European Technology Report

Courtesy Aker Solutions

Expanded subsea campus aims to propel deepwater technology

Features advanced manufacturing tools, processes

LORENZO ROMAGNOLI, *BAKER HUGHES*

SUBSEA TECHNOLOGY is a part of the industry experiencing huge advancements, largely due to the need for infrastructure and equipment that can cope with the increasing challenges of mature basins, ever deepening water, and ever narrower economic margins.

In June 2019, Baker Hughes launched its Subsea Centre of Excellence (CoE) in Montrose on the northeast coast of Scotland. A purpose-built hub of design and manufacturing, it is the result of a £31-million ($40-million) investment by the company, supported by a £4.9-million ($6.3-million) grant from the Scottish government, through Scottish Enterprise.

The CoE has been designed to leverage the best of industry innovation, engineering, manufacturing, test and assembly facilities in the world, all in one place. Created with the specific vision to transform deepwater technology development, it is packed full of some of the most advanced product design and manufacturing equipment the industry has seen.

FACTORY OF THE FUTURE

The upgraded and expanded CoE was created to encourage product innovation on a new scale. Its systems and products serve the worldwide energy industry mainly in the hydrocarbons segment. To do so, it houses a variety of advanced manufacturing tools and processes, which are there to improve the design and creation of subsea architecture. These tools include:

- Virtual reality systems and digital platforms
- Automated processes, robotics
- Additive manufacturing with 3D printing capabilities
- Laser measurement devices.

In addition, it is the home of the 'Aptara Design Centre', dedicated to the development of the Aptara Totex-lite subsea system. This new family of products has been created to support life of field operations, featuring a range of lighter, modular technology solutions re-engineered to enhance production efficiencies and introduce a 'make-to-order' concept in the design phase. All of which is coordinated from Montrose.

AN ENDURING MODEL FOR THE FUTURE

Following the shift in industry dynamics since 2014, the Baker Hughes team identified a need to, in its own words, "rethink, recalibrate, and reposition the capability of future manufacturing, while finding ways to continue bringing efficiencies to the business and its customers."

Aptara compact tree. *(All images courtesy Baker Hughes)*

The company's existing Montrose base already contained machining and manufacturing capability. This was originally created in the region, a few miles south of Aberdeen, due to its strategically important geographic position. It has the benefit of its own local port authority and excellent road links, leading directly to a reduced carbon footprint through reduced transport needs.

When all the factors related to logistics were combined with Scotland's reputation for engineering capability and expertise, Montrose became the obvious choice to base the new CoE.

In parallel with machinery and digital systems, the 600 strong team of people also formed an intrinsic part of the investment. Indeed, the campus will develop the next generation of the workforce through a series of additional investments, including a dedicated Montrose Learning and Development Centre (MDLC) on site.

The training on offer will also directly support the company's

The Subsea CoE in Montrose has the capacity to design, manufacture, and test a complete subsea tree.

existing STEM programs, as well as initiatives within local schools. The Apprenticeship intake doubled in 2019 as the center looks to cement its strategically important position in the global energy industry, not only now but over the long term.

INDUSTRY 4.0

This sustainable outlook is reinforced by the developments to manufacturing capabilities within the CoE, in particular when it comes to subsea trees. It has the capacity to design, manufacture, and test a complete subsea tree, all under one roof. And not just any tree, for the first time a complete subsea tree system can be built and shipped with the most advanced technology systems in the world.

Production machinery is digitally connected to advanced systems so that data can be downloaded in real time, and then programed to create an optimization algorithm. In turn this enhances the process, making each product in the most efficient and productive way possible.

Taking the impact of digital technology further still, the power of virtual reality has galvanized the technology research and development process. It gives the CoE team the ability to recreate and simulate the assembly procedures of a product, time and time again, with improvements made and elements thoroughly tested in the virtual world at every stage of design.

This means that more than simply testing and assembling trees, the CoE team can simulate the engineering design upfront; continuously optimizing and refining the design and ultimately eliminating defects before the physical assembly of any piece of equipment.

The CoE has further innovated tree manufacturing by introducing additive manufacturing (3D printing) capability for the first time. This was inspired by aviation – an industry that shares a need with the energy industry, to continually evolve to create safe, efficient and technologically advanced components. Because of that, until now, many companies have tried to minimize unscheduled downtime by maintaining large stores of critical spare parts. The process, therefore, allows for simplified manufacturing of components that can reduce costs and enhance performance accelerating the product development through rapid prototyping and shortening the development cycle of oil and gas components, thereby reducing the time it takes to proceed with full production.

The introduction of automation is helping to improve the company's efficiency on activities like welding, testing and material-handling, i.e. its fully-automated cladding process for tubing hangers and flexible pipe end-fittings improves operator safety, quality, and productivity. Also, recently introduced was the 'cold metal transfer', a robot that can improve welding operations, without the need for human intervention. Marking a step forward in the new generation of workplace optimization.

A SUBSEA VISION – ON LAND

This, however, seems to just be the start of the story for the CoE. The company plans to continue to develop and invest in its people, technology and products, making the site key for exporting subsea products. In 2020, Baker Hughes will continue to invest in the Montrose center, developing new capability in manufacturing and technology development.

The campus features virtual reality systems and digital platforms.

Developing a subsea project today is no mean feat. Mature areas, remote locations, arctic temperatures, high pressure and temperature, and marginal reservoirs mean that every project has its own unique set of challenges.

New infrastructure needs to be more robust than ever before, and requires experience and technology to be able to consistently adapt to everything the industry throws at it. This CoE is not just about manufacturing efficiency, it is about building a sustainable industry through advanced design and manufacturing. Bringing benefits now and well into the future.

‘World-first’ resident subsea drone to operate at Njord for Equinor

Hydrone vehicles taking inspection, intervention to new level

JEREMY BECKMAN, *EDITOR, EUROPE*

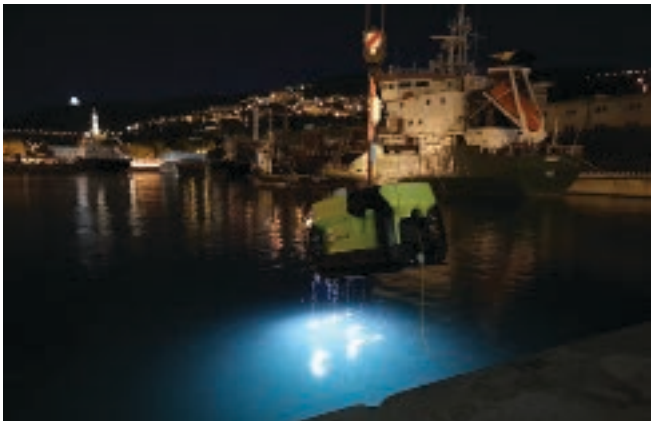
EQUINOR’S NJORD Future project in the Norwegian Sea is the first confirmed setting for Saipem’s new Hydrone subsea drones. In September, the Norwegian major awarded the company a 10-year contract to support drilling and inspections/interventions on subsea facilities at Njord and other satellite fields in the area. The program will take effect next year when production resumes through the upgraded Njord A semisubmersible platform.

Hydrone-R undergoing endurance trials in open sea in Trieste port, northeast Italy, at daytime. *(All images courtesy Saipem)*

Sonsub, Saipem’s business division for Life of Field, Underwater Technology and Subsea Processing, is currently putting the underwater intervention drone (UID) Hydrone-R through endurance trials at a test bed and in open sea offshore Trieste, northeast Italy. Once these have finished, the vehicle should be ready to start operations at Njord next year, performing light interventions and subsea inspections and potentially functioning autonomously for months in between scheduled maintenance.

Sonsub expects to complete development and testing of the all-electric work class ROV Hydrone-W in 2021, at which point it will be ready to undertake heavy intervention and other tasks via a tether connection to Njord A. Saipem’s Norway division will supervise the two vehicles from Njord A and from shore, via proprietary remote control technologies.

Roberto Di Silvestro, head of Sonsub, commented: “We believe that Equinor’s decision to select Hydrone was primarily for three reasons. First, our Hydrone technology is mature: SIT and EFAT [Extended Factory Acceptance Test] were completed this June and the Hydrone-R is now performing an extensive endurance campaign with the objective of reaching TRL5 [Technical Readiness Level 5] soon. Second, Hydrone-R and Hydrone-W not only meet but exceed



Hydrone-R in night time trials off Trieste.

Equinor’s technical specifications and requirements. Finally, Saipem has been working on the Hydrone program since 2015 with a global business vision and a deployment plan for various subsea fields in the world’s key energy areas. This may have given Equinor the necessary assurance that aside from the benefits of the technology we have incorporated operational inputs from other subsea applications.”

There are, in fact, three vehicles in the Hydrone series, the other being the FlatFish (or Hydrone-S), an evolution of the Flatfish concept initially developed by Shell Brasil under the Brazilian National Petroleum Agency (ANP) R&D levy program for deepwater operations. Sonsub obtained an exclusive license for the industrialization and commercialization for oil and gas applications that Sonsub is pursuing with its Brazilian robotics team in collaboration with SENAI Cimatec, a Brazilian academic center in Salvador, Bahia.

DUAL-ROLE SUBSEA TASKS

From the outset, Sonsub envisioned the Hydrone program as a set of different vehicles with different mission profiles for specific Life of Field subsea applications, Di Silvestro said. “Hydrone-R is a hybrid AUV/ROV. Like a traditional ROV, it can do interventions via manipulators, but it can also operate autonomously, as an AUV, performing inspections.”

According to Sonsub, Hydrone-R will be the world’s first commercially deployable resident subsea intervention drone, capable of remaining underwater without interruptions for up to 12 months. In this mode the vehicle provides remote operability and can be connected to subsea infrastructure via through-water communications links, covering an area within a 10 km (6 mi) radius

Hydrone-R during tests at Sonsub headquarters in Marghera (Venice).

Hydrone-R control room.

for inspections and interventions. The distance covered could be extended through use of intermediate subsea docking stations (also part of the current trials), for re-charging of the vehicle and for mission downloads or survey data uploads. The vehicle's embedded sensors and proprietary artificial intelligence (AI) features allow it to undertake autonomous navigation and anomaly detection on a wide range of subsea systems.

Typical tasks foreseen range from periodic general visual inspection to assessing structural integrity (including cracks and corrosion) to close visual inspections of risers, mooring lines, anodes, insulated cables and connectors. Interventions could include installing bypass valves, rectifying leaks, and connection/disconnection of flying leads.

After the first prototype vehicle was completed in June, tests followed in July on the electronics and software at Sonsub's facilities in Venice, and the 3.5 x 1.5 m (11.5 x 4.9 ft) vehicle has since been undergoing tests at the company's marine base in Trieste where an extensive network of subsea structures has been installed including 500 m (1,640 ft) of pipelines, and a docking station. These are positioned close to the quayside, from where the vehicle can be launched and recovered easily.

Functional tests were due to finish by the end of October. During November, the vehicle was due to be taken to another location 300 m (984 ft) offshore, in a water depth of 22 m (72 ft), to perform tasks such as hook-up of a pipeline end termination (PLET); pipe recognition and tracking; analysis profiling based on a 3D reconstruction of subsea structures; and navigating point-to-point in several kilometers of open water. Another priority is demonstrating remote control of the vehicle via its through-water communications link while in fully autonomous mode, as this is a major issue for offshore operators, Di Silvestro said. The combination of acoustics and optics are designed to allow the vehicle to position itself very close to the subsea structure. DNV GL has been overseeing the Hydrone-R's design and qualification program.

The Hydrone-S is similar to a traditional AUV, Di Silvestro said, but with a capability to hover and to traverse longer distances of up to 50 km (31 mi). "It is designed to perform inspections, not interventions, and it is not intended to be resident in a single field – unless a giant – but to move from one field to another every few months. Its AI features allow it to operate fully autonomously for following networks of subsea pipes, flowlines and umbilicals and for more detailed inspection of subsea structures." Industrialization of the vehicle has finished, and the prototype should be ready for first subsea trials in April-May 2020. The Hydrone-W, he added, is a fully electric, remotely operated work class ROV, able to remain resident subsea for a period of time, but not as continuously as the other two vehicles.

Sonsub has developed two other devices under the Hydrone program for periodic re-charging of the vehicles, mission and data downloads. The prototype HyBase, designed for permanent deployment, was featured in the test campaign off Trieste; the other is the HyBuoy, a smaller power/communication buoy for temporary or permanent deployment that will be powered via wave or wind energy, with subsea re-charging of the vehicle enabled via a 2-kW subsea inductive connector.

The company is also developing what Di Silvestro describes as a "flying garage" with SENAI Cimatec and Shell Brasil that would enable launch and recovery of FlatFish potentially from FPSOs or smaller support vessels. Shell/Sonsub aim to start a pilot test of the Hydrone-S/FlatFish and the ancillary equipment as soon as possible offshore Brazil, he explained, adding that other majors have also been monitoring progress of the Hydrone series development. Eni, for instance, has been supporting the test set-up at Trieste.

"In our vision, 'Life of Field' is an IMR engineering support concept that involves a combination of asset management and inspection/intervention. Typically, oil companies have commissioned annual inspections of their subsea assets, but in some cases, these are only performed every three years. And these campaigns have not been generating sufficient information for the industry's present needs. If, however, you can provide low-cost inspection with a resident Hydrone, you can then start generating large volumes of 'big data' that allow you to really monitor any changes in the subsea asset. You can then do preventive intervention or predictive maintenance.

"When you design a pipeline and riser network to last for 25 years, you are forced to make a number of conservative assumptions, all of which leads to quite a constant capex. But if you can reduce the level of uncertainty, you can also reduce capex over the life of the field: the Hydrone-S, for example, can be configured to perform dialogue and analysis, using the data it has collected to assess the reliability of the subsea infrastructure. This is part of a movement within the industry towards an Internet of Subsea Things."

Aerial view of the Mittelplate A drilling and production platform. *(Courtesy Wintershall Dea)*

Digital twin extending life of North Sea Mittelplate platform

Improved data flow brings maintenance benefits

SEAN MACKIE, *WINTERSHALL DEA*

WINTERSHALL DEA'S Mittelplate drilling and production platform in the German North Sea and nearby Dieksand land-based facility are getting a digital twin. The aim is to optimize the operations and production of the Mittelplate oilfield and improve maintenance and work processes on Dieksand by making all necessary data available and usable so that advanced analytic and predictive tools can be deployed. This requires new technology and new ways of working.

The digital twin will provide a complete virtual representation of operational reality, with both real-time and historic data, making it accessible to anyone regardless of their location or device. The objective is to gather all data, bring it into context and visualize it using dashboards in combination with powerful analytical tools to provide engineers and operators with the information they need to make better informed decisions and increase long-term profitability. To help achieve this Wintershall Dea has formed a strategic partnership with Norwegian-based technology company Cognite.

The Mittelplate platform, which started production in 1987, is in the Wadden Sea tidal flats off the Schleswig-Holstein coast and is connected to Dieksand land via two pipelines, one exporting the field's oil, the other returning associated produced water for re-injection. The platform, which is protected by 11-m (36-ft) tall sheet piling, is effectively an ultra-shallow water artificial island.

Mittelplate and Dieksand were chosen as a lighthouse digital twin project at Wintershall Dea as the field is well-known beyond Germany for its high environmental and safety standards

The Mittelplate platform features separate living, drilling and process areas. *(Courtesy Wintershall Dea)*

as well as its long extended reach production wells. The fact that Mittelplate is more than 30 years old does not change what the company is setting out to achieve. In fact, there is a benefit in being able to draw upon skilled personnel with the domain knowledge needed to develop valuable digital solutions. Of course, it is a different dynamic with an older asset. There is not the luxury of implementing digital capabilities into the design like a brand new one, which is the typical scenario presented at technical conferences today. However, at Mittelplate and Dieksand the company is making significant progress and is proving that digital transformation is achievable on any asset regardless of its age.

Like many oil and gas companies, the problem Wintershall Dea faced was that access to data is cumbersome as information such as sensor data, equipment history, and other documentation are locked away in multiple systems potentially with different data owners and system experts. This meant that equipment alarms and personal experience were driving maintenance analysis and decisions – not necessarily data. Of the many problems that face data-driven decisions, a lack of liberated, usable, and sharable operational data stands out. This was one problem management wanted to tackle together with experts from the asset.

The company decided to partner with Cognite because of its cloud-native Cognite Data Fusion technology where data is not just stored but also contextualized and available as a service. Furthermore, digital transformation is not only about technology, it is in fact largely about organizational transformation. This was another area where Cognite could help as they are adept with agile ways of working, something that management was eager to implement.

In May 2019, two crews were assembled consisting of domain experts, data scientists, data engineers, and solution architects to develop digital solutions for the Digital Twin project using Scrum methodology (an agile way of working typically used for software development). This was done from a central innovation environment in Wintershall Dea's office in Hamburg.

With one crew, the focus was on the use of hand-held devices (Digital Worker) to help with maintenance-related tasks in the field; with the other it was making effective use of available data for next generation equipment monitoring and maintenance operations (Smart Operations) using dashboards and analytical tools. For the Digital Worker crew one important topic was to improve the way we work. The back and forth process of checking equipment, printing checklists and P&IDs (piping and instrumentation documents), long walks between the field and the office, scanning and sending emails is very time-consuming. Our goals were to help workers free up time, rethink and reshape routines and enable them to focus on more important tasks.

The Digital Worker crew piloted explosive-proof hand-held iSafe mobile and tablet devices on Dieksand with Cognite's Operations Support application. *(Courtesy Wintershall Dea/ Achim Multhaupt)*

The Mittelplatte platform in the German North Sea. *(Image courtesy Wintershall Dea/ Christian Bruch)*

At the end of July, the Digital Worker crew piloted explosive-proof hand-held iSafe mobile and tablet devices on Dieksand with Cognite's Operations Support application as well as other standard Office applications. Operations Support is a web-based application and can be accessed both in the field and office. It enables field workers to view live and historic data trends of equipment, maintenance history, equipment documentation and upload photos directly from a mobile device. All trends and documentation can be viewed by simply taking a picture of the equipment tag number.

For the Smart Operations crew, another application was deployed known as Asset Data Insight - a desktop application that allows the workforce to view and compare data trends, create their own dashboards and infographics, and find all related equipment documents, events and time-series data. Furthermore, the crew also built decision support tools for critical equipment such as multi-phase and injection pumps as well as a comprehensive maintenance overview tool. Having such an overview of critical equipment and incorporating a system of rules and alerts empowers the engineers and operators giving them a better oversight of their equipment. This will ultimately increase the lifetime of equipment and reduce maintenance costs.

Prior to this project, the project team had live data stored in one system, maintenance information in SAP, and other documentation in Documentum and file drives. Now all of this has been ingested onto Cognite Data Fusion and contextualized so that all data sources are connected and linked to individual pieces of equipment within an asset hierarchy all the way down to individual sensor data. Having all this data structured and in context makes it much easier to deploy advanced analytical and machine learning tools going forward.

In addition, a 3D model of the Mittelplate and Dieksand facilities was also implemented, enabling users to view the platform and its equipment in a 3D visual environment. This allows users

to, for example, click on a piece of equipment within the Mittelplate 3D model and get instant access to live streaming data as well as historic data trends and equipment documentation.

At the EAGE exhibition in London in June, I presented a small 3D printed model of the Mittelplate platform, created via taken from a smartphone. This was done using a process known as photogrammetry – similar to the technology used to create Google Maps. It demonstrated the ease of updating the actual 3D model of Mittelplate where workers could use this technology onsite to update it regularly. The neat part is that if the photo picks up the tag number of the equipment then all data will automatically be available for that piece of equipment. Photogrammetry is one technology the company is considering for updating its 3D model, if it can identify use applications of significant value.

The products that each crew has developed were built in an iterative way. The crews shared their results with end users and experts from Mittelplate and Dieksand every fortnight where they could test applications and prototypes, provide feedback and help the team define the next iteration of the product. The idea of building products in such an iterative way is to help the crew catch problems early before the final product is developed making the product development much more efficient and cost-effective. Results were also presented to colleagues across the entire organization via live demonstrations on Wintershall Dea's learning platform.

The Mittelplate Digital Twin project has now been running for close to one year and many lessons have been learned. The most important lesson is maintaining close collaboration with the asset and building strong relationships, something that was underestimated at the beginning. Their knowledge is essential and going forward we plan to be present in the asset every week in order to create products they feel comfortable with. The crews are now in the process of deploying further use cases consisting of analytical and decision support tools for turbine monitoring, gas distribution optimization, well monitoring and inspection applications for hand-held devices where they have begun collaborating with Inovex, a German-based IT company focused on digital transformation services.

Next year the project team plans to extend into the domains of production and drilling optimization, where it can learn from ongoing digital activities on Wintershall Dea's Brage field platform in the Norwegian North Sea, which is also working on a digital twin. There is also a plan to scale the solutions already developed to operations in Egypt, which are already showing a keen interest - particularly with the hand-held devices. With the second Supersprint now under way, the project team hopes to showcase the new digital solutions it is developing in early 2020.

Aker Solutions' subsea products are designed to be configurable, but using standardized components. This allows the same products to be used globally, by the same customers, but meeting different field requirements. *(All images courtesy Aker Solutions)*

Aker Solutions adopts 'intelligent' approach to subsea field optimization

Integrated design, faster schedules among the benefits

JEREMY BECKMAN, *EDITOR, EUROPE*

AKER SOLUTIONS claims its new 'Intelligent Subsea' approach can halve the cost of subsea field developments and reduce the time needed to generate optimized subsea field layouts by 75%. ***Offshore*** spoke to Knut Nyborg, the company's Executive Vice-President, about the background to the development and how the company plans to persuade the industry of the benefits of this new approach.

***Offshore*: What is Intelligent Subsea all about?**

Nyborg: Intelligent Subsea enables us to define, execute, and operate tailored and optimized subsea solutions based on standardized components, providing real total cost optimization over the life of the field. It brings cost, schedule, and quality improvements from re-using standardized products, and field optimization potential from applying bespoke solutions. The combination of automated engineering software, configurable product platforms and standardized hardware components mean we can automate more of our execution and thus reduce project engineering lead times. The effects of standardization has reduced engineering hours by 60-70% in some areas, cut assembly hours 25% and reduced procurement cost and lead time. These kinds of efficiencies are only possible through standard, configurable products. Our latest generation of subsea equipment is standardized, smaller, lower cost and simpler - ensuring predictable quality, repeatable volumes, and accelerated delivery.

Knut Nyborg

Standard, configurable product platforms based on standardized hardware components (Product Catalogue) is a key enabler in Intelligent Subsea. Combined with our automated engineering and configuration software (Insight) we can automate more of our execution and reduce project engineering lead times.

***Offshore*: Can this approach be adapted to changes in**

the subsea system, which can be frequent as the design evolves?

Nyborg: Digitally-enabled design helps us drive efficiency and standardization in our design processes to rapidly create, test, and adjust design concepts based on standardized products and components, with each field development proposal costed. Changes to the subsea system are seen in the context of corresponding efficiencies in topside facilities and wider infrastructure to ensure the most efficient design possible. Our digital tools can reduce concept selection timelines dramatically. Software applications in ix3's Concept Insight and Engineering Insight portfolios shorten the time it takes to select the best subsea layout by 75%.

Using our Subsea Configurator, we can rapidly search our product catalogue to find standardized components and products that fulfill a specific field configuration and related design parameters such as pressure, temperature, water depth, fluid composition and so on. This significantly improves speed, consistency, and accuracy.

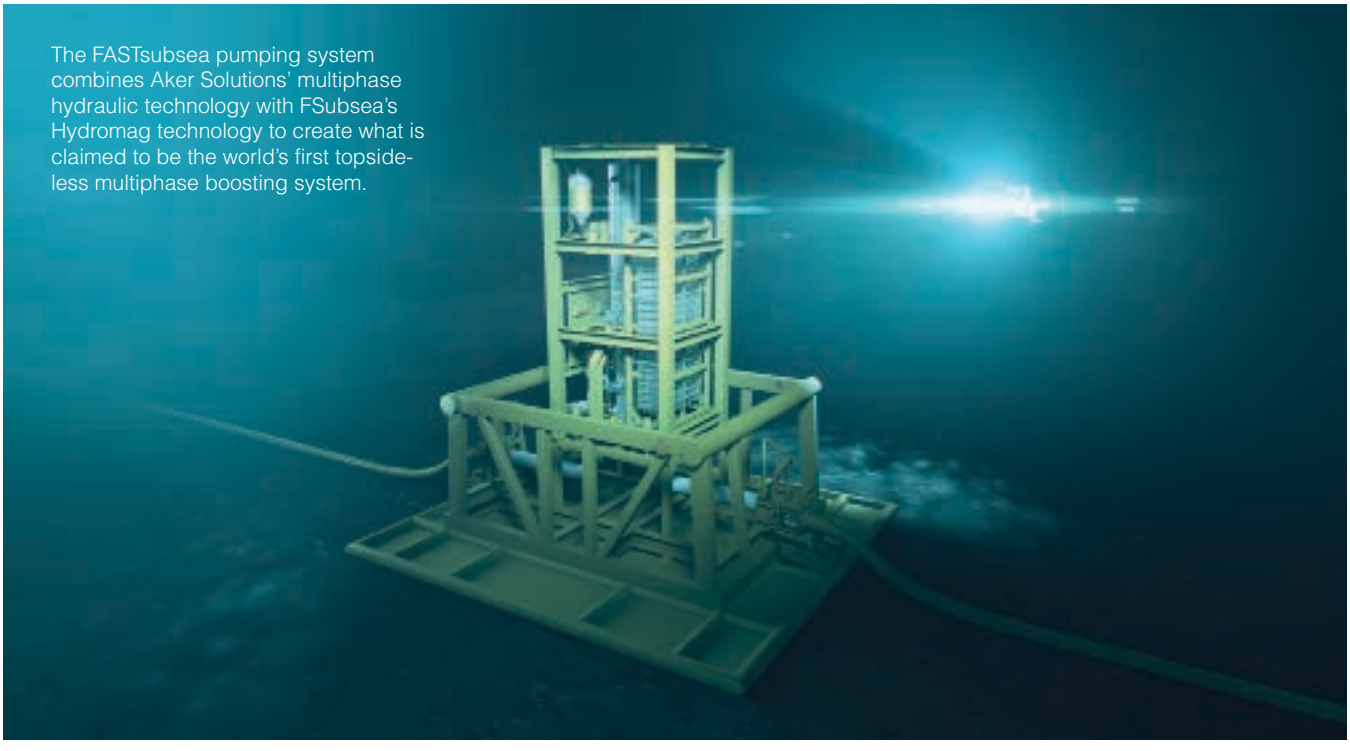
During execution, our configuration and design automation tool can cut engineering hours by up to 90%. In the case of wellhead systems, we have developed a configuration and design automation tool which can cut engineering hours by up to 90% and lead time by half. The end result is a cost-effective product that reduces time to first oil. During the operations phase, our digital insight, predictive maintenance, standardized equipment and enhanced oil recovery techniques, can drive lower operating costs, increased uptime and extended field life.

***Offshore*: Is the concept being pitched mainly at the company's established clients in the North Sea area?**

Nyborg: Intelligent Subsea is relevant worldwide. The core value of this approach is found in the intersection of three themes - integrated system design, which encapsulates the complete system not just subsea; accelerated field development, through standardized design and manufacturing; and maximized performance, through life of field via advanced condition monitoring and predictive maintenance, enhanced recovery solutions, and simplified system extensions. The company does have a strong track record on the Norwegian continental shelf as well as West Africa and Brazil. We are applying this integrated system thinking with customers in many regions, and we believe it is the right approach for deepwater developments. It directly solves performance issues with fit-for-purpose products designed for installability and flow assurance, both essential in deepwater.

***Offshore*: Does the concept work best with new or bolt-on offshore developments?**

Nyborg: It works equally well for greenfield projects and for brownfield projects. The core of Intelligent Subsea is still the automated design using standard configurable product platforms. This is valid for any type of field. For example, our Subsea Alliance with Aker BP and Subsea 7 supported the brownfield development of the Alvheim area in the Norwegian North Sea. This involved the development and tieback of mature fields to an existing FPSO to ensure high capacity utilization. With



The FASTsubsea pumping system combines Aker Solutions' multiphase hydraulic technology with FSubsea's Hydromag technology to create what is claimed to be the world's first topsideless multiphase boosting system.

Wellhead manufacturing in Aker Solutions' Port Klang, Malaysia, facility. The company claims to have developed a configuration and design automation tool for wellhead systems that can cut engineering hours by up to 90% and lead times by half.

our digitally-enabled approach, and cooperation with our alliance partners, we were able to shorten the schedule from 22 to 13 months and deliver a 30% cost reduction.

Look at marginal tiebacks in general. One of the key drivers is maximizing capacity utilization on an existing topside facility. By applying our system thinking approach we can optimize the field design, taking into account all client priorities, both topside and subsea. Capex and schedule often have a huge impact on the subsea production system (SPS) development case; while both are important drivers for the topside facility, it is also critical to design potentially new topside equipment according to size and weight requirements for the dedicated topside in addition to existing capacities for power and utilities. And to ensure that execution of the work can be performed in planned revision stops or with a minimum of 'hot work', which requires shutdowns of ongoing production.

***Offshore*: Is the concept applicable solely to Aker Solutions subsea products?**

Nyborg: Our digital technologies are applicable to multiple vendor products. For example, ix3's Subsense field condition and performance monitoring tool is monitoring a UK subsea field where we have delivered the controls, but the trees were delivered by a different vendor. Through our own alliances, we are used to dealing with products from a mix of vendors. By applying our digital tools in the front-end phase, we can define optimized field design solutions and accommodate aspects such as installed infrastructure and use of existing spare parts and tool sets.

***Offshore*: Is full alignment needed among all major parties in a project, from start to finish, for the concept to work?**

Nyborg: No, major parties do not have to be fully aligned from the outset – but what makes a difference is early engagement in the front-end phase. Understanding the interfaces between the parties in the front-end phase and ensuring that inter-dependencies are taken into consideration when establishing different field solutions are both critical.

***Offshore*: Can you outline some of the benefits of standardization that this new approach provides?**

Nyborg: We have standardized many deliverables that would

have been variable between projects a few years ago. For example, our vertical trees are absolutely standard but at the key function or component level. A client may, for example, select a 5-in. outlet for an oilfield and a 7-in. outlet for a gas field. Both outlets are standardized, and both have the same interfaces. This means they can be configured to different field conditions and functional requirements by simply selecting the best suited standard components for each function.

The Vectus control system is also standard on every project with field variability done only at a software level. Using the SCM configurator software tool has been proven to cut engineering hours by 90%. The engineer is guided through a set of configurations based on the product structure, generating hydraulic and electrical schematics as examples. Years ago building a project could take many hundreds of hours but this can now be done in minutes, with the added benefit of predictable and repeatable quality and delivery.

The standardized approach means that subsea fields can be easily extended and upgraded as the field matures. In the case of the Troll field in the North Sea which has been in production since 1995, Aker Solutions more recently applied its subsea configurator tool to prove examples of reduced well-set installation costs by up to 70% through rigless operations. We introduced Vectus controls, enabling seamless phasing in of future expansion tiebacks and data-driven insight with Subsense condition performance monitoring software.

***Offshore*: For marginal tiebacks, Aker Solutions claims to be able to achieve a 50% capex reduction with a new subsea pumping solution. How is this achieved?**

Nyborg: When the FASTsubsea X multiphase pump module is qualified and deployed, FASTsubsea estimates that capex for a pumping system can be reduced by 30-50% compared to conventional subsea pumping system costs. The rapidly deployable FASTsubsea multiphase pump solution has no need for topside infrastructure, therefore offering significantly reduced capex. The project was established in April 2019, and we are currently approaching potential JIP partners for funding.

***Offshore*: Can you explain some of the benefits provided by the company's digital tools and ix3's 'Insight' modules, as applied to Intelligent Subsea?**

Nyborg: We have a range of advanced recovery enhancement technologies that boost recovery and extend the life of the field as reservoir pressure drops and recoverable reserves become harder to reach. Re-applying the configurator apps in ix3's Concept Insight portfolio, working with our front-end teams, and using the latest innovation of intelligent products, we can re-invent the field both subsea and topside and extend production.

Aker Solutions has a long history and extensive experience with field designs across all regions. Prioritization of different client drivers enables different field designs and with these digital tools we can now us this experience to create a set of different field solutions. And when we put in the field-specific design parameter, for example, pressure, temperature, water depth, our digital tools will populate the field solutions with feasible technology within our database.

In other words, our front-end field modeler and subsea configurator apps, part of the Concept and Engineering Insight portfolios, work together with our other automation tools to help engineers' decision making. Multiple fully-costed scenarios can be trailed in a short space of time.

***Offshore*: Aker Solutions is working on a project in the Barents Sea involving a 190-km (118-mi) subsea tieback of a gas system. Is Intelligent Subsea assisting this development?**

Nyborg: Intelligent Subsea can be used for any field. The Concept Insight tool is used to develop, test, and cost alternative field configurations. For long tiebacks it is important to consider two main aspects - one, the flow assurance aspect of transporting hydrocarbons across long distances and two, ensuring capacity for power (hydraulic and electric), utilities and communication. Intelligent Subsea interfaces both multiphase flow simulators, integrated production modeling tools as well as normal steady state process simulation tools. These are used to define the overall field configuration as well as defining the relevant field design conditions. This provides input to the Subsea Configurator when searching for standardized and proved products and components.

This particular project is an example of the company's integrated system thinking approach, meaning we challenged assumptions, rapidly trialed multiple scenarios of a full field system, applied innovative technology, and adapted our solution to use the existing infrastructure. This allowed the reduction of the capex and opex costs, mainly by avoiding the need for a topside production platform.

***Offshore*: Can you comment on some of the other product innovations relevant to Intelligent Subsea?**

Nyborg: The company has developed a configuration and design automation tool that cuts engineering hours by up to 90% and lead times by half. Standardizing on component level and enabling configuration of the wellhead system to meet the field requirements are key to achieving these efficiencies. Standardization enables us to use the design automation tool to generate the drawings required. This results in repeatability and volumes for our engineers, manufacturing and suppliers, as well as predictability when it comes to quality and delivery.

The sixth generation of the Vectus controls system is being deployed for the first time this year. It is central to Aker Solutions' condition monitoring and predictive maintenance offering.

The jackup *Maersk Intrepid* is working for Equinor on the Martin Linge project in the North Sea. *(All images courtesy Maersk Drilling)*

Maersk Drilling converting North Sea jackup for lower-emissions operations

First hybrid-power rig in company's global fleet

JEREMY BECKMAN, *EDITOR, EUROPE*

MAERSK DRILLING is converting the harsh-environment jackup *Maersk Intrepid* for 'cleaner' and more efficient drilling operations. The rig, currently contracted to work for Equinor until August 2020 on the Martin Linge project in the North Sea, will soon become the first 'hybrid' low-emission rig in the contractor's fleet. The upgrades include installation of a new battery-based hybrid power solution that makes more efficient use of the engines, thereby lowering carbon dioxide (CO_2) emissions; selective catalytic reduction (SCR) systems that minimize nitrogen oxide (NOx) and soot emissions; Energy Emission Efficiency software that monitors and optimizes all energy use onboard; and implementation of the NOVOS drilling system to help the drill floor team execute processes more consistently, with interfaces to third-party algorithms to further improve drilling performance.

Norway's NOx Fund, an industry scheme dedicated to cutting NOx emissions on the Norwegian continental shelf, is funding up to 80% of the upgrade costs, and Equinor is providing further support via its compensation format arrangement for emission-reducing measures. Assuming a successful outcome to the project, Maersk Drilling will seek to extend the upgrades to other rigs in its fleet.

The *Maersk Intrepid*, a CJ70 XLE design jackup that entered service in 2014, is equipped for year-round harsh environment operations.

Offshore spoke to the rig's Technical Superintendent, Mikkel Sondergaard Pedersen, and to Maersk Drilling's Chief Technical Officer, Frederik Smidth, and Senior Mechanical Engineer Jan Hoffner, about the background to the conversion and the progress achieved to date.

***Offshore*: Is the Martin Linge development Equinor's first acquaintance working with the *Maersk Intrepid*?**

Pedersen: The rig had worked previously for Equinor on the Sleipner field in the North Sea, and its first ever job was in fact on Martin Linge back in 2014, when the field's operator was Total. The current upgrade program has led to further enquiries from Equinor regarding energy efficiency and we have an ongoing dialogue on further initiatives.

***Offshore*: Was Equinor's desire to comply with future Norwegian emission reduction targets one of the main drivers?**

Smidth: Maersk Drilling had been working for some time on development of energy emission efficiency solutions for various rigs. When we saw the opportunity to help Equinor, as our client, achieve its carbon reduction targets, we approached them with the solutions now being implemented on *Maersk Intrepid*.

***Offshore*: Are there certain characteristics of this rig, or the CJ70 design in general, that facilitate the planned upgrades?**

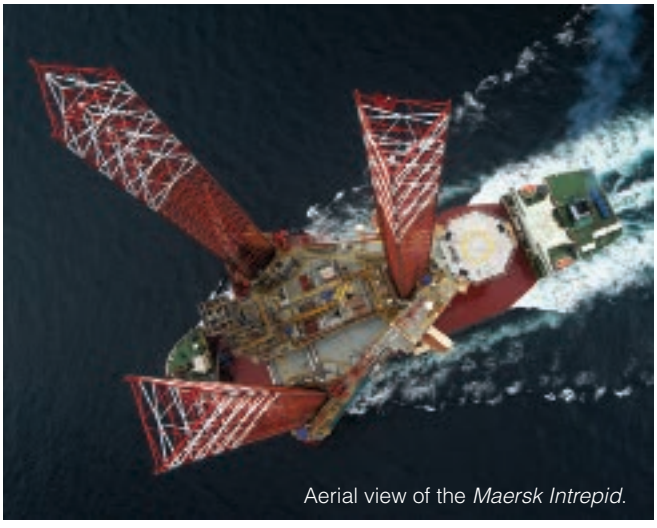
Hoffner: All electrical motors above a certain size have been equipped with variable-frequency drives (VFDs) to control the output of the motor to the required demand. Motors for the topside drilling equipment are also controlled via VFDs. This means the reverse power generated when the motor has to stop a load, with the implemented upgrades, can be stored in the energy storage system. It should also be noted that Maersk Drilling's CJ70 designs are specially equipped and prepared for these kinds of upgrades.

***Offshore*: When the company first made the announcement of this program in May, it hoped to complete the emissions-related upgrade in July, for the hybrid batteries. What has been the reason for the delay?**

Pedersen: Extensive simulations have been performed, in co-operation with Aalborg University in western Denmark, to ensure the correct capacity of the battery bank. In addition, a completely new design of a turnkey container solution had to be developed with a supplier to obtain the most optimal solution for the CJ70 XLE rigs. As *Maersk Intrepid* will likely also be in accommodation mode in 2020, we have decided to install the batteries next spring. The installation of the selective catalyzer reduction (SCR) units is already under way.

***Offshore*: Are the SCR systems a new development?**

Hoffner: Maersk Drilling installed an identical solution on *Maersk Innovator* in 2014, so from our point of view, this is proven technology. The selected system is particularly well suited to the dynamic load patterns encountered in offshore operations, combined with a patented high efficiency urea injection system.



Aerial view of the *Maersk Intrepid*.

***Offshore*: What level of emissions do you expect to achieve compared to the rig's existing output?**

Smidth: The simulations of the power grid on a CJ70 XLE rig indicate an estimated fuel saving in double-digit percentage figures compared to the current average operational consumption on a CJ70 – with, of course, a corresponding reduction in CO_2 emissions. With the SCR units we expect a minimum 90% reduction in NOx emissions.

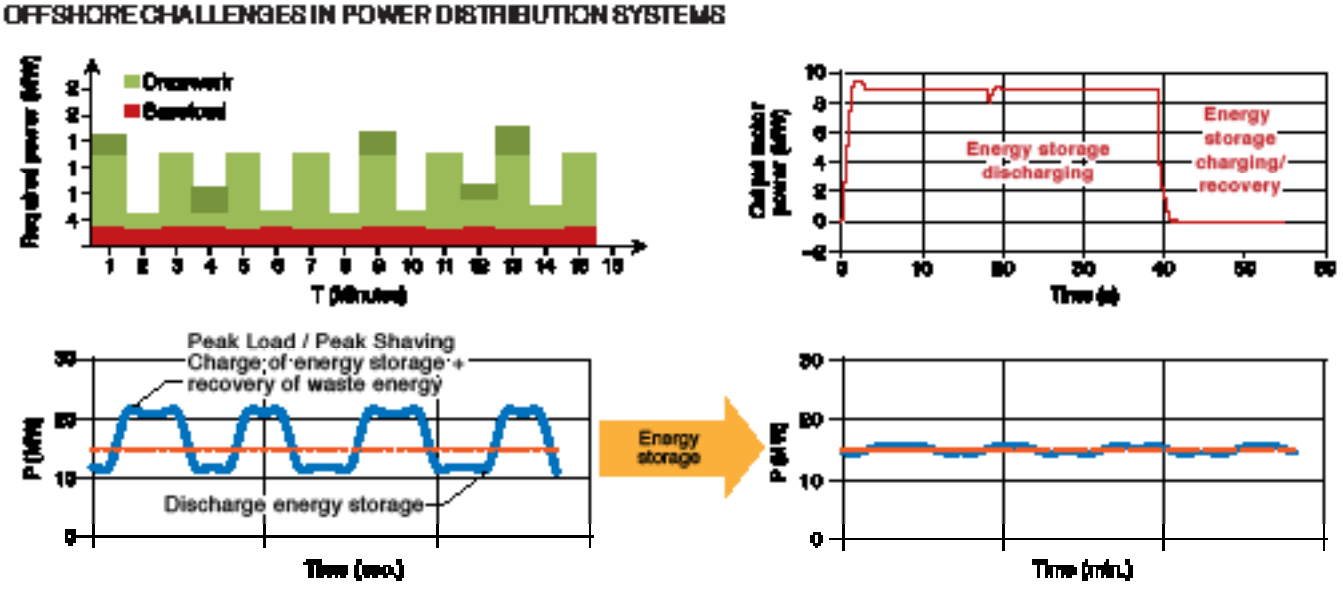
***Offshore*: In terms of energy use, can you provide scenarios of how the hybrid power approach might work, depending on the drilling task?**

Hoffner: The peak-shaving capability introduced by the hybrid power energy storage system (ESS) will result in a reduced number of engines running during tripping in/out operations while running the drawworks in Multi Machine Control (MMC auto function), manual operation or other high power consumption activities on topside.

Implementation of the ESS adds energy to the grid, leveling out power peaks to obtain a constant load on a reduced number of engines. This results in a higher average load on the engines at a more optimal point on the Specific Fuel Oil Consumption Curve, which also leads to enhanced engine performance. Furthermore, waste energy recovered from electrical braking of the drawworks can be used to charge the ESS. In the current rig layout this energy is not being used and is therefore disposed of in the water-cooled brake resistors as heat.

In general, the installation of the ESS on the rigs topside provides attractive possibilities to operate the rig in an ever-more responsible and cost-saving way when operating heavy machinery on the drill floor.

***Offshore*: Are Maersk/Equinor already looking ahead to further refinements to reduce energy use/emissions?**



Pedersen: Yes, we are looking at other solutions that will contribute to a further reduction in CO_2 and NOx emissions. For example, Maersk Drilling has initiated an internal campaign that encourages all employees to submit suggestions for potential fuel savings. The next CJ70 is in the pipeline for a similar upgrade and we are also considering these solutions for semis and drillships. Our drillships have been designed with energy storage in mind, so they could be equipped with these new measures with only minor rig modifications. We are seeing more and more focus from our clients for these kinds of solutions and we are assessing the possibilities for some of our long-term drilling program proposals.

***Offshore*: What is the background to the cloud-based Energy Emission Efficiency software?**

Smidth: This tool was developed in-house at Maersk Drilling with a big data approach, with *Maersk Integrator* used for the first pilot in 2016 when the rig was working for Equinor. The Energy Emission Efficiency software visualizes how and where energy is consumed on the entire rig, and this allows the operator to focus on unnecessary power consumption. To an extent it has changed the mindset of the personnel running the power plant on a rig, leading to substantial fuel savings. Following the upgrades to *Maersk Intrepid*, there will be a continuous focus offshore on the rig's fuel consumption.

***Offshore*: Finally, can you supply how the NOVOS drilling system works and the benefits to Martin Linge or other projects?**

Pedersen: NOVOS manages safe operation of rig equipment through automated processed while allowing external parties to optimize performance within the process. NOVOS offers a software developer kit that allows personalized applications to be created. Hence operators, contractors or service companies can apply optimization with their own applications while maintaining the proven safety and precision of NOV control systems.

Dual-vessel QUAD Lift technique speeds platform installation

Reduced hookup times for large integrated decks

JEREMY BECKMAN, *EDITOR, EUROPE*

HEEREMA MARINE Contractors has developed and proven a pioneering installation technique for giant platforms. QUAD Lift, which is equally applicable to decommissioning, involves parallel deployment of two of the company's semisubmersible crane vessels to speed up installation/mating at the field location. *Thialf* and Heerema's new flagship vessel *Sleipnir* will jointly provide the capability through their four cranes to quickly install integrated decks weighing up to 30,000 metric tons (29,762 tons), via their respective 14,000 and 20,000-metric ton (15,432 and 22,046-ton) lifting capacity.

According to the company, this capability gives design houses greater freedom early on in a project to optimize platform designs, also providing spin-offs in terms of fabrication flexibility. Decks can be dispatched from a yard to the offshore installation location fully integrated; alternatively, deck modules can be ordered from various fabricators in different countries and then integrated at a yard or a floating barge near the site for subsequent shipment to the field for QUAD Lift installation.

The new procedure was first demonstrated in October 2018 in the US Gulf of Mexico when *Thialf* and Heerema's *Balder* operated in tandem to lift a test structure. The trials fully validated the modelling that had been undertaken at the company's new Simulation Center in Leiden, the Netherlands.

When Transport and Installation Director Michel Hendriks started working for Heerema over 30 years ago as a young engineer, the company had two semisubmersible crane

The *Balder* and *Thialf* during QUAD Lift trials in the Gulf of Mexico in October 2018. *(All photos courtesy Heerema Marine Contractors)*

The *Balder* and *Thialf* during the QUAD Lift trials at night.

vessels, *Balder* and *Hermod*. "Even then, we were thinking of using the vessels' four cranes to double their capacity," he said, "and that thought remained with the company for a long time. But in those days the vessels were new, and we had to get to know their capabilities. And they were operating only with anchors – *Balder* did not get dynamic positioning (DP) until the late 1990s, and that too took time to fully master. Then we added *Thialf*, which had DP from the outset."

According to Coen Spanjers, Engineering Manager T&I Projects, the real impetus for QUAD Lift came in late 2014 when the company sanctioned construction of *Sleipnir* and started thinking in earnest of combining two heavy-lift vessels for the same project – coinciding with the period when the industry was entering its severest downturn for decades. "Oil and gas is a very cyclical business," Hendriks explained, "and Heerema is not only driven by how the world might look tomorrow. The vision of the owner is to develop technology for future application."

"QUAD Lift has also been about harnessing the power of digitalization via the Simulation Center, which opened four years ago. This has two crane domes, each replicating all aspects of the vessels in exact detail, a bridge and control rooms. That technology helped speed up the development and gave us the confidence that we could do QUAD Lift successfully."

"With this facility," Spanjers added, "there was no need for conventional tank tests to simulate the vessels' motions. The full digital twin of the vessels gave us a realistic experience of how they would perform working in parallel under dynamic positioning. When we launched *Sleipnir* this summer, its first job [installation of the topsides for Noble Energy's Leviathan platform offshore Israel] was fully successful, proving that what we had seen had been very well mimicked in Leiden. The digital twin provides a hydrodynamic database of all the sea states that we may work in: it allows you to change wave height and wind speeds and to observe how the cranes move. Many of our clients have come to visit the center to see it in action."

GOM TEST RUN

QUAD Lift is said to suit a wide variety of shapes, sizes, and weights of topsides and jackets. The two vessels' four offshore cranes can boom up to follow the contours of the largest and widest structures, irrespective of the orientation or the foundation type. Working in tandem the cranes lift the topsides cargo from the transport vessel at the field location, position it above the jacket and lower it securely into place. Following set-down, one of the vessels departs while the other typically remains at the site to perform remaining installation activities such as bridges or flares.

For last year's trial run in the Gulf of Mexico, Heerema used a 400 ft barge which was outfitted to serve as a 4,000 metric ton test weight for the QUAD Lift operation.

"The trial program was designed to confirm all the DP requirements and communication protocols, as modelled in the simulator," Spanjers explained. "It started with *Thialf* and *Balder* opposite each other, stern to stern. Next, the two vessels performed a 'DP dance', including a full simultaneous rotation without any loads in the cranes. They then executed the 4,000-t QUAD Lift with the barge, which first was lifted out off the water and thereafter repeating the DP tests.

"Some of our clients that witnessed the trial, asked us why we hadn't used a heavier test structure, of around 10,000 t, to more accurately simulate a heavier deck lift? In fact, the procedure is harder with a lighter structure: with QUAD Lift, the heavier the load, the slower the response. That makes the cranes and the wires stiffer, and the system therefore more stable."

"It's a master-slave arrangement," Hendriks added, "in which one of the two boats (the master) leads while the other (the slave) follows, and increased stiffness of the system makes the operation easier for the following vessel.

"One of the bigger challenges we were expecting ahead of the trial was the communications: how do you ensure coordinated co-operations between the two vessels' captains, two superintendents, four crane drivers and two DP operators? So, we called in people from aviation to develop strict communications protocols in order to manage the operation effectively.

"But this is all part of a learning process that goes back to when I first went offshore for Heerema in the late '80s. As the company's fleet has expanded, it has always been a case of understanding how a new vessel operates and its response capabilities. From this latest trial, we learned that we had 100% confidence in the QUAD Lift concept, and DNV GL, which witnessed the tests, has certified the process to TRL 6 state of readiness."

According to Spanjers, "there may be a perception that the process involves having two heavy-lift vessels available for the full duration of a project. In fact, we would typically only need two vessels at the field location for a single day. For virtually any project we would expect to complete the actual installation process within less than a day."

The sole reason *Balder* participated in last year's trials with *Thialf* was that *Sleipnir* had at that point not yet been delivered. For topsides of a certain weight, the concept works equally well with any combination of the three vessels, Spanjers

Simulated lifts in 3D

Heerema Marine Contractors describes its Simulation Center in Leiden as a real-time, virtual offshore environment that allows it to integrate clients' proposed project activities into a 3D view of operations. The crane and vessel controls and the simulated weather and sea swell patterns are said to provide authentic visualization and a 'feel' for all aspects of how the planned operation might pan out.

The Simulation Center can be used to assess and test offshore installation programs prior to going offshore, allowing designs to be 'frozen' earlier. This helps speed up engineering and onshore fabrication, ensuring a greater likelihood of timely delivery of all installation components and required hardware. In addition, the facility can be used to test new approaches for existing or future projects, or to scrutinize critical planned operations in order to check for potential trouble spots.

Heerema can adapt a wide range of 3D models of, for example, jackets and topsides to run realistic scenarios, including single, repetitive or dual-crane lifts, and float over operations. The engineering department develops 3D drawings for each project, incorporating the selected equipment characteristics in order to recreate the components' natural behavior, uploading the results into the Simulation Center system. The offshore crew will then come in to perform a dry run of the planned operation for the benefit of the client and project team, helping all parties anticipate any technical issues or potential failure modes that might occur.

The *Sleipnir* lifting the topsides for the Leviathan platform offshore Israel.

said, so *Balder* could still feature if, for instance, *Sleipnir* was ruled out due to a prior commitment elsewhere. But for really large development projects Heerema will need to ensure that *Sleipnir* and *Thialf* are both in a certain area for the required installation schedule.

In early September, *Sleipnir*, using its two revolving cranes, set down the two main deck structures on the pre-installed steel jacket at the Leviathan field location offshore Israel. The 15,300-metric ton (16,865-ton) module lift set a new record for a semisubmersible crane vessel, Heerema claimed, the second deck of 9,200 metric ton (10,141 ton) was installed thereafter and the combined operation with a total installed weight of 24,500 metric ton (27,000 ton) was completed in just under 20 hours: "It could have been done in less than 12 hours," Hendriks said, "if we had not decided to do something else in between the two lifts."

RE-SIZED GRILLAGE

Heerema can transport fully-integrated decks from most locations directly to the offshore installation site, depending on the client's fabrication set-up. The company operates its own fleet of cargo barges, the largest of which can carry loads of up to 50,000 metric tons (55,155 tons). For Leviathan, the two main decks were transported from the quayside at the Kiewit yard in Corpus Christi on respectively Heerema barges the *H-591* and *H-627*. "However, we can also accommodate an alternative arrangement," Spanjers acknowledged, "if, for example, the platform is built in a yard in Asia and the client prefers to use, say, an HTV for the long-haul transportation."

The company has also optimized the grillage on its cargo barges to be at a height just sufficient to spread the load into the framing. This arrangement is said to minimize the amount of steel in the grillage, with a positive impact on the fatigue life of the topsides. Spanjers explained: "For a heavy floatover installation, you typically need much higher grillage, 10 m (33 ft) up in the air, which is more expensive and leads to significantly increased dynamic loads on the topside.

"With QUAD Lift, there is also more room below our vessels' cranes and that allows you to design wider, spacier topsides. Spacier also means more design freedom to increase distance between certain functional elements of the topside, which increases the safety of the platform. We have been talking to various design houses which are supportive of this development, because to realize the full benefits QUAD Lift provides to the platform's design, it is important for it to be considered during the project's early stages. Early generation platforms also had to have a lot more stiffness built in with elongated support points to connect the load paths. With QUAD Lift, we can position the cranes where we want to optimize the load paths, and that makes both platform assembly and decommissioning process far less costly."

Hendriks added: "This development is more about the 'total cost of ownership' of the project. The physical action of installing a 25,000-t deck is only a relative small part – what is most important is to be able to optimize the design and layout by involving the installation contractor before the EPC award. In this regard we have also been talking to fabricators about really lowering total cost of ownership – because building wider topsides is also cheaper than high topsides.

"Another benefit of our method is that it allows large, fully integrated and commissioned topsides to leave the quayside ready for a QUAD Lift installation, with minimized offshore hook-up and therefore a shorter and more predictable interval until first oil. Twenty-five years ago, topsides design was constrained by the lifting capabilities of the available crane vessels, and typically meant 5,000 to 6,000-t lower deck modules with smaller modules on top (until *Thialf* arrived, allowing a combination of larger modules – up to 12,000 t – and smaller 6,000-t structures on top)."

The same basic principles of the QUAD Lift method can be re-applied for removing ultra-large and heavy topsides. *Sleipnir*'s 20,000-t lifting capability should be sufficient for safely removal of most jackets: the vessel's first job in this mode will be the removal of Shell's Brent Alpha jacket in the UK northern North Sea.

Johan Sverdrup has shown that the era of large new platforms in the North Sea is not quite over, but the main market for QUAD Lift in this sector is likely to be decommissioning.

Pre-project calibration approach improves CT scanner operations

JENNIFER BRIDDON, *TRACERCO UK*

ONE AREA which can be overlooked when considering pipeline inspection, despite the impact it can have on the success of a scanning campaign, is the pre-project calibration or factory acceptance testing of the inspection instrument. A well planned and targeted pre-project calibration test can be designed to focus on maximizing the capabilities for expected conditions and defects, while maintaining resilience to natural variations in these parameters. An inadequate or poorly planned pre-project calibration test can result in poor quality information, which could lead to an unexpected failure of the item being inspected.

Tracerco's Discovery, the world's only field proven subsea computed tomography (CT) scanner, has been used in a number of inspection projects in the North Sea, Gulf of Mexico, and West Africa. It provides asset integrity and flow assurance data on a range of pipeline systems. Prior to any offshore inspection campaign using the CT scanner, pre-project calibrations are performed to help ensure that the maximum quality of the data is produced for each operator, and to improve analysis as well as expedite reporting times.

CT SCANNING

Operating along the same general principles as CT scanners used in hospitals worldwide, Discovery is a non-intrusive external scanning technique designed specifically for subsea pipeline inspection. As it is non-intrusive, it does not affect the operation of the pipe, or require removal of any external coating applied to the pipe prior or during inspection. It is adept at scanning through 50 mm (2.17 in.) of heavy concrete weight coats as it is at scanning through micron-thick fusion bonded epoxy coatings.

A good calibration test can help ensure the complete success of a Discovery subsea pipeline inspection campaign. *(Courtesy Tracerco)*

The principle behind Discovery (and CT scanning) is relatively simple – the inspection beam passes through a material and the density of this material can then be calculated by how much the beam is weakened (this is the attenuation coefficient of the material). Reconstruction models then take this information and use it to generate an accurate image of the scanned item. As CT scanning produces a complex grid of data, it is often likened to a sudoku puzzle, except one which can only be "solved" using computers and iterative algorithms. While this analysis is complex, the advantage of CT over other inspection techniques is that it can generate information about the pipeline wall thickness and integrity, the product flowing conditions and the condition of any coating applied to the pipeline, all in a single scan.

TARGETED TESTING

The Lloyd's Register Discovery certification program, performed in 2017, demonstrated that its scanning and analysis software could provide a measurement capability equivalent to that provided by conventional magnetic flux leakage (MFL) inline inspection tools, in terms of the probability of detection (POD) and sizing accuracy for detecting metal loss type anomalies. The testing program was performed on pipelines of a range of dimensions which covered approximately two-thirds of the most commonly used pipes. For pipelines outside of this range, a specific pre-job calibration is required. Pre-job project calibrations are always recommended and advised for all the scanner's inspection campaigns, in the same manner as the standard MFL approach for performing pre-project pull-through testing to help ensure a successful inline inspection campaign.

The precise goal of a pre-project calibration for the scanner may vary depending on the exact parameters of the pipe to be scanned, type and nature of any expected anomalies and defects within the pipe. Typical goals for a pre-project calibration include:

- Determination of "hits" (variations in wall thickness which can be matched to known features confirmed as valid from alternative pipeline inspection methods) and "misses" (variations which were missed by the scanner but identified by the alternative pipeline inspection method)
- Determination of sizing accuracy and standard deviation values (in particular if these are outside of those recognized by the 2017 Lloyd's Register certificate)
- Determination of the most likely features identified in either the pipeline or fluid, and the associated feature reporting tolerance
- Determination of the most suitable feature detection and wall thickness analysis algorithms from Tracerco's bespoke Discovery analysis software.

REAL-TIME RESULTS

Discovery CT image reconstructions are available immediately offshore, allowing for a preliminary real-time assessment of the data. This includes wall thickness measurements for any identified defects, product bore analysis, or deposit detection. The results can also be used by an operator to help target inspections. For example, if an area is inspected which contains an unexpected level of build-up, an operator may choose to perform additional inspections at this location to monitor for the presence of any under-deposit corrosion. For a Discovery inspection, an additional benefit of a representative pre-project calibration is that it allows Tracerco's offshore technicians to determine the likely early-scan indicators that can be used to confirm if a significant wall thickness variation is present at the scan location. This is of value for an operator who has chosen to use the system's "fast scanning" technique. The scanner, which was developed by the company for rapid pipeline inspection, was formally unveiled in January 2018 and can reduce overall scan time by a factor of five. In summary, it has been proven that it is possible to detect potential anomalies and defects by identifying a key characteristic in the scan data prior to a full scan being performed. Although these characteristics do not include enough information to enable the dimensions of the anomaly to be determined to within Discovery's stated tolerances, the fact that the anomaly can be identified means that a scan can be performed only where it will add value, i.e. at areas with significant defects. Once this characteristic has been identified then a full scan to enable complete characterization of the defect can be performed. If this characteristic is not present, then this scan can be terminated, and the next position can be scanned. Using the fast scanning technique in this way helps maximize the amount of valuable inspection data for the operator, while helping to minimize the overall project duration for the same inspection area.

IMPROVED PROJECT DELIVERY

Performing a pre-project calibration also has additional benefits for the onshore project delivery process. If the parameters (wall thickness, defect type, pipe fill, etc.) used in the pre-project calibration are confirmed to be sufficiently representative of the parameters seen offshore, then it is reasonable to assume that analysis values derived from the calibration will also be the same. For a Discovery inspection campaign, this can (depending on the number of individual full scans to be assessed) reduce the overall final reporting time by a factor of four.

In the project illustrated here, the pre-project calibration approach was successfully applied as the company detected a small pinhole type metal loss anomaly at the bottom of line. When the inherent Discovery under sizing tolerance is considered, it is possible that this defect could be a significant area of concern. This could have been missed using a simple rejection limit-based approach (which potentially could have been used if a representative pre-project calibration had not been performed). However, the pre-project calibration had been performed with the operator providing a representative sample with similar defects which had been recovered from a pipeline failure in field. Consequently, both the analysis technique and the technicians offshore were able to easily detect and size this defect.

Apart from this single defect, no other anomalies were identified in any of the other segments of the flowline at the chosen inspection locations. This information provided the operator with good confidence about the condition of the rest of the line.

CONCLUSION

Although a pre-project calibration is not, by itself, an important component of pipeline inspection and integrity, a good calibration test can help ensure the complete success of an inspection campaign. By targeting and refining the analysis approach during the pre-project calibration, the results can be provided quicker and with a higher degree of accuracy and confidence.

Low-dose hydrate inhibitors present new flow assurance option

LDHIs offer logistical, cost advantages over traditional treatments

ZACHARY T. WARD, NIRUPAM PURKAYASTHA, FELIX HOEVELMANN, JONATHAN J. WYLDE, DIRK LEINWEBER, *CLARIANT*

WHILE OIL PRICES have settled down from the volatility seen in recent years, further expectations indicate that the market is in a realignment phase. Within this realignment, new strategies for oil and gas production must be explored to remain competitive in this new environment.

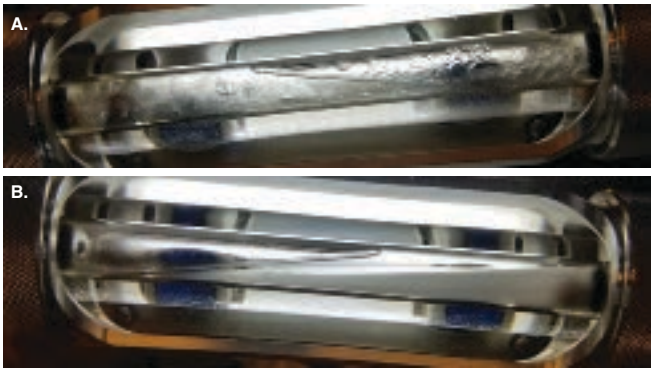
In deepwater production, one of these new strategies is the installation of longer subsea tiebacks to develop remote reservoirs, where no existing host facilities are nearby; and a fixed installation is considered uneconomical. Subsea tiebacks with distances of more than 60 mi (97 km) between the well and host facility are not uncommon, and new technologies continue to push the boundaries of what was previously thought infeasible.

A principal consideration for subsea flow assurance is the prevention of gas hydrates. Formation and agglomeration of gas hydrates in pipelines may result in a plug that terminates oil and gas flow. Remediation costs for a gas hydrate plug are relatively high and the prevention of these plugs is of great importance. A number of mechanical and chemical options exist for the mitigation of gas hydrates. A classic method for hydrate prevention involves the use of antifreeze chemicals like methanol or ethylene glycol to thermodynamically inhibit hydrate formation.

However, oil producers and service providers must innovate to remain competitive. A relatively new technology for hydrate mitigation is the family of chemical additives known as low dose hydrate inhibitors (LDHI). LDHIs consist of two classes of chemicals: kinetic hydrate inhibitors (KHI) and anti-agglomerants (AA). Both classes are successfully used to mitigate gas hydrates in subsea and deepwater applications globally, though neither can be considered a universal solution.

LDHI chemistry provides a significant logistic and operating expense advantage over traditional alcohol treatments, where steep methanol-in-crude penalties have rendered methanol injection uneconomical for many fields. As deepwater production continues to push toward higher pressures, longer tiebacks and increasing water cuts, gas hydrate treatment using LDHIs is approaching the limit of current technology.

To remain competitive under this new market paradigm, Clariant has developed a high throughput experimentation (HTE) platform to rapidly accelerate new product development. This new platform brings together automation and intelligent analytics to fully automate all aspects of product development, including: test planning, formulation and synthesis, application testing, and results analysis. This platform only requires the chemical and test fluid inputs for testing. When combined with traditional application testing methods, such as the rocking cell, autoclave and/or flow loops, new products can be developed and delivered to market in a fraction of the time.



Gas hydrates with no anti-agglomerants (a) and gas hydrates that have been treated with anti-agglomerants (b). *(Courtesy Clariant)*

The typical life cycle of an innovation project is divided into several phases. The initial discovery phase involves extensive searching and application testing of a wide array of available materials to determine a potential solution. This is where the new HTE platform is capable of rapidly accelerating the innovation life cycle in addition to finding more candidates, leading to the determination of a better potential solution. Where traditional rocking cell methods would typically run two experiments per week, the HTE platform will run up to 24 experiments per day.

Once candidates are determined, the product identification phase begins where these candidates are fully tested on traditional methods to verify their performance. Once the ideal product is identified, the HTE platform may be used again to optimize the formulation with more granularity than traditional methods. Resulting in a more efficient product ready for introduction to the market.

This method was used to develop the first product in a suite of next-generation AA-LDHIs capable of reducing current LDHI consumption during production up to 30% as compared to current state of the art technology. These chemicals were developed using the new HTE platform in conjunction with currently established rocking cell and autoclave technology. This technology will enable continued production in fields that are currently reaching LDHI injection capacity due to design constraints.

Looking forward, additional products may be developed that are better tailored for their target application.

Consortium completes first 3D OBN seismic survey offshore Poland

GRZEGORZ ZAJFERT, *MEWO S.A.*

POLISH CONSORTIUM MEWO S.A. and Pro Geofizyka Kraków has completed the first 3D ocean bottom node (OBN) seismic survey in the Polish Economic Zone of the Baltic Sea.

The Wolin 3D seismic project is a first stage of prospecting in the offshore concession acquired by Central European Petroleum in 2017. The concession is in the southwestern part of the Pomeranian Bay in the Baltic Sea. Carried out from May to June 2019, the project consisted of 48,500 source positions over 125 sq km (48 sq mi) in water depths of 2-15 m (7-49 ft), with some 22,800 man-hours recorded on site. Because of port traffic, shallow water, yachting and fishing activity 785 OBNs were deployed as receivers.

Six vessels dedicated to specific tasks such as deployment, source, equipment recovery, guard and multi-task were based in the port of Świnoujście.

The first stage of the campaign included pre survey performed by a Reson SeaBat 7125 multi beam echo sounder. This allowed accurate bathymetry and seabed quality of the area to be determined.

The next stage was to prepare the 785 OBN receivers (OBX 750E from Geospace Technologies) with appropriate gain settings determined during a test on site. Then the OBNs were deployed on the seabed in a regular 400-m x 400-m (1,312-ft x 1,312-ft) grid. Then the seismic source line acquisition was carried out over predetermined lines.

This acquisition phase, despite marine traffic, fishing, pleasure yachting, marine mammals and weather, had to be completed within 60 days due to the battery life in the OBN receivers. To avoid exceeding the OBN battery time it was necessary to maintain a sufficiently high shot repetition rate (2,800 shots per day) on the Sercel GI gun seismic source which was fired every 50 m (164 ft).

TOP: The source vessel *Imor* was one of six vessels used in the project. BOTTOM: OBX 750E nodes ready for deployment. *(All images courtesy MEWO S.A.)*

After the source acquisition, a Seaeye Falcon ROV was used for OBN recovery.

Due to the ultra-shallow water, vessel choice was critical. The vessel had to have shallow draft but large enough deck space and payload capacity to install the compressed air supply for the air gun source. It also had to have accommodation for 20 people, data acquisition rooms, workshop and technical facilities as well as supplies. Being able to manage this all on a single vessel platform saved cost and time.

During the survey work, high standards were maintained to protect the natural environment and minimize any impact on it. A passive acoustic monitoring system for detecting and identifying potential marine mammal presence, source soft start procedure, and an acoustic deterrent device were all employed to ensure the disturbance of marine life was minimized. During the main seismic acquisition, the onboard marine mammal observers did not detect any marine mammals in the vicinity of the operation.

While the final processing of the seismic data is yet to be completed the acquisition and initial results point to a highly successful survey outcome for Poland's first ever offshore 3D OBN seismic survey.

The digital portal for Lundin Norway's drilling operations went live in September. *(Courtesy Eigen)*

Digital portal delivers drilling operations overview

Developed in collaboration with Lundin Norway

OFFSHORE OIL AND GAS digitalization software provider and systems integrator, Eigen, rolled out a unique digital portal for Lundin Norway's drilling operations in September.

The Drilling Portal is now live and combines remote monitoring of information from different systems to provide a quick and intuitive overview of all drilling operations. A search functionality also allows access across historic information, reports, and 'lessons learned.'

Imagine an offshore operative coming in to work and within 30 seconds being able to know the current state of your drilling operations and where you needed to focus your attention that day. This is now the reality for drilling operations staff in Lundin Norway thanks to the new digital drilling portal developed in collaboration with Eigen.

The system is an online portal that shows key information on the status and activities across all rigs on hire and provides a platform for sharing the numerous daily reports from each rig.

An overview page shows a map with the exact location of all active rigs with aggregated key performance indicators such as overall productivity, NPT, active safety cases, meters drilled, etc. Everything is interactive and users can drill down further, to view a breakdown of NPT, for example.

Dedicated pages for each rig (accessed by either clicking on the rig in the map or navigating to the operations page) give detailed information such as the drilling supervisor, links to the current reports, drilling progress against plan, time/depth plots, and safety status.

One of the most powerful features behind the portal is an intelligent email processor. The system intercepts the emails normally sent from each rig with various information from reports to alerts and lessons learned. It automatically extracts the relevant data, categorizes it and stores it, publishes it to the portal, and makes it available for searching and filtering.

This piece of technology means that the workflow for the operators on the rig remains unchanged but the work process for onshore teams is improved, because it has removed the email inbox clutter and made it much easier to find information. The latest version of anything is always on the portal, which reduces the risk of acting on the wrong information. There is no need for engineers to file the information themselves, which saves time and removes frustration - and past information is always easy to find.

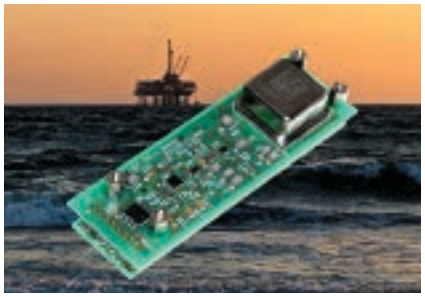
The system also interfaces to the central 'lessons learned' database which makes it much easier for people to find relevant learnings, making it more likely that they will access them.

The portal is also being made available as a mobile app.

Rugged gyro sensor designed for small bore tube-based systems

SILICON SENSING Systems has developed the CRS39 gyroscope specifically for the oil and gas industry, with offshore applications. The device is intended for platform stabilization, downhole surveying, north-finding and robotic control.

With a form factor created specifically to suit systems operating within small-bore tubes, the company says that CRS39 will provide optimal solutions for applications where bias instability, angular random walk and low noise are critical. Depending on the requirement, CRS39 can be used alone or in combination – as in complex applications such as drill hole mapping systems.



The CRS39 gyroscope has been developed for oil and gas industry use, with offshore applications. *(Courtesy Silicon Sensing Systems)*

Silicon Sensing says that recent technological improvements afford its gyros the sensitivity to detect the earth's rotation, allowing north to be determined without using magnetic means. This is advantageous in systems performance, especially underground where using conventional magnetic compass or GPS technology can be difficult or impossible.

The company says that the CRS39 is based around a proven and robust silicon micro electro-mechanical system (MEMS) vibrating ring sensor which delivers ultra-low noise performance, high shock tolerance and excellent vibration rejection. The patented MEMS device is the outcome of 15 years of design evolution and refinement.

CRS39 is one of the most capable sensors in Silicon Sensing's single axis gyro portfolio. The technology is used as the basis of the company's highest performance IMU – the DMU30 which challenges the performance of bigger, heavier and far more costly fiberoptic-based inertial systems.

Silicon Sensing says that it continuously evolves and enhances its products, aiming to reduce size and extend performance. Currently the company is introducing improvements which will reduce the existing two board structure of CRS39, making it a single PCB component and reducing the size. At the same time engineers are incorporating changes to update the gyro sensor head and associated drive electronics – enabling improved north-finding-performance.