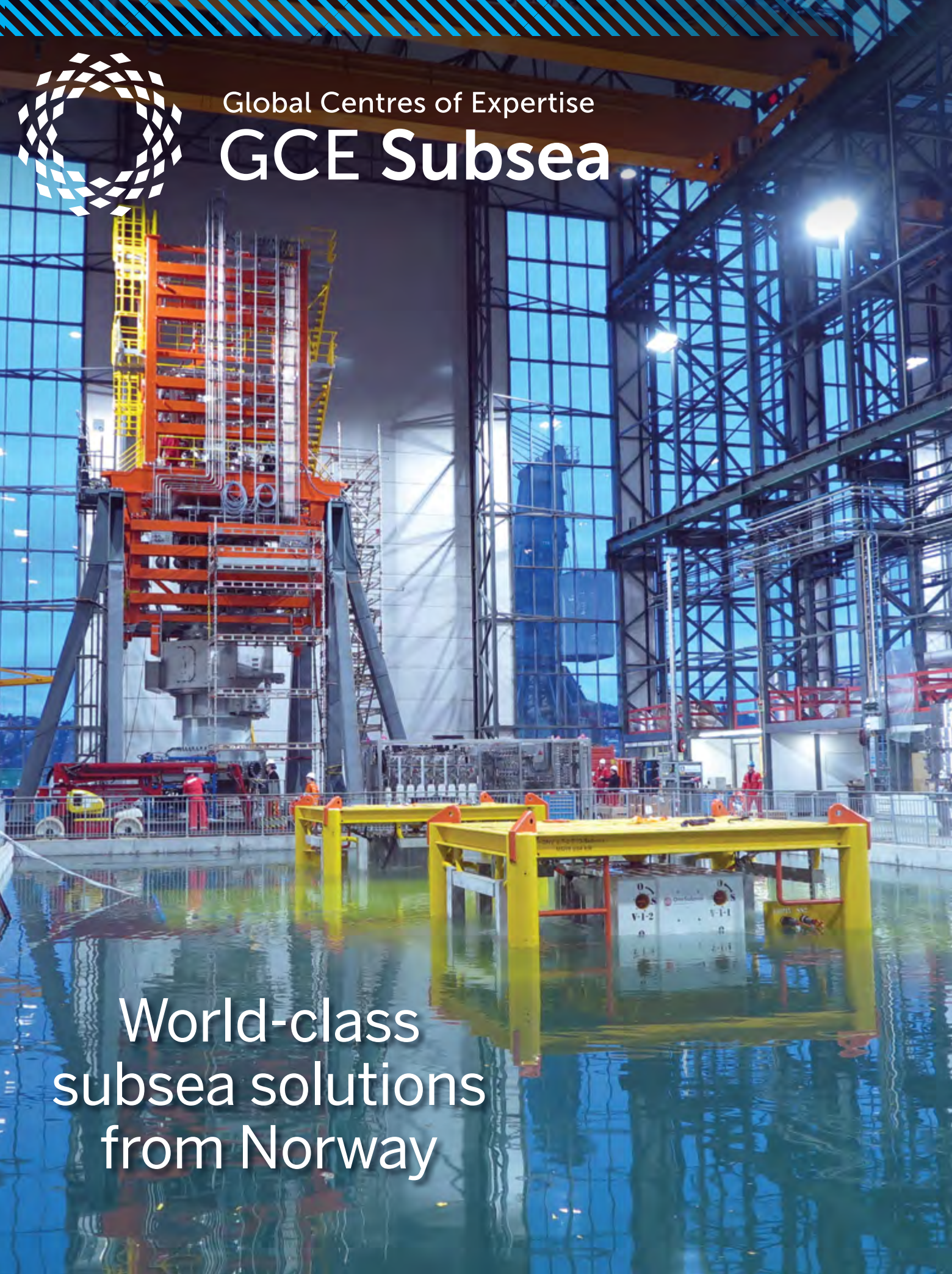
Global Centres of Expertise

GCE Subsea



World-class subsea solutions from Norway

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Onward and upward

Jon Arve Sværen, chairman of GCE Subsea and VP Business Strategy Processing in OneSubsea, a Schlumberger company.

Last year, the oil industry began its recovery from the greatest downturn on record. With several large subsea projects being sanctioned and contracted during 2017, this was especially true for the subsea industry. Now, after a hard, but necessary cost optimization, a strengthened industry can yet again face a market that shows positive signals.

Entering its 11th year as a cluster organization, GCE Subsea continues to focus on building competence and fostering innovation, both within the industrial subsea players and, more importantly, in the SMEs and start-ups that represent the majority of our more than 130 member companies.

Downturns always stimulate alternative thinking, and our industry is no exception. While the oil industry will continue to be the backbone of subsea technology development, the technology has started penetrating other industries, such as next-generation seafood farming, offshore renewable energy, subsea mining and so on. Significant advances are being made here. GCE Subsea will continue to stimulate this crossover with regards to competency, project support and marketing.

Digitalization will continue to be a prime focus in 2018, as will building up subsea technology with regards to competence, crossover and enabling technology. Together, with our joint project with the Massachusetts Institute of Technology – Scale-Up for SMEs (small- to medium enterprises) – and pre-funding the technology and commercialization projects of our members, these represent the foundation for further growth in all areas.

Whether it is business development support, access to funding or assistance in marketing their skills and technologies to a broader audience, each company featured here has been aided by GCE Subsea in some way. The current GCE Subsea supplement covers the wide range of activities within our member companies, from monitoring mercury content in seawater during remediation works on a World War II submarine, to developing the next generation subsea processing technologies. Of course, the technologies take center stage – they will unlock the oil and gas fields of the future, after all – but it's the people themselves who drive the creation of these technologies by working together, across borders and disciplines, through universities, companies and expertise outside the oil industry. ■

Smart and ambitious

Electrifying not just the subsea BOP, but combining it with managed pressure drilling technology for riserless deepwater drilling is an ambitious task. Elaine Maslin reports on ESD's progress.

Test of RCD sealing assemblies at Mongstad, Norway 2017.
Photo from ESD.

Electrical Subsea & Drilling (ESD) is a small Norwegian firm, but it has big ambitions, which could help change the economics of deepwater developments.

ESD's initial aim is an all-electric BOP, while also developing a rotating control device (RCD) for managed pressure drilling (MPD). The ultimate goal is to combine the two, creating a riserless drilling solution.

The company is moving along, first developing electric actuators. But, a deal with the global supplier of drilling equipment, MHWirth in autumn 2017 gave the firm another nudge towards commercialization. First, through MHWirth, the firm will have access to a wider pool of facilities, as well as manufacturing and aftermarket services expertise. This will help ESD become an original equipment manufacturer. Second, the firm will also have access to new barrier technology from MHWirth, which ESD will electrify to accelerate its development of an all-electric BOP, probably starting with a surface BOP before moving subsea, says Magne Rød, chairman and cofounder.

Having an electric BOP brings increased reliability and reduced downtime, says Rød. Elimination of downtime and faster turnaround between operations reduces operational cost, especially for deepwater drilling. "If you can reduce the cost of drilling, it will make deepwater fields more economic. Over 60% of field development costs in deepwater can be related to drilling."

"Today's BOP is congested with equipment and heavy (>400-tonne)," he says, adding that conceptually BOPs are the same as they were in the 1970s. "When electric, we will be able to create a simpler system, reduce the weight (to 150-200-tonne) by removing hydraulics and by using well barrier technology from MHWirth to reduce the stack size, too." This also means less equipment topside, to support the hydraulics, and none of the testing requirements needed on existing hydraulic systems. Wellhead fatigue will be reduced with a lighter BOP stack and reduced height and weight will also provide benefits for the rig and equipment handling.

Electric batteries will offer better energy density than hydraulic accumulators and will be more space and weight efficient. Furthermore, the electric BOP can offer more information about system status, for condition based monitoring, he says. During subsea well completion with horizontal Xmas trees, it would also be possible to operate the Xmas tree controls, with the BOP controls and a subsea hydraulic power unit, which means that a second workover control umbilical and umbilical disconnect facility isn't needed. Rød says that an all-electric BOP with the new barrier technology would also be able to meet new US Bureau of Safety and Environmental Enforcement requirements post-Macondo, which existing systems struggle to meet, and will also have mechanical actuator overrides for ROV.

ESD has been taking a step-wise approach, first focusing on actuators. If all goes well, they could have an electric BOP ready by 2021, says Rød.

The firm is also working on a RCD for MPD, using ceramic rotating bearings/seals and an aramid reinforced sealing sleeve. The ongoing RCD development, with support from DEMO 2000 as well as private funding, is qualification of the sealing system.

The concept will be more wear resistant than today's RCD technology, says Rød. It will also allow operational flexibility, because the seal can be opened when required to bring the well in overbalance. "We will hopefully have a fully developed RCD to test at Ullrig in Stavanger in early 2019, then a prototype would be ready for offshore trials," says Rød.

Ultimately, the aim is to combine the RCD with an electric BOP and a mud return riser system, to enable drilling without the drilling riser. Instead of the RCD being in the riser, it would be part of a module on top of the BOP, in place of the lower marine riser package, with a slim return riser, for mud returns. ▪

The OneSubsea subsea multiphase boosting system is tested under water in one of the pools at Horsøy testing facility. Photos from Schlumberger.

Boosting tiebacks

Arill Småland Hagland, of OneSubsea – a Schlumberger company, looks at increasing record-breaking tiebacks with multiphase pumps.

The Dalmatian field, a remote brownfield development in Vioska Knoll 786A, in the US Gulf of Mexico, is an example of several first-time developments in subsea technology and contracting strategies.

Dalmatian is the longest deepwater multiphase boosting step-out distance across a record-breaking 35km tieback. The project was the first boosting project based on an engineering, procurement, construction, installation, and commissioning contract,

The contract scope called for the supply and installation of a subsea multiphase boosting system at 1775m water depth, including topside and subsea power and control systems, as well as a 35km-long combined power and control umbilical.

Boosting strategy

Subsea boosting can improve field economics by reducing backpressure on the reservoir, increasing production rates. By allowing the pump to reduce the backpressure, an increase in well flow rates and total recoverable reserves results. The tieback option decreases overall field development costs and using a subsea pump improves recovery rates.

The subsea multiphase pump system planned for Dalmatian was a complete, standalone system, and included subsea pump station, umbilical and topside power, and controls. The subsea pump system was installed at an existing oil pipeline end termination, immediately downstream of the designated well. All production at the field was routed through the pump or bypass header. The pump system for this field was designed using only known or prequalified components and equipment, and it will be controlled from the host platform by an electrohydraulic multiplex control system through a combined power and control umbilical.

The Dalmatian field pump system conforms to technology used on high-boost multiphase pumps developed through an extensive joint industry program. The standard design for this type pump had unexploited built-in margins that allowed the voltage rating to be increased to 10.5kV. Because the rating was increased, the step-out distance was significantly extended, with limited downside and without requiring additional component qualification.

The subsea multiphase pumping technology from OneSubsea, a Schlumberger company, has been developed and continuously improved since the 1980s, with a portfolio of more than 100 pump units in 30 projects and more than three million accumulated hours in operation.

To replicate the actual field conditions, a large flow test facility was built at Horsøy, near Bergen, Norway. The facility allows for full-scale testing of pumps systems while submerged in seawater so that installation sequences and ROV operations can be verified. An electrical cable simulator for long step-outs is available in addition to a multiphase flow loop.

Sustainable development

A key aspect of making a marginal field development economically viable is to limit the time from project sanction to first oil. The goal of the Dalmatian boosting project was to engineer and deliver, install, and begin operating a complete subsea pump system in under 24 months. The high-boost pump is identical to a previously built and tested pump, lending high confidence in the performance and reliability of the pump. Combined with a known design and completed engineering documentation, this made it possible to optimize manufacturing time for a long-lead component while reducing the overall schedule.

Development and field experience of the high-boost pump significantly extends the range of existing and future wells that can be cost effectively tied back to existing facilities. For example, this technique and technology will soon return to the North Sea. OneSubsea and its Subsea Integration Alliance partner, Subsea 7, will supply and install a multiphase boosting system including topside and subsea controls, as well as associated life-of-field services. Operated by TAQA, the project will result in a 34km subsea tieback to the North Cormorant platform along with a 23km step-out from the Eider platform with fluids boosting to the North Cormorant platform. ■

Arill Småland Hagland *is a technical sales manager within processing for OneSubsea, a Schlumberger company. Hagland holds a Master of Science in offshore technology from the University of Strathclyde, Glasgow.*

Seabed Separation

Seabed Separation hopes to move its subsea dual pipe separator a step closer towards commercialization this year, following successful full-scale, high-pressure trials in 2017 and finding a commercial partner, reports Elaine Maslin.

Seabed Separation's dual pipe separator (DPS) works differently to conventional retention time separators, by separating fluids under flowing conditions, and virtually without the pressure losses seen in a conventional separator. This is achieved using a set of fixed size, small separator pipes, the number of which can be changed to adjust capacity, making it highly flexible. The Trondheim-based engineering firm has received support from Lundin, Wintershall and Aker BP, for the concept, and public funding for commercialization. Seabed Separation has also worked with Subsea 7 on field development project proposals.

CEO Asle Jostein Hovda says that Seabed Separation is now working on a number of business case studies for operators in Norway and internationally, and that the next step is most likely an onshore pilot in the Middle East or at a US research facility.

Subsea DPS deployment is the firm's main goal and where the technology offers most value. Separation under flowing conditions is more efficient and easier before additional forces have been applied to the well fluids, Jon Sigurd Berntsen, the firm's chief technology officer Berntsen says. Removing water as early as possible subsea is a subsea factory enabler, but could also reduce subsea infrastructure requirements, as well as reduce chemical use for flow assurance and enable topside debottlenecking. By lowering back pressure, it could also increase recovery and accelerate production.

According to Rystad Energy, "The removal of produced water at the seabed has similar effect to a subsea booster pump with increasing effect as a function of increased water depth and water cut. The DPS could in some cases effectively boost production by 25-30%, and increase asset valuation by as much as 100% in the most extreme cases."

However, due to the compact, low weight design, a land-based DPS version could easily be skid-based and truck transportable, and favorable for applications where well site water removal is required without significant pressure loss. This would give the DPS System more operational exposure.

Weighing less than a third and with a smaller footprint than a typical topside gravitational separator makes the system a good topside solution, Hovda says, because it could be installed with a conventional topside crane. A conventional 60,000 b/d throughput topside separator in operation weighs 120-tonne, while a DPS system would weigh <40-tonne.

The DPS could also be used in brownfield environments topside, to reduce water cut and increase oil production or for debottlenecking.

The system comprises two slanted, concentric pipes, the inner and outer pipe, and is mainly a separator for water producing oil wells where the free gas is first stripped from the well stream using a gas harp. Then, the fluids go through an inlet arrangement to slow down the fluid velocity and to remove solids by gravity. The fluids then enter into the heart of the DPS system, the slotted, inclined inner closed end pipe. The internal pipe has outlets (perforations) through which the water can drop out and down to an outlet at the bottom of the outer pipe, and the oil rises up and out through an outlet at the top of the outer pipe. Full-scale pilot testing at Statoil's Porsgrunn test facility, near Oslo, last year, proved that the DPS could serve as a standalone separation unit with oil in water results below government requirements, or, together with a water polishing unit at increased capacities, with sub 30ppm results. The test results are being verified by DNV GL.

To help make its case, Seabed Separation is also developing a business development screening tool for operators, to help them assess how the technology would impact the overall cost of a project, compared with other options. ▪

A full-scale and fully tested DPS system. Photo from Seabed Separation.

Not so mercurial monitoring

In 2016, the Norwegian Institute for Water Research (NIVA) carried out "the largest underwater environmental monitoring project" in Norway. The tools used could prove useful in the oil and gas industry.

German submarine *U-864* was torpedoed by British submarine *HMS Venturer*, off the island of Fedje on the Norwegian west coast on 9 February 1945, while enroute from Germany to Japan. In 2003, the *U-864* wreck was rediscovered by the Norwegian Navy, broken into two large sections, plus a lot of smaller debris, at 160m water depth.

Documents indicate that its cargo included 65-70-tonne of mercury, stored in steel flasks, still thought to be inside the wreck, while the sediment surrounding the wreck is also heavily contaminated.

In 2015, it was decided to stabilize the *U-864* by placing a counter fill in front of the bow section, which was resting on a slope with unstable sediments. NIVA was picked by Dutch contractor Van Oord to create a monitoring program to minimize spreading any mercury during operations (May-June 2016), as well as to estimate the total amount of mercury removed from the working area.

Frequent data transmissions

The counter fill covered 200m x 60m immediately north of the wreck's bow. Five landers – which can carry various sensors – measured turbidity at 1.5m and 10m above in a ring around the surrounding seafloor. Data were transmitted every 5min to relevant email accounts, visualized on the Geoview website, and used to generate automatic alarms (when turbidity was >10 nephelometric turbidity units/NTU above the reference value). Data was also collected locally on an SD card and stored in a database.

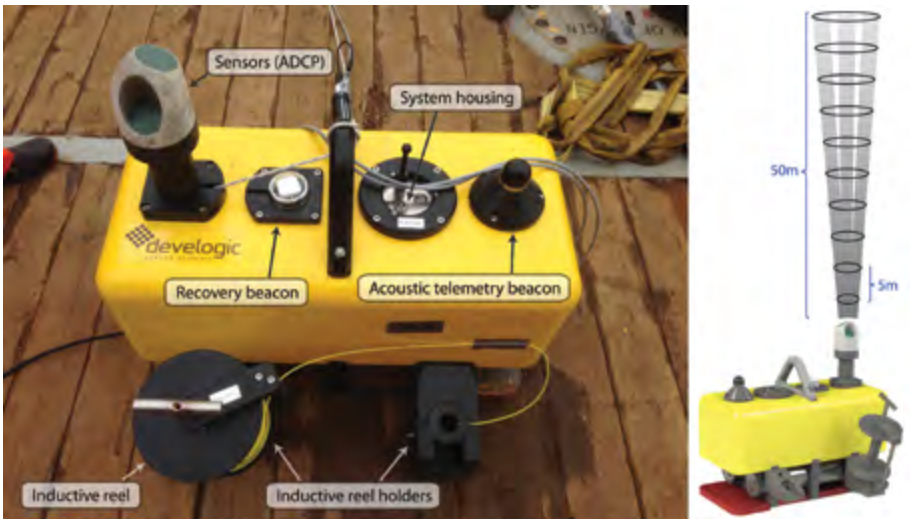
Should an alarm sound, the environmental monitoring vessel *Siddis Mariner* would initiate water sampling, with mercury content analyzed onboard within 30min to a detection limit of 0.5 ng/L. Levels above a 50 ng/L threshold would trigger a stop to work and initiate mitigation actions.

All five landers were linked and connected through an inductive cable, allowing data transmission to a surface buoy with an Iridium satellite connection. Hydro acoustic modems were also installed on the landers, as a backup. Daily routine sampling included salinity, temperature, and turbidity (CTD) and laser in-situ scattering and transmissometery, which measures particle size distribution. Analyses of mercury and grain size was performed on particles collected in sediment traps and vibrocore samples.

"Mercury concentrations in the water samples never exceeded 1.3ng/L, much less than the predetermined limit of 50 ng/l," says Anders Gjørwad Hagen, NIVA research manager and project leader. This meant operations were never stopped due to risk of mercury spreading. There was an estimated total flux of 34g of mercury over the operation, two orders of magnitude less than 3kg acceptance criterion. Furthermore, the data collected are aiding a more complete understanding of the mechanisms controlling the spread of mercury during such operations, Gjørwad Hagen says.

Use in upstream

"This type of equipment has previously been used in oil and gas operations and may be applied to a range of interventions where short-term subsea environmental monitoring may be required," says Chris Harman, senior research director at NIVA. This includes decommissioning, plugging and abandonment, CO_2 storage, drill cuttings relocations, other work in historically contaminated sediments, pipe installations/removals, etc. The work and the equipment developed and deployed for this project, including the landers, produced by Develogic, could help the oil and gas industry in many operations requiring temporary real-time environmental monitoring below water. ■



Lander with current meter. Photo by Odd Arne Segtnan Skogan, NIVA. R. Measuring cells (not to scale). Image from NIVA and Develogic.

OceanTeam's SCCO2 unit. Photo from OceanTeam.

Super flushing

CO_2 in a supercritical state is helping to not only keep clean lines clean, but unblock lines other methods have been able to treat. Elaine Maslin reports.

When Ocean Team Group (OTG) launched its supercritical CO_2 flushing technology it had its eye on just that – flushing long lines, particularly those that are very long and narrow, and the ones that need high levels of cleanliness to prevent equipment failure. Yet, since its launch last year, the firm is already finding the technology has other uses.

OceanTeam has developed a line cleaning method, using CO_2 in a liquid or super critical state. The CO_2 has a viscosity 10x lower than water and a carrying capacity similar to oil, says OTG. The supercritical liquid state CO_2 (SCCO2) is able to maintain a turbulent flow inside pipes narrower then ¼in in diameter and longer than 40km, degreasing and removing contaminated sludge as it goes.

Since 2015, the firm has gone from testing the technology on a 6.5km-long, ¼in control-line in-house, to deploying its system offshore in a 10ft container in order to flush a 12.7mm, 38km-long, cross-maritime borderline and back. Next, it has its sight set on 60-70km lines, with its next unit, which will enter the market mid-2018.

The technology was developed to ensure pipes like umbilicals, for the subsea systems, and wells were flushed clean to high standards to prevent contamination of fluids. "[However,] because of the solvent effect of the CO_2, blocked lines can be cleared," says Espen Kähler Amundsen, managing director of Ocean Team Scandinavia. This even includes one-way lines, where there's not a loop to flush the CO_2 around.

OceanTeam's first trialed the technology with Maersk Oil, offshore Denmark, Wintershall in Holland and has since worked with a pipeline sealant firm in Norway, which wanted a way to unblock pipe bores, if it's technology, a sealant for pipe wall pits or holes, causes a blockage.

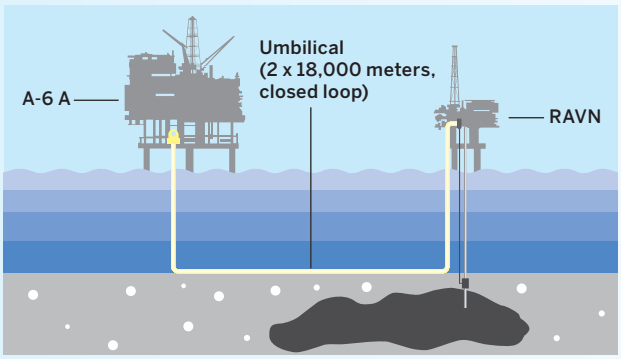
But, OceanTeam's biggest SCCO2 project to date was last in summer, flushing a 12.7mm diameter, 38km-long umbilical, and its high-pressure nylon asphaltine inhibitor hose (18-19km with return line), in an umbilical, which runs between the A6-A platform to the Ravn platform, spanning the Danish and German North Sea boundaries. Because the inhibitor is like ketchup, the line it flows into has to be as clean as possible.

Wintershall wanted the line to be clean to National Aerospace Standard (NAS – a measurement of purity of a hydraulic system) Grade 6, but the CO_2 flushing achieved NAS 3 (Which is the best seen for OTG). The result was impressive: due to its unique properties, the patented SCCO2 technology achieved NAS 3, significantly better than NAS 6.

"That is exactly what we need: maximum high turbulences that transport all debris out of high pressure hoses and pipes," says Wintershall engineer Ulrich Tiefes. "We achieved unprecedented levels of cleanliness with CO_2-flushing."

On another project was done with the patented technology, a 3km one-way was also unblocked. Diesel had been pumped in to it to try unblocking it, but this hadn't worked. SCCO2 couldn't be circulated because the line wasn't in a loop, so the SCCO2 was pumped in past the diesel, then the pressure was reduced, creating back pressure which drew the SCCO2 back out, flushing out the line as it did so. This was also a first for OceanTeam. A second similar line also needs unblocking and the team is due to return to clear this.

With more opportunities in its sights, from flushing lines for Statoil in Norway, to unblocking lines, OceanTeam is now working on a bigger unit, which meets more standards and requirements than its initial units, including NORSOK, ATEX, IECEx, and ASME VIII in Australia. It will also have a different type of pump to the existing system, says Amundsen, to handle more flow and pressure. It's due to be complete after the summer [2018] and will be looking to be able to flush lines as long as 60-70km or more, depending on inner diameter. The firm also just applied for Australian grant with government to take a unit to Australia and prove the system there with its cooperation partners from Aussie Fluid Power. ▪



Super clean, from Ravn to A6-A and back.
Image from OceanTeam.

WORLD-CLASS SUBSEA SOLUTIONS FROM NORWAY

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GCE Subsea is an industry driven initiative for strengthening and internationalisation of businesses, research and education. We represent the world's most complete cluster for subsea life -of-field solutions. Our goal is to increase the cluster's competitiveness and global market share, and take a leading position in sustainable utilisation of ocean resources.

In order to achieve these goals we focus on:

- Develop competence and attract talents and investors
- Develop subsea solutions beyond oil and gas
- Stimulate technology development
- Create new entrepreneurs and grow businesses
- Succeed in the global market
- Improve work and production processes

About 120 companies and organisations form the GCE Subsea cluster today.

GCE Subsea is supported by: Innovation Norway, the Industrial Development Corporation of Norway and the Research Council of Norway.

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Predicting the next wave

Having more accurate knowledge of "next minutes" wave patterns would help speed up subsea operations. A multi-organization project has joined forces to make it a reality, says Morten Lund Bjarnar and Morten Lund Bjarnar of Kongsberg Seatex.

SolstadFarstad's *Norman Ocean*.
Photo from SolstadFarstad.

Ocean wave dynamics is a major challenge for all ocean operations. Yet, information of useful accuracy about instantaneous wave patterns, i.e. wave height, period and direction, and corresponding vessel motions, is not available today.

In the project Kongsberg Seatex ECOSTEPS, we are developing "next minutes" wave and vessel motion prediction tools, to reduce waiting time and increase efficiency during subsea lifting operations. The key focus is being able to predict large incoming waves for the next five minutes, so that a decision can be taken whether to start a lifting operation or not, or to continue or stop a critical subsea operation. This could reduce waiting and completion time and increase efficiency for operations on the sea surface, through the wave zone and subsea, in oil and gas, as well as offshore renewables, deepsea mining, fish farming etc.

The ECOSTEPS project, funded by MAROFF, will be tested and further developed on the SolstadFarstad's IMR subsea construction vessel *Normand Ocean*, which is contracted to Statoil, and operated by DeepOcean, and has through the moonpool MacGregor module handling system (MHS).

A standard Kongsberg navigation radar and a MIROS Wave Finder will be installed on the vessel, with fullscale testing starting early this year.

GCE Subsea member Uni Research Polytec, together with the Meteorological Institute, is developing the new instantaneous wave pattern calculation method, using standard navigation radars. Kongsberg is already collecting radar data from a Norwegian coastal ferry and the wave pattern predictions are being compared and improved, against new advanced wave buoys on Norway's west coast.

The Wave Prediction software is being developed in cooperation with MIT Ocean Research – the first and only institution that's developed algorithms able to obtain next minutes wave prediction, based on the physical behavior of waves using standard onboard navigation radars.

Sintef Ocean is developing a method to predict real-time vessel motions that will be correlated and improved against the Kongsberg VMM-200 (vessel motion monitor) that measures and analyzes vessel motions from MRU sensors on the vessel.

In the ECOSTEPS project, we will develop a prototype decision support system based on the Kongsberg VMM200 system and a real-time digital twin of the MHS in MacGregor's C-HOW simulator, with real-time wave and vessel motions as input. The goal is to run real-time decision support simulators in parallel with real subsea operations for continuous guidance on operating margins ahead in time, which means the consequences of different choices can be checked during operations, as well as during planning and training and to aid design work.

The initial focus is through moonpool MHS lifting operations. However, for the Normand Ocean, the most critical operation in bad weather is ROV launch and recovery through the wave zone. Wave and motion prediction will help reduce launch and recovery waiting time.

For the wider industry, increasing the operating window and reducing completion time for subsea crane operations would offer significant efficiencies. Typically, in winter, subsea operations operability is only about 30%, according to subsea operators. Using real-time measurements of vessel motions in combination with next minutes wave predictions, it will be possible to operate in higher sea states than using existing conservative operations criteria, based on weather forecasts. Today offshore crane operations over ship side are often limited to significant wave heights of only 1.5-2m. Increasing the limitation on maximum wave heights by just 0.5m can reduce waiting from one week to one day.

A spin-off project "Increasing efficiency of subsea crane operations over ship side with main focus on immersion of objects in wave drop zone," will focus on ways to do onboard real-time calculations, working with MIT Ocean Research. MIT's WAMIT software will be further developed to calculate the influence of the vessel on the waves around the vessel, enabling vessel heading optimization to minimize vessel motion during both lift-off from deck, and then rotating the vessel to minimize wave effects and dynamic forces during immersion through the splash zone. ▪

Jupa staff, ready with loaded cartridges and interfaces. Image from Jupa.

Scaling up

Making an arduous task easy is at the core of Jupa, a young firm hoping to make light work of subsea scale removal.

Limescale formation is a problem in everything from domestic kettles to subsea equipment, where cathodic protection can help make the issue worse, increasing the rate of limescale formation on bare steel.

It's a problem that's generally resolved by applying citric acid, a natural product, using an ROV with a hose. It's inefficient, with time on site, having to mix citric acid solution on deck and a lot of solution wasted to the surrounding environment. Others just use hard brushing ("elbow grease"), which also means time on site.

Jupa, formed in 2012 by three former university friends, and based near Stavanger, has come up with a more efficient idea – SolidCitric. They've created cartridges of solidified citric acid that can be applied and left unattended to dissolve on the area to be treated, using adaptor tools which interface with and contain the acid over the treatment area.

"Scale becomes a geometrical problem on a connection because the internal diameter will decrease as the scale grows and you might have a problem fitting the connection," says John Harald Schjelderup. "It could be a problem if you want to connect a BOP stack to a well head interface, for example."

Schjelderup worked at Statoil before founding Jupa with Hallvar Møller and Endre Birkeland, who were at Subsea 7 and Statoil, previously. They met at Strathclyde University, in Scotland, where Møller was on an exchange from the Norwegian University of Science and Technology, Trondheim.

"With SolidCitric, you can install it quickly and go and do something else. When you return the remnants of scale can be just blown away," says Schjelderup.

The cartridge can also be left for longer periods without doing any damage. "We have had scenarios where the cartridge has been installed and left for 1-2 weeks before the rig arrives to connect. The rig saved time not having to clean the connection [before it could start operations]," says Møller. Installing a cartridge is also easier for ROV operators than manual application, an eliminates handling the acid and dealing with a compensator on the ROV.

The SolidCitric acid comes in standardized cartridges made by the firm, and is applied with a range of tools, each designed to fit over whatever needs de-scaling. The firm plans to sell or rent the tools, which can be reused, and sell the SolidCitric cartridges.

Island Offshore showed an interest in using the product off its light well intervention vessels, Island Frontier and the Wellserver, which operate for Statoil, and become the company's first customer (in 2014), with TechnipFMC and then others.

To date, the tooling has been used in 600 operations, 50% in the last 18 months alone, and mostly on wellheads and other hubs. Most have been in Norway, with one in Egypt, with BP on the Taurus-Libra field in 2017. But, there's also been a take-up in use on standard Class 4 operated valves on trees and manifolds in the past nine months. This includes valves that had become troublesome to operate that are now operating fine.

It's also been used to 600m water depth, although it's thought scale formation is more prevalent in shallower and warmer waters, where scale forms faster, making regions such as Australia and the Middle East potential markets for Jupa. ▪

The strength of a cluster

Norwegian subsea technology development, within and beyond oil and gas, is strengthened by the GCE Subsea cluster.

Some 120 companies and organizations form the GCE Subsea cluster, representing a complete cross-section of the subsea life-of-field supply chain. Coupled with the innovation ecosystem in Southwest Norway, it paves the way for future subsea technology advancements within, and beyond, oil and gas.

GCE Subsea cluster structure

GCE stands for Global Centre of Expertise and represents the highest level in the Norwegian Innovation Cluster program. The two leading Norwegian operators within oil and gas, Statoil and Gassco represent the client-side. Approximately half of the member base consists of system and equipment suppliers, including the three leading subsea EPC (engineering, procurement and construction) contractors: Aker Solutions, TechnipFMC and OneSubsea.

The second largest segment is inspection, maintenance and repair (IMR), technical services and yard services, which account for about 20% of the members. Support Services is also a significant segment, and includes non-technical support services such as financial and legal services, transport and logistics services, insurance and other consultancies.

In terms of company size, GCE Subsea members represent the full range; from the large multinational companies with thousands of employees, to one-man-bands. In recent years the number of innovative start-ups has increased and shows a high level of both promising entrepreneurship and scale-ups.

Capital

GCE Subsea has a long track record of providing pre-project funding and assisting member and partner companies in obtaining further financing for industry driven innovation and R&D projects from Innovation Norway, the Research Council of Norway and EU programs (Horizon 2020). Over the years, some NOK8 million in pre-project funding has led to almost NOK1 billion in further project financing. On the equity side, GCE Subsea advises members and partners of relevant angel-, seed- and venture capital sources depending on the company's developmental stage.

International Efforts

GCE Subsea works closely with its members and helps them join forces towards international markets. Small- and medium-sized enterprises often have limited resources, and it's important to learn from each other, and customers, to succeed in new markets. The larger companies are eager to get Norwegian sub-suppliers to join them internationally.

In 2016, GCE Subsea hired a dedicated resource as EU Advisor in collaboration with NCE Seafood Innovation Cluster. The EU Advisor will especially contribute in strengthening the international innovation and R&D cooperation in the ocean industries, on themes where the subsea and seafood clusters are world-leading and complement each other. The EU research and innovation programs are key instruments in achieving this.

Exhibitions and Conferences

To form new ties with international business partners, innovation and R&D environments,

The Norwegian Innovation Clusters

is a government funded three-level cluster program (Arena, NCE and GCE) that contributes to value creation through sustainable innovation. Currently there are some 40 different clusters within a variety of industries.

The program aims to trigger and enhance collaborative development activities in clusters. The goal is to increase the cluster dynamics and attractiveness, the individual company's innovativeness and competitiveness. The program is organized by Innovation Norway, and supported by Siva (The Industrial Development Corporation of Norway) and the Norwegian Research Council.

GCE Subsea is actively present at several international conferences and exhibitions every year. Furthermore, GCE Subsea takes part in the annual planning and execution of a delegation branded Norway2OTC, in conjunction with the Offshore Technology Conference in Houston.

Since 2008, GCE Subsea has been organizing partner of the annual Underwater Technology Conference (UTC) in Bergen. From 2017, GCE Subsea hosts the event together with Underwater Technology Foundation (UTF). In 2018, the international Underwater Mining Conference (UMC) 2018 will also take place in Bergen, with GCE Subsea as one of the co-hosts.

Crossover

Benefits do not only arise within clusters; there is also much to be gained by more work across cluster boundaries to spark cross-industry innovation and business opportunities. In 2016 and 2017, GCE Subsea has involved cluster members in many crossover activities towards marine renewable energy, notably offshore wind, aquaculture and deep-sea mining. These are market areas where world leading Norwegian subsea technology and services have a large crossover potential as enabling technology.

GCE Subsea has several joint projects with the two sister GCEs, GCE NODE and GCE Blue Maritime. This cooperation involves common entrepreneurial and scale-up training programs (MIT REAP), common programs on digitalization, IoT and Industrie 4.0, and export strategies for Norway as a global leader in the Ocean Industries.

Why Cluster?

Research has shown that companies in business clusters typically have higher value creation, productivity and growth than the industry in general. It is also easier to facilitate change, entrepreneurship and innovation within clusters, with the cluster management playing an important role as facilitator.

Through participation in cluster events, companies increase their networks and even find new market opportunities among other cluster members. Cluster-initiated business acceleration programs help overly technology focused companies in improving their business orientation. Cluster theory and experience have shown that it is very important to stimulate increased collaboration within the innovation ecosystem between industry, government, finance, academia and R&D institutions. GCE Subsea haS therefore enrolled many of the major universities, university colleges and R&D institutes, along with county and municipal authorities. ▪

GCE Subsea Services and Benefits

GCE Subsea strengthens innovation and knowledge collaboration in the subsea cluster with increased innovation and internationalization being the main goal. All cluster activities and services target six focus areas, aiming to:

- **Develop competence and attract talents and investors**
- **Develop subsea solutions beyond oil and gas**
- **Stimulate technology development**
- **Create new entrepreneurs and grow business**
- **Succeed in the global market**
- **Improve work and production processes**

Go to www.gcesubsea.no to read more about membership

Shuffling the deck

Good things happen when people come together and the fruits of such collaboration are shown here. Gaming technology is being used to aid offshore mobilization. Elaine Maslin reports.

Bring together a 3D visualization and animation firm and a sea fastening specialist and what do you get? Backdeck Tetris? A new company, set up by visualization software firm Goontech and a sea fastening specialist, is doing a more useful version of that, for planning where equipment will go back deck. Unlike in the game, with Mobideck you can move the pieces around if you decide they're in the wrong place.

It's a step forward for seafastening for offshore mobilization, says John Sverre Gundersen, general manager for MobiDeck, based near Stavanger. Gundersen has worked with seafastening for subsea construction, which is the process of welding modules on to vessel decks to stop them moving (or falling over board) during transit and operations.

Planning where these modules are welded down in advance and performing the lengthy calculations needed to then gain class acceptance is an arduous task, involving liaison with multiple parties – vessel owner, client, contractor, etc. – and often layout revisions. "The calculations for each and every unit to be seafastened would result in 20 pages of calculations," says Gundersen. Any layout revision would mean all those calculations have to be repeated.

Initially, Gundersen just wanted a tool that would help automate those calculations. But, working together Goontech and MobiDeck has have developed a new system, DeckPlanner, through which all this can be done on a desktop, with the calculations and forms to be sent to verification societies auto-generated. Moving modules, skids, A-frames, cylinders, etc., around on deck is done via drag-and-drop onto a digital model of the vessel being used, with a library of items being built (and all viewable in 3D and soon by multiple parties at the same time online).

"We had to learn a lot to do this," says Bjarte Sebastian Hansen, Goontech's CEO. "It's not just transportation of equipment, there are many parties involved; the operator that's ordered the job, one or more engineering companies that produced the equipment to be used, the shipping company responsible for the vessel, the marine crew working on deck, etc.

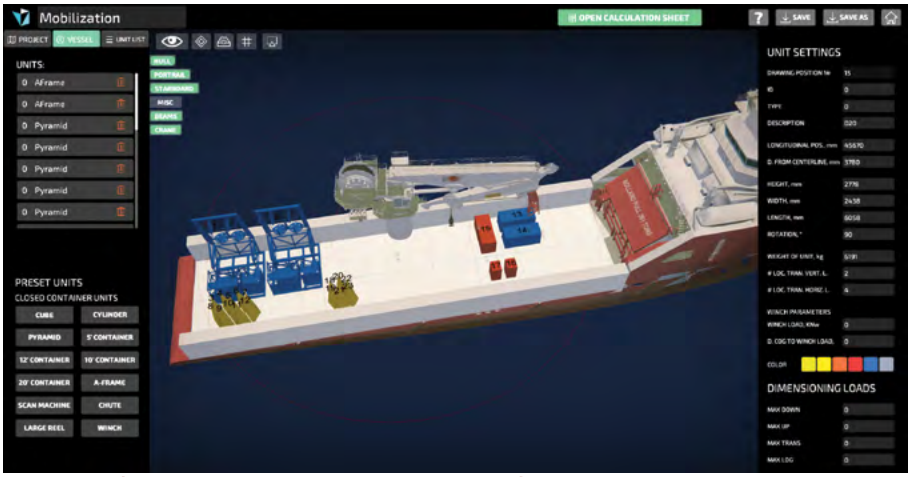
"We need to coordinate all these parties, there's a lot of planning and working out how put items on deck in order to get work done safely, for everyone, in the most efficient way," he adds.

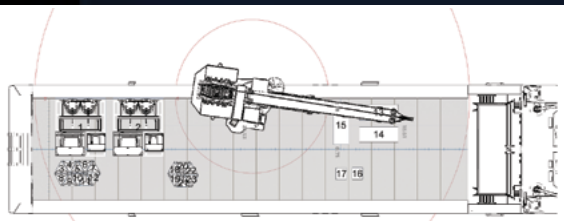
A plan could be completed, and then during welding, a hatch that cannot be covered is discovered, and then it's back to the calculations, delaying mobilization. But not now.

"You can do everything you want in one or two meetings and not having one person trying to coordinate a lot of wishes," says Gundersen. "One of our clients estimate they save up to 200 hours in pre-operation hours within the team. If they use DeckPlanner."

The system is built by building something similar to a game world, incorporating existing digital vessel models and creating models of any items to be fixed, using a gaming engine, in this case Unity 3D. Any items created are then stored in a library for future use.

MobiDeck has been working with Petromarker, which performs EM (electromagnetic) surveys, to run pilots. Previously, the company used an external firm for seafastening calculations, but now they can do it all themselves, says Gundersen. It's also reduced their mobilization time from five to two days. Taking that a step further, they can also use the software to see which vessels would be the most efficient to use for a particular spread. ▪





POS #	UNIT ID	DESCRIPTION	LONG LOC	TRANS LOC	LENGTH	WIDTH	HEIGHT	WEIGHT
1	0	AFrame	3510.613	360.9865	1000	1000	1000	0
2	0	AFrame	24473.12	-2271.529	1000	1000	1000	0
3	0	Pyramid	13434.44	2508.627	2500	2500	5000	0
4	0	Pyramid	6723.778	6783.272	2500	2500	5000	0
5	0	Pyramid	51370.3	1697.582	2500	2500	5000	0
6	0	Pyramid	32937.82	-5955.007	2500	2500	5000	0
7	0	Pyramid	29776.05	6395.412	2500	2500	5000	0
8	0	Pyramid	42090.57	4522.362	2500	2500	5000	0
9	0	Pyramid	20330.34	2166.244	2500	2500	5000	0

Deckplanner, how it looks on screen and a certification ready print out.
Images from Mobideck.

Putting moorings to the test at DNV GLs Technology Centre for Offshore Mooring & Lifting.
Image from DMV GL.

Smart deepwater mooring

DNV GL's Bergen Technology Centre has been helping operators make the optimum choice for mooring selection, says Mads Arild Eidem.

Any type of offshore floating installation needs to manage its mooring system to lower the risk of failure over its lifetime. With greater depths being explored, the mooring system is a substantial part to the overall cost of development.

Mooring systems can be subjected to intense loads, especially when being deployed in deep waters and harsh environments. Chain is the most common choice for permanent moorings in shallow water up to 100m, whereas steel wire rope is lighter weight and has a higher elasticity than chain, which is a better choice in water depths greater than 300m. However, synthetic fiber rope is the lightest weight of all three, and is the preferred option for deepwater mooring, going as deep as towards 3000m water depth.

When a major operator wanted to judiciously select and design mooring components for its deepwater project in US Gulf of Mexico, it chose DNV GL's Technology Centre for Offshore Mooring & Lifting in Bergen, Norway, to conduct testing as part of a technical pre-qualification program for polyester ropes made by several manufacturers.

The center now features one of the world's largest tensile testing machines with a 2900-ton (28,500 kilonewton) load capacity, and a 20m-long test bed.

In its work for the operator, DNV GL's experts at the center tested the tension-elongation characteristics of the polyester ropes the operator planned to use, as well as their permanent non-recoverable elongation.

The results were used in the early stages of the mooring system's design and analysis to verify that it could fit within tight constraints specific to the operator's deepwater project and meet the performance criteria required for installation and in-service conditions. The work also contributed to a reduction in total project costs. The savings achieved on one project are estimated to be US$1-2 million in steel mooring chain costs, and $1 million in mooring system installation time.

For mooring systems using fiber ropes in areas with trawling activity, operators have challenged the industry to provide solutions to protect the fiber ropes from damage. Several concepts for protection were validated and tested in a customized cut resistant jacket rig at the DNV GL center, giving operators sufficient trust to move forward with fiber ropes in areas where there is trawling.

For mooring design lifetime management, replacement of mooring components represents a big investment – and operational cost. Through condition assessment and testing of selected lines taken out of use, reliable data can be used for lifetime analysis, enabling sufficient trust in lifetime extension of several years. This work has been done for several installations and operators, giving substantial savings.

Through failure investigations and root cause analysis, supported by static and dynamic testing of chains, steel wire ropes, fiber ropes, shackles and other mooring equipment, DNV GL has revealed the causes of mooring failures. According to a Norwegian Petroleum Safety Authority (PSA) summary report, the number of mooring failures needs to be reduced. Learning from past failures to prevent reoccurrence is of substantial value.

DNV GL's technology center in Bergen is also able to help companies assess the merits of technologies. Being an independent company makes DNV GL a neutral voice. To assess technologies, the right equipment and capacity for repeatable tests is required, so that testing is consistent. ▪

Mads Arild Eidem *is Head of Section Materials Bergen and Site Manager, for DNV GL Bergen.*

GCE Subsea, World Class Solutions
from Norway, 2018.

www.gcesubsea.no