

INSIDE

NOVEMBER 2018 #30

SMART SYSTEMS SAFE SOLUTIONS

GustoMSC



an NOV company

THE PIONEERS OF OFFSHORE ENGINEERING

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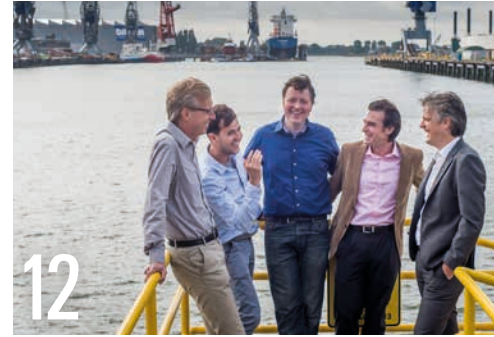
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COLOPHON

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PREFACE EMBRACING THE DIGITIZED FUTURE



Dear readers,

There is no doubt that digitalization and automation are transforming our industries. The potential is huge in terms of increasing safety and operational efficiency, whilst at the same time reducing operational costs.

Our company's future is based on continuous innovation, central to which must be the development and implementation of digital technologies. To do this successfully requires the significant critical mass and effort that only large companies like NOV can deliver. That is one of the reasons why we are excited to have joined NOV as per June this year.

While we work within the NOV family on these digital technologies, we will continue to offer our customers the flexibility of combining GustoMSC's mobile offshore unit designs with any mission equipment available in the market. At the same time NOV continues to serve clients that prefer to work with other designers. By combining GustoMSC's advanced engineering and designs with NOV's leading equipment suites, we aim to provide the industry with optimized and integrated solutions that best serve our clients' needs and offer advanced future possibilities.

In this issue of Inside Magazine a number of experts discuss and explore the ways in which they deploy digital innovation.

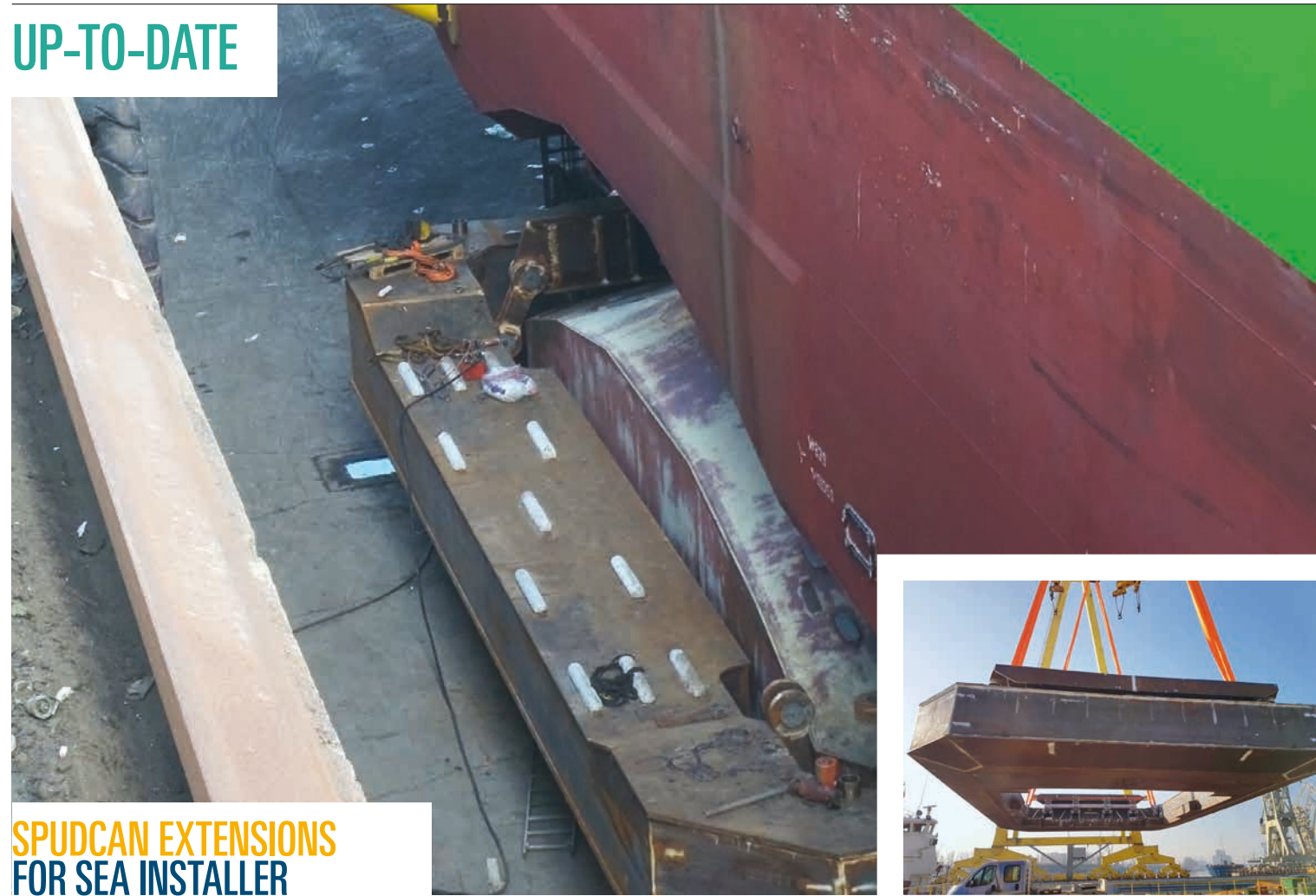
Hege Kverneland, Chief Technology Officer at NOV, talks in our cover story about the 'new era' that digitalization is creating for the Oil & Gas sector. The possibilities range from a dramatic increase in the speed at which seismic data is analyzed and archived, to optimized equipment performance and predictive, condition-based maintenance. These developments will make the exploration process much smarter, and the extraction process much more efficient, resulting in significantly reducing total cost of ownership for our customers.

Robert van Kuilenburg and Jason McMullen, Managers at Noble Drilling, elaborate on the drivers of the company's superior performance and how the company constantly looks for ways to improve processes, including digital opportunities. In particular, the company reveals how NOVOS allows them to benefit from a whole new level of operational support.

These new technologies will profoundly affect the ways in which people work at sea as they provide the resources the world requires for its growing population and increasing living standards. GustoMSC's contribution is to make this process as safe and efficient as possible. In this issue our Engineering colleagues share their view on how their services contribute to this mission.

I very much hope you will enjoy reading, and I'm looking forward to your continuous feedback.

Nils van Nood
Managing Director GustoMSC
inside@gustomsc.com



SPUDCAN EXTENSIONS FOR SEA INSTALLER

In May 2018, Sea Installer received spudcan extensions designed and engineered by GustoMSC. Additionally, GustoMSC modified the jacking system in order to make it fit for handling these extensions. Since her sister Sea Challenger has the same spud cans, one set of spudcan shoes fits both units. Both units are NG-9000C self-propelled wind-turbine installation jack-ups designed by GustoMSC in 2010 for GeoSea.

The purpose of the extensions is to reduce the spudcan penetrations in the seabed for one of the projects for GeoSea. Minimizing these penetrations has two main advantages:

reducing the required leg length and reducing the time for removing the unit from its location.

In principle, divers installed and removed the spudcan extensions while Sea Installer was floating. Only the first installation was carried out in the drydock in connection with uncertainties in tolerances on the spudcan shape.

The design, fabrication and installation of the spudcan extensions was a fast-track project. GustoMSC received the order for the concept design at the end of November 2017.

US OFFSHORE STEADY TOP WIND FEEDER SOLUTION

In order to serve the emerging US offshore wind markets, GustoMSC and Barge Master joined forces in the development of a motion-compensated feeder solution. The motion-compensated platform BM-T700 will be placed on a US-flagged offshore vessel or a seagoing barge in order to feed the wind-turbine components fast and safely to the wind-turbine installation jack-up at the offshore installation site. This US offshore wind-feeder solution is able to comply with the Jones Act and overcome the operational restrictions of US ports.



By compensating the motions of the vessel, the BM-T700 platform creates a stable lift-off base for a maximum weight of 700 tons in sea states up to Hs 2.5 meters, and is Lloyds certified under the lifting appliances rules. As a result, operations can continue in more adverse weather conditions, enabling



Two weeks later the draft design was delivered and the yards started their work based on the draft design drawings and a 3D model of the extensions. The first set of the basic design drawings was ready mid-January 2018 while the full design was finalized mid-February 2018.

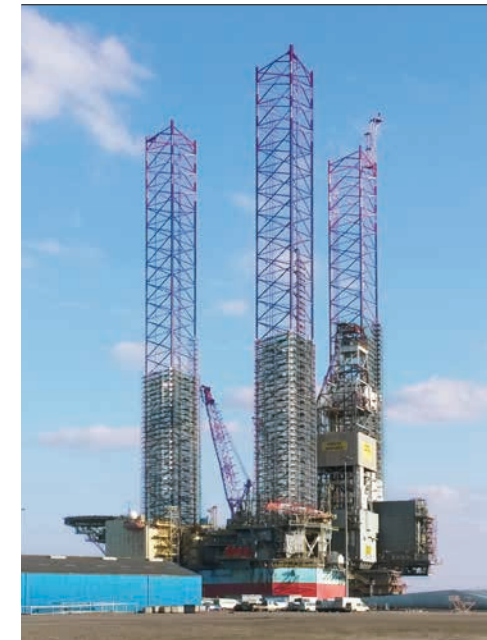
This fast-track project is a good example of how GustoMSC's operational support services can improve the capabilities of units and equipment in operation.

Kees Verdouw
Project Manager

completion within the execution timeframe. GustoMSC will perform the naval engineering and the integration of the BM-T700 platform onto a new or existing DP2 feeder barge. Although GustoMSC sees sufficient potential for larger purpose-built Jones Act compliant installation jack-ups to cope with the expected increase in turbine size, weights and hub heights. This is a solid solution for the first wave of US projects within the remaining timeframe.

By offering this steady top-feeder barge, GustoMSC and Barge Master offer the capability to overcome current obstacles and make the successful development of the first US offshore wind projects possible within time and budget constraints.

Karel Wagner Senior Engineer
Brian Cheater Senior Consultant



MAERSK INSPIRER CONVERSIONS

Maersk Inspirer will serve as a combined production/work-over unit for the Yme New Development (YND) project on the Norwegian Continental Shelf, with scheduled start of production by the end of 2019. For this project, the Maersk Inspirer will be converted and will undergo numerous changes.

Owned by Maersk Drilling (MD), Maersk Inspirer is a GustoMSC designed CJ70 drilling jack-up. GustoMSC has supported MD for the conversion needed for the prior Volve project, and is now again supporting MD for the YND project. The focus of GustoMSC's work is on the structural aspects of the unit. Special emphasis is placed on the fatigue life: the required service life on Yme is 10 years with an option to extend this to 15 years. GustoMSC has carried out very thorough analyses to demonstrate the fatigue service life, using high DFF safety factors due to the prolonged stay of 15 years on location, and taking all fatigue history into account. An independent fatigue verification by DNV GL fully confirmed GustoMSC's results. Other topics of GustoMSC's work-scope involve the overall strength in operational and storm conditions, hull strength verifications, strength of the unit in several accidental cases (10,000-yr wave; vessel impact; earthquake; fire; explosion), as well as detailed structural verifications of load introduction points of newly added modules for the YND project.

This project demonstrates GustoMSC's capability and dedication to support owners of mobile offshore units during the entire lifetime of these valuable assets.

Jos van der Hoorn
Project Manager

DELIVERY AND COMMISSIONING OF CRANE BOOM EXTENSION FOR BRAVE TERN

Mid-June of this year, GustoMSC delivered and commissioned the crane boom insert truss of the Brave Tern (NG-9000C design). It is the fourth GustoMSC around the leg crane to be upgraded to keep pace with the ever-growing requirements in the offshore wind installation sector.

The order was received in July 2017 and resulted from earlier work upgrading the Bold Tern and the Brave Tern and is similar to the lengthening of the boom already performed for the Bold Tern. This time, our delivery for the Brave Tern included supplying the insert truss to Fred. Olsen Windcarrier, as well as on-board measurement of the existing boom to make sure the new boom section will be seamlessly integrated when finished.

This crane boom extension enables the vessel to handle the largest turbines in the market, such as the MHI Vestas V164 model. In July, the Brave Tern loaded the first set of wind turbine components in Denmark and installed them on Vattenfall's Horns Rev 3 offshore wind farm.

Alain Wassink
Commercial Director



27 FEBRUARY – 1 MARCH 2019
WIND EXPO TOKYO

Participation in Dutch pavilion

6 – 9 MAY 2019
OTC HOUSTON HOUSTON

Stand 115

25 – 26 JUNE 2019
GLOBAL OFFSHORE WIND LONDON

Stand 78

SEPTEMBER 2019
OFFSHORE WIND EXECUTIVE SUMMIT HOUSTON

NOVEMBER 2019
ADIPEC ABU DHABI

Participation in the Dutch Pavilion

26 – 29 NOVEMBER 2019
WIND EUROPE OFFSHORE COPENHAGEN

Stand C2-B6

SMART IRON

SOPHISTICATED SOLUTIONS FOR OIL AND GAS OPERATIONS

Digitalization is an emerging technological driver of change in our industry. Hege Kverneland is Chief Technology Officer at NOV. In this cover story, Hege addresses some of the most interesting new benefits of this transformation, such as reducing total cost of ownership, optimizing performance and safety, and predicting maintenance.



“Of course, we will still make big machines — you can’t lift or move heavy things with big data.”

Hege Kverneland
Corporate Vice President
and Chief Technology Officer, NOV

Inspiring encounter at RDM Campus Ground

On 20 March, Hege Kverneland visited GustoMSC in Schiedam. While meeting Nils van Nood (Managing Director GustoMSC) to go to RDM Campus Grounds on the other side of the Rotterdam Harbor, they shared their insights on digitalization within the offshore industry.



According to Hege Kverneland, big data is dramatically changing the core working processes of the oil and gas industry. Hege: “For instance, a lot of seismic data is being gathered from the formation before drilling even begins in order to identify where there is a chance of finding oil or gas. With ‘big data’ processing technology, this seismic data can now be processed and optimized faster and better than ever before, and the risk of drilling a ‘dry’ exploration well is reduced.”

As a second step in that evolution process, Hege mentions the archiving of all this data: “This will help us with the analysis and comparison of data and the output it will deliver. So the exploration process will not only become smarter, the expected output of the various wells can also be predicted more precisely.”

From scope to scale

Another interesting development is that big data is also being used for monitoring the functioning of equipment. “If we can predict a failure in the future, this offers a huge added value to customers.” As a striking example, Hege describes the Blowout Preventer (BOP) and the recently developed Condition-Based Maintenance system for the BOP. Every BOP, by regulation, has a dual control system, also called ‘pod’ (a yellow and a blue pod). If one of these control systems fails when it is deployed at seabed, the BOP must be pulled to the surface and repaired. This means that the rig is on “downtime”, since it cannot be drilling. A BOP may weigh up to 500 tons, and if it is deployed at 3000 meters of water depth, it takes at least 24 hours just to get it up to the surface. Then we need to find the error, we need to get hold of spare parts and finally we need to deploy the BOP to the seabed again. This ‘roundtrip’ can take anywhere from one to two weeks. With a typical day rate of 300,000 US dollars, this is very costly for both the drilling company and the operator.

What NOV has developed, is a Condition-Based Maintenance that can predict that a component or a system on the BOP is going to fail. “We can now predict a failure a couple of

weeks before the part fails. We can thus notify the drilling contractor about this, so that he can shift to the second control system (from yellow to blue pod).”

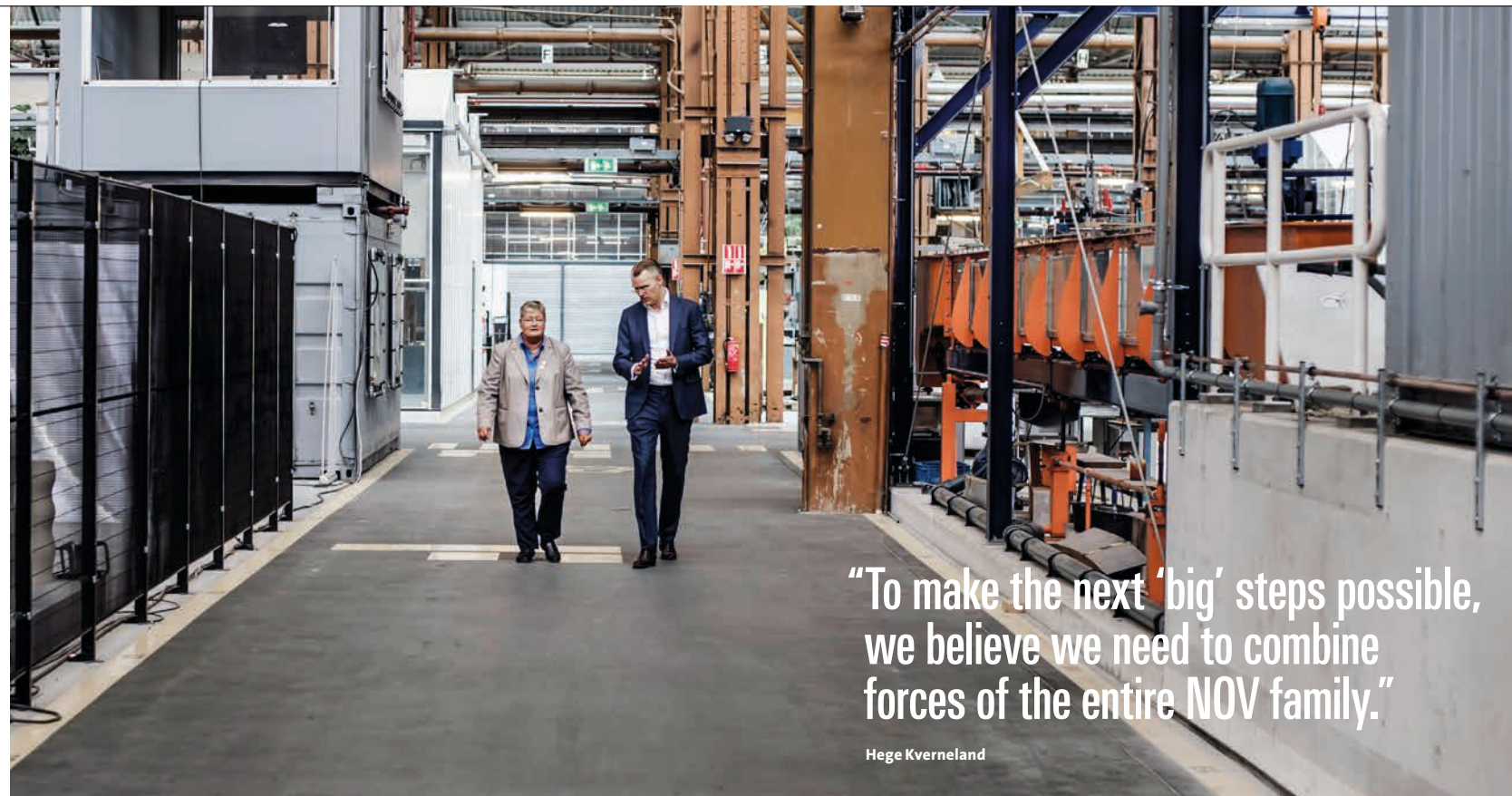
An impressive piece of product development that Hege enthusiastically describes as an industry first.

The day rates in the industry remain high, with 300,000 to 400,000 US dollars per day. So reducing the customer’s total cost of ownership and improving uptime have always been the main focus in our industry. Hege: “We are leveraging our expertise with condition-monitoring technology and reliability centered maintenance. Improving the customer’s performance as well as reducing the total cost of ownership of the rig equipment is the key to success.”

From ‘pain points’ to overall performance

Hege assures us that the use of data is not something that is just starting in the industry: “The digitalization on the BOP is just one example of all the innovations we have already been working on for quite some time. It is true though that we are at the beginning of a totally new era.” She describes the current developments: “Using data for analysis and comparison is a big step in developing new ways of working. NOV used to monitor equipment for maintenance purposes and offered clients advice or support in connection with specific problems — ‘pain points’ if you will. But in the future we will monitor the system as a whole. We started with the BOP, but now we are also working on all the other equipment on the drilling rig as well, for instance the top drive and the draw work; all the other equipment that might fail.”

Another step in the new approach is the ‘flexible riser’. Hege: “We have a specialized company in Denmark that produces flexible risers. Their technology offers the option of embedding fiber optical monitoring systems into the flexible risers. These systems offer continuous measurements of the temperature along the entire length, in some cases even up to 4 kilometers long, and of fatigue in the upper parts of the flexible riser.”



“To make the next ‘big’ steps possible, we believe we need to combine forces of the entire NOV family.”

Hege Kverneland

Providing predictive maintenance

According to the product specifications, the flexible riser can detect hot spots, breaches – position and time, position control of external mounted accessories, and the control of remaining fatigue life. Hege: “We offer a substantial advantage with this real-time monitoring system; checks with ROV (Remotely Operated Vehicle) Submarines are very expensive. So with the monitoring system of the flexible riser, we are saving valuable time and money!” A very good example of the huge added value of providing predictive maintenance.

“Standardizing software components to become an industry platform; this is one of the recent developments that I’m most enthusiastic about,” Hege states. “At NOV, we are creating a ‘standard’ software platform together with all participating companies. To make the next ‘big’ steps possible, we believe we need to combine forces of the entire NOV family.” To support this vision, Hege mentions software innovations like GoConnect and NOVOS. “These innovations can only be realized by big companies, or at least by companies working closely together, due to the necessary – high – investments.”

“But there are also other important factors involved,” Hege states. “Think of the legal issues, and don’t forget the issues in connection with sharing data or the ownership of data. The data that is gathered, also from the client’s equipment and working processes, is in fact critical information. Nowadays, companies are less reluctant to share data, because they see the various benefits. But when it comes to the ownership of data, it continues to be a major issue. Therefore it is elementary to develop policies on those matters as well.”

Breaking boundaries and entering new frontiers

Another challenging issue that the industry has to face, is finding the right personnel. “When I left university in the nineties of the last century, there were no computers.

I did follow a course on Data, but I didn’t know – then – what it was for. And look how the world has changed in that direction over the last decades!” Hege describes the informal culture, in any case the not corporate looking engineers, at the NOV labs in Houston: “This hip and hot group of young engineers, or data scientists as they are called, walk around on sandals. This might sound ironic, but do not underestimate the importance of this change in our company culture. The innovative power that these young engineers bring to our industry will certainly have a major impact on how we will be doing business in the – very near – future. I believe that’s the main reason why our industry needs to attract new, young talent: they are the ones that will make the digital transformation really happen.” And this may also be the main reason why NOV is thinking of starting one or two new innovation hubs with data scientists in Europe.

To our question of what her future focus will be for the coming years as Chief Technology Officer at NOV, Hege answers, “We will focus more and more on software development. Of course, we will still make big machines – you can’t lift or move heavy things with big data – but we can make our equipment smarter, safer and more efficient. So unlike manufacturers from China that are making equipment cheaper, we believe in quality, safety and above all in improving performance.”

“Using data for analysis & comparison is a big step in developing new ways of working.”

Hege Kverneland

Hege Kverneland Corporate Vice President and Chief Technology Officer, NOV

Hege Kverneland received an M.Sc. in Mechanical Engineering from the Norwegian University of Science in 1990. She also graduated from the General Management Program (GMP) at Harvard Business School in 2009. Hege has more than 25 years of extensive engineering and product management experience, contributing to quality assurance, research and product development. Hege began working at FluScan in 1991, which was acquired by Hitec in 1994, and thus joined National Oilwell® through the acquisition in 1999. She has authored numerous SPE/IADC papers on drilling as well as two textbooks on Offshore Hydraulics. She held the position Corporate R&D manager at National Oilwell Varco from 2001 to 2009 and contributed to several new product developments in this period, including a new Mud Pump Design, different PM-motor designs, Winches, Heave Compensation Systems, Automation and Drilling Optimization projects.

She has served and still serves on several SPE / IADC committees and is currently a member of the 2018 ONS Innovation Award Jury. Since 2009, she has held the position Corporate Vice President and Chief Technology Officer at National Oilwell Varco.

National Oilwell Varco

National Oilwell Varco (NYSE: NOV) is a leading provider of technology, equipment, and services to the global oil and gas industry that supports customers’ full-field drilling, completion, and production needs. Since 1862, NOV has pioneered innovations that improve the cost-effectiveness, efficiency, safety, and environmental impact of oil and gas operations. Over the course of its 156-year history, NOV and its predecessor companies have helped transform the way the industry develops oil and gas fields. And over the past few decades, the company pioneered and refined key technologies that helped make frontier resources, such as unconventional and deep-water oil and gas, economically viable.

RDM ROTTERDAM

The photoshoot with Hege for this cover story took place at the RDM Campus Grounds in the middle of the Rotterdam Harbor. Being part of the Rotterdam Makers District, the location suits the article’s theme of digitalization perfectly. The Port of Rotterdam Authority and Rotterdam University of Applied Sciences bear joint responsibility for the development of the RDM Campus.

The area is the hotspot for innovation in the port: this is where the manufacturing industry of the future is taking shape. The former shipyard of the Rotterdamse Droogdok Maatschappij (RDM) – where shipbuilders once worked on world-famous vessels like the SS Rotterdam – is now home to a range of exciting private-sector, education and research initiatives. In the heart of the port area – but still surprisingly close to the city center – they work on a range of innovations that will contribute to a ‘smarter port’.

At RDM, companies have access to cutting-edge facilities, and can easily team up with partners in education and research. This acts as a major booster for new innovations. At RDM Rotterdam, you can find a diverse collection of start-ups, SMEs and global players in the maritime and offshore sectors. Over 40 innovative companies – including Ampelmann, Franklin Offshore, Energy Floors and Urban Green – have found a home here.

A special feature of the education facilities at RDM Rotterdam’s Campus is that senior secondary vocational education (mbo) and higher professional education (hbo) programs can be found working together under the same roof. The students can make use of state-of-the-art facilities, labs and equipment. And since they often work on real-life projects, working at RDM also has a positive effect on their job prospects. This makes RDM an interesting location for talented students. It encourages young people to opt for a technical degree program.

6,000 T

VARIABLE LOAD

NG-8000X LEAN & FUTURE PROOF

The rapid development of wind-turbine technology is one of the most exciting industry developments in the global energy sector today. The wind turbines of the near future will require a new generation of larger and smarter installation equipment, capable of handling the great weight and extreme installation heights. The challenge lies in still delivering the high safety standards and the efficiency that is required to ensure that wind power remains a viable alternative to hydrocarbons. The existing fleet and equipment are not suitable to meet these future requirements. To date, sizeable installation jack-up designs like the NG-14000XL, NG-20000X and NG-9000C are the only solutions that can keep up with the requirements of future foundation and turbine installation work, providing a secure and safe solution, combining proven technology with practical innovations. By introducing the NG-8000X, GustoMSC offers a new well-balanced solution focused on economical and safe installation of wind-turbine components.

The NG-8000X is the developers' choice for their future requirements: a larger NG-9000C for deeper waters, with greater capacity and lifting heights. A stable, solid and safe self-propelled platform tailored for a wide range of services throughout the total lifecycle of an offshore wind farm, but also suitable for safe and efficient work in oil and gas applications, such as installation or decommissioning of platforms. In addition, the flexibility of the unit enables a high utilization rate over its lifetime.

The NG-8000X is suitable for the future-proof, high-end installation work of wind turbines in an economical way. The unit is designed for use in water depths of up to 60 m, survival in harsh North Sea type environments, and suitable for the US North East coast and the Taiwan Strait waters. The robust and industry-proven Variable Speed Drive (VSD) controlled jacking system provides a controlled ramp-up / ramp-down and speed and torque control, securing frequent, fast and safe jacking operations.

A key feature of the NG-8000X is the GustoMSC telescopic boom leg crane. This is a leg encircling crane with the innovative combination of a high hoisting height for tower, turbine, and blade installation and heavy load capability at a lower height. The telescopic boom breaks with the cumbersome pattern of extreme boom overhang over the bow of the vessel and breaks with the pattern of growing crane weights and subsequently growing installation jack-ups. By mitigating the size and weight increase, the total solution of jack-up and crane is more cost effective and leaves more variable load capability available in operations. The compact storage of the crane boom increases the allowable sea states in transit conditions, creating better performance and uptime.

An optimized leg design provides the finishing touch to the new jack-up design, optimizing the overall performance of the unit even further. The end result is a lean and highly effective installation jack-up with a well-balanced CAPEX to OPEX, ensuring safety and efficiency at a low risk.

Jan-Mark Meeuwisse
Commercial Director

HIGH REACH TELESCOPIC LEG CRANE
1,250 T @ 35 M
(1,377 US SHT @ 114 FT)
capacity in both extended and retracted mode. With extended boom a height of 148 m (486 ft) above deck can be reached. With retracted boom a height of 108 m (354 ft) above deck can be reached.

VARIABLE LOAD
6,000 T
(6,600 US SHT)
Large variable load in transit and in operational jacked-up condition.

SELF-PROPELLED
12 KNOTS
AND DP2
Cost saving by eliminating support vessels, reduced mobilization time. Full control entering ports and reducing risk by precise and safe navigation.

JACKING SYSTEM
> 3,000
CYCLES
For daily jacking moves, 150 per year, with VSD controlled system.

FREE DECK SPACE
3,000 M²
(32,292 SQFT)
4 x 8MW turbines and blades, or 2 x >10MW turbines and blades or 3 x >10MW turbines excl. towers, including mission equipment.

MAXIMUM WATER DEPTH
65 M
(213 FT)
Max. 100 m (328 ft) leg length and 79 m (259 ft) leg length under the hull.



This is the third article in a series addressing developments around the theme 'working safely and highly efficiently at sea'. In this article Sjoerd Hendriks, Engineering Manager, and his colleagues from the Engineering Team elaborate on the contribution of our Engineering Department to our company's mission. Senior Expert Engineer Hugo Hofstede, responsible for jack-up analysis technology and Maas Hoogeveen, Ronald van der Meulen and Kayo Vanderheggen, working on engineering tool development, give their view on our engineering services and how these safely push the boundaries of offshore equipment.

A COMPLETE RANGE OF ENGINEERING SKILLS A STRATEGIC ADVANTAGE FOR THE DIGITIZED FUTURE

GustoMSC is a leading design and engineering company. One of our core strengths is that GustoMSC integrates a diverse range of relevant experts, skills and technologies in one company, things that are otherwise found only within separate specialized companies. In addition, GustoMSC is able to draw from its long history and the experience of having designed and installed over 250 units. The result is a company that offers everything from pioneering technology and designs to operational support, always in line with highest safety standards.

Shared experience and knowledge

We are proud to say that GustoMSC has a remarkable track record of having designed and installed more than 250 units of different design types and for different markets. This represents an incredible body of experience. Crucially, it also generates unrivalled user and in-house feedback on the construction, operation and performance of different designs for a wide range of locations. This feedback enables us to gather in-depth knowledge of all the technical aspects of operations, and to increase our understanding of the practical and operational aspects of Mobile Offshore Units (MOUs) and their equipment.

In order to remain at the forefront of new developments in the industry, we collaborate. Not only with our customers, but also with the academic world and partners within joint-industry projects, technical committees for design standards, and industry platforms such as the jack-up conference. This makes the most of our ability to think creatively, allowing us to come up with novel solutions.

Different solutions

Ultimately, we believe, this open approach of knowledge sharing and sparring with peers is the best way to innovate, because different people create different paths towards a solution. As engineers we certainly enjoy working this way. And with its complete range of experts, GustoMSC is able to achieve this level of multidisciplinary innovation.

One of the outcomes is that we have developed a suite of proprietary software geared to the specific requirements of our designs and customers, which is one of our strengths. For our designs and engineering work we may use regular off-the-shelf analysis software. But our own in-house developed software allows us to efficiently perform analyses for our customers' units, while making sure we follow the latest developments in technology, insights, and design standards. Moreover, we remain flexible enough to perform the most challenging one-off assignments.

Legload analysis

For jack-ups this has led to the development of the Legload software, which we use in all our designs and site-specific assessments to study the interaction between a jack-up, the seabed it is standing on, and the action of waves, current, and wind. The analysis can be performed according to any design standard required and the results are easily interpreted and compared to design limits.

We have also developed a version of Legload that clients can use themselves, called the Site Feasibility Tool. This tool has all the properties and limits of jack-ups in a client's fleet programmed in. It thus allows the client to quickly assess the suitability of its jack-up for a specific site, and requires only a limited number of properties to be entered by the client in a simple and understandable interface.

Simsep for simulation

The dynamic response of a jack-up to the waves is an increasingly important aspect of the type of analyses GustoMSC performs. For this purpose we have developed the Simsep program. The dynamic behavior of a jack-up in sea states can be studied by simulating time series of various sea states. One significant recent development is that we are now able to perform the highly accurate simulation of extreme irregular waves.

All these advances were partly driven by specific customer requirements, and were instrumental in allowing jack-up operations in the demanding northern part of the North Sea.

Owing to these advances in available computer power, and the improvements in our software, we frequently run statistical analyses involving many hundreds of hours of simulated storm conditions in a couple of hours. Until recently we relied much more on deterministic analyses that would cost us a day.

The Site Feasibility Tool allows clients to quickly assess the suitability of its jack-ups for a specific site

Sjoerd Hendriks, Maas Hoogeveen, Ronald van der Meulen, Hugo Hofstede and Kayo Vanderheggen.



A new world of digitalization

In light of our pioneering approach, you won't be surprised to learn that GustoMSC is eagerly embracing the wave of digitalization that is transforming the industry. Indeed, the benefits of digitalization already have an important influence on our engineering toolset, while big data allows us to gain even more feedback on the performance of the units, improving our understanding of both technical and operational aspects.

Exciting possibilities

Digitalization will result in new services and products for our customers that are not possible using the traditional engineering methods. The effect the digital transformation could have on the quality of our services and products is impressive.

In the near future we will benefit from live data from the unit. And our parent company NOV has developed truly exciting cloud-based big-data solutions. This will give clients a website dashboard allowing them to monitor ongoing operations, the health of their hardware, and predict required maintenance. In addition GustoMSC is exploring various ways to facilitate on-board decision making and ways to unlock the full potential of units.

Needless to say, GustoMSC aims to remain ahead of the competition via the continuous development of smart and safe solutions, with digitalization forming a key consideration in most of our new developments.

Total engineering support

But whatever the future brings in terms of new and yet unimagined technologies, GustoMSC will never lose sight of the fact that we are here to support our customers, every step of the way. That means dedicated and active engineering support for all lifetime phases of a mobile offshore unit.

Thus we provide technical consultancy services and market studies, we offer fully customized design packages, we supply specialized offshore equipment, and we provide operational support to existing units, including aftermarket services. All these different businesses demand their own specific engineering support, and they are all characterized by advanced technology and cooperation. Being active in all these specific segments strengthens our capabilities in other areas, and we are able to create state-of-the-art knowledge. The operational support gives us practical feedback that enables us to improve our designs, or to recognize the need for a specific equipment set.

Excellence for Noble

A perfect example of this process is the way in which we have supported Noble Drilling – a leading offshore drilling contractor for the Oil & Gas industry – to achieve operational excellence. Noble has eight GustoMSC designed jack-ups and vessels in its fleet.

It is not only about performing the calculation it is essential to know what to do with the results

We offer not only the required operational support of the rigs and equipment in operation, but together with NOV we delivered big data processing technology for the analysis and comparison of data, which is going to continue to drive excellence and safety of their operations.

Proud of our role

People have always found their way to the oceans in order to find resources for living, and they will do so in the future. GustoMSC's contribution is to make this as safe and efficient as possible via technology that enables the building of highly efficient and safe MOUs, while providing support for the operational excellence of these units.

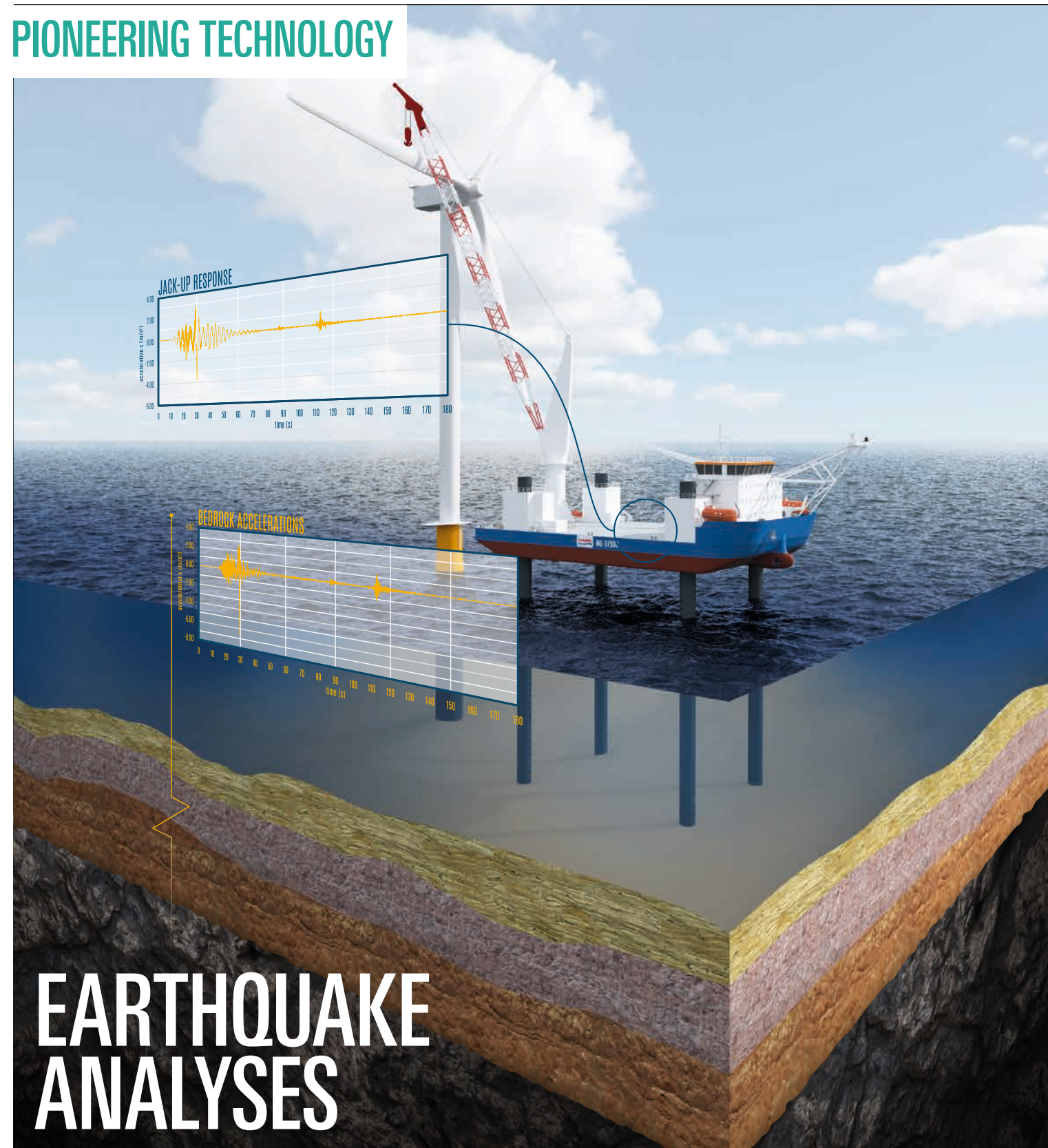
Within this context, engineering can be defined as the application of science and mathematics by which the properties of matter and the sources of energy in nature are made useful to people. As such it is obvious that Engineering, and our range of Engineering skills, is fundamental to our company.

But it's not only about performing the calculation – it is essential to know what to do with the results. And while our advanced technology and engineering toolset is an important differentiator for GustoMSC, it is our people that make the difference. Give them the right tools and they will achieve wonderful things.

THE PIONEERS OF OFFSHORE ENGINEERING

GustoMSC is a reputable design & engineering company of mobile offshore units and equipment. In close cooperation with our clients, we translate experience, science and technical knowledge into realistic & innovative ideas. The performance of new and existing jack-ups, vessels and semi-submersibles is further optimized by our operational support and engineering consultancy. In this way, GustoMSC enables and supports safe and efficient operations at sea, contributing to a sustainable future.

PIONEERING TECHNOLOGY



EARTHQUAKE ANALYSES

Bottom-founded offshore structures, such as jack-ups, have to be able to withstand earthquake events (seismic loading) of which the intensity depends on the area of operation and the risk involved. Changes in regulatory standards (e.g. ISO 19905-1), awareness in the sector, and the industry trend to install jack-ups in more seismically active regions mean that seismic analyses have become an important consideration in demonstrating the safety of a jack-up operation at a particular site, or in the design of new-built units.

There is a significant growth of interest for offshore wind-turbine installation in the Japanese and Taiwanese regions. Wind farm projects are slowly materializing in these regions and the first jack-up built in Japan, Penta-Ocean's CP-8001, a GustoMSC NG-3750C design, is close to completion. From the start, severe earthquakes in these regions were significant for the design of this unit.

GustoMSC provides engineering and consultancy support regarding the structural response and verifications of bottom-founded structures subjected to seismic loading. With our comprehensive understanding of jack-ups, our expertise with new designs, and

our development of seismic analyses, we are in a unique position to provide advice, site-specific seismic analyses, and feasibility studies.

Response Spectrum Analyses (RSA)

GustoMSC provides simulations in the frequency domain for generic seismic analysis and screening purposes. The RSA method is generally sufficient for jack-ups in mild seismic regions like the North Sea.

Time history analysis

In addition to RSA, we provide advanced time domain analysis in which (scaled) historical earthquakes are applied to the structural

model. This type of analysis is appropriate for more severe seismic regions as found for example in the Far East. The method is applicable for in-depth and/or site-specific studies and for situations in which high structural and foundation utilizations are expected.

The time history analyses could include soil-structure interaction, non-linear material, and structural behavior. The method is thus more realistic and less conservative than the RSA approach. It allows for an enhanced investigation of local structural parts of the jack-up, such as drilling cantilever, crane boom, and helideck.

New designs

Considering seismic loading directly in an early design phase of new units allows for an optimized design where seismic resistance can be assured with a minimal cost and weight. Seismic analysis allows GustoMSC to provide designs tailor made for the Far East offshore wind farms. The advanced calculation capabilities facilitate an increase in the safety in the offshore industry and, at the same time, enables contractors to safely reduce the level of conservatism where possible and take maximum advantage of the capabilities of their equipment.

SKIDDING AUTOMATION

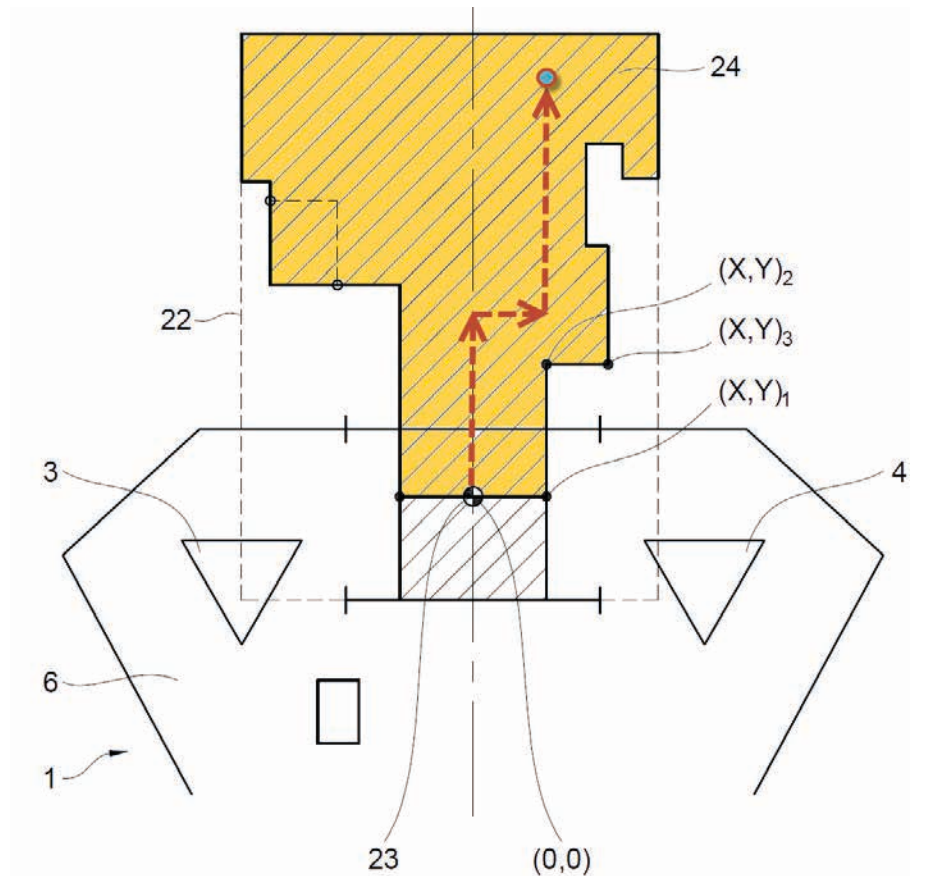
Since the first delivery of the GustoMSC X-Y Cantilever Skidding System in 2001, many have followed. From the smallest for the light drilling unit SEA-2750-LD to the biggest for the Cat-J CJ70s.

We recently developed several software modules to improve the operability, safety and maintainability of the X-Y Cantilever Skidding System.

Cantilever Mapping

For the X-Y Cantilever Skidding Systems currently in operation, the maximum longitudinal and transverse skidding distance is safeguarded by maximum outer boundaries of the skidding envelope, i.e. the maximum aftward, forward, port and starboard reach. The actual maximum skidding envelope normally does not follow this rectangular shape but has different boundaries depending on the actual position of the cantilever. During skidding operations, eyes on deck will normally be in contact with the skidding operator to ensure the operation is performed without any clashes.

The GustoMSC Cantilever Mapping module allows the operator to define the maximum skidding envelope for each longitudinal and transverse position of the cantilever, i.e. the 'boundary model'. Additionally, temporary



structures on the main deck or a nearby platform that limit the boundary model, can be defined precisely with the Cantilever Mapping module.

During skidding operations of the cantilever, the cantilever position is continuously monitored with respect to the boundary model. If the cantilever approaches a boundary, the skidding speed is automatically reduced and the cantilever will automatically be stopped at the boundary. This add-on software module enables drilling operators to safely utilize the maximum skidding envelope.

If the skidding control system is equipped with the Cantilever Mapping module, it is also possible to safely skid the cantilever autonomously from starting position to target position. We developed the Automatic Skidding module for this additional functionality.

Automatic Skidding

With the "Automatic Skidding" module, the operator can enter the target position (coordinates) or select the target position from preset positions, e.g. pre-defined positions applicable for the project, via the user interface of the skidding system. The skidding control system will propose a trajectory from starting position to target position and visualize the trajectory on the control screen. By accepting the proposed skidding trajectory, the cantilever will skid autonomously from starting position to target position taking into account all applicable conditions and safeguards.

Low Wear Trajectory

Various jack-ups equipped with the X-Y Cantilever Skidding System also have GustoMSC's Operational Support Software (OSS) installed. The OSS Weight Management module presents the loads on the skid boxes for the actual position of the cantilever and cantilever loading condition. Using this data, a check is performed whether the cantilever is skiddable and the skid box loads are within the allowable design conditions.

With the OSS connected to the skidding control system and combined with the above-mentioned skidding software modules, we are able to further optimize the skidding trajectory from starting position to target position. The input from the OSS system in combination with the actual well center position is used to determine the "Low Wear Trajectory". The low wear trajectory is based on the lowest skid box loads per unit of travel and will reduce the amount of wear of the skid pads. Furthermore, it also reduces the required skidding force needed to move the cantilever, and accordingly the wear of the X-Y Cantilever Skidding System drive.

The skid box loads per unit of travel are also logged, which is an indication for operational wear of the skid pad, and accordingly of the remaining lifetime of the skid pad. This can also be taken into account when calculating the low wear trajectory to relieve the skid pads with the highest operational wear.

INTERVIEW NOBLE

EMERGING TECHNOLOGIES

A PATH TO THE RIG OF THE FUTURE

"We've already been using data for years, but the quality of data is a decisive factor for real success."

Jason McMullen

Noble is a leading offshore drilling contractor for the oil and gas industry. The company's proactive style of management has guided it from a one-rig operation in 1921 to one of the highest performing offshore drilling contractors in the world today. Operational excellence, integrating data streams to support decision-making and a competent and engaged workforce are driving the company's superior performance. Robert van Kuilenburg and Jason McMullen, both managers at Noble, represent this impressive company culture.

During an interview at the GustoMSC headquarters in Schiedam, McMullen explained that Noble started late in the last decade with the decision to upgrade the fleet to a premium fleet mix of high specification floaters and jack-ups. The vision was a preemptive move to position the company in such a way as to offer customers the most sophisticated offshore drilling solutions, providing the drilling efficiency and redundant features that customers desired.

From 2011 to 2016, fifteen new state-of-the-art drillships and jack-ups were delivered to Noble. McMullen: "From the first moment, our focus was on the clients and meeting all their requirements. When you look at Noble's culture, what is most significant is that we are customer driven in everything we do. That's the driving force behind our growth."

Gaining competitive advantage

McMullen: "Embedded in the company's culture is a desire to understand the client's needs and today this means a strong focus on performance. The ability to measure down to the component level is going to continue to drive excellence. We just haven't had sufficient quality data in the past to do it. Now this data is available, so operations can be broken down into small steps and automatic logging of the steps can help identify trends and help achieve consistency.

We monitor parameters such as speed, temperatures, pressures and vibrations to build baselines, and we track real-time data to look for trends pointing to potential upcoming problems. This predictive maintenance model will allow us to plan around critical operations. These models can also use this data to track the effectiveness of maintenance operations to adjust service intervals based on need and benefit instead of defaulting to calendar-based scheduling."

Van Kuilenburg agrees that performance improvements are vital in the current market, but he also reiterates Noble's continued commitment to safety: Predictive maintenance helps to increase safety by avoiding unnecessary interventions and therefore leads to less exposure to the marine environment and to possible human error."

McMullen: "It is critical that any automation or maintenance program should avoid false positives or false negatives, in order to create trust in the output of these systems. This has been a work in progress over the last two years. For example, we have worked with rig crews on training, including sensor maintenance and cybersecurity."



Noble

Noble owns and operates one of the most modern, versatile and technically advanced fleets in the offshore drilling industry. Through its subsidiaries, Noble performs contract drilling services with a fleet of 25 offshore drilling units, consisting of 12 drillships and semi-submersibles and 13 jack-ups, focused largely on ultra-deep water and high-specification jack-up drilling opportunities in both established and emerging regions worldwide. Noble Drilling has recently incorporated various digitalization upgrades in Noble's fleet.

GustoMSC designs in Noble fleet

Two jack-ups: Noble Lloyd Noble (CJ70) and Noble Johnny Whitstine (CJ46). Six vessels: Noble Bob Douglas, Noble Sam Croft, Noble Tom Madden & Noble Don Taylor (P10,000), Noble Bully I and Noble Bully II (PRD12,000).

Technology trends for new builds

The working relationship between Noble and GustoMSC has developed over time since the delivery of the first units to the industry in 1979. Van Kuilenburg: "In those days there was no real deep water. Therefore the industry's first objective was to be able to design and build equipment that could drill deeper – even at water depths of 10,000 feet plus where we are drilling nowadays. We also suddenly had to consider the possibilities of working in remote areas, from the Middle East to the Arctic and back, and in rough situations like in the North Sea."

The second objective in this development, Van Kuilenburg adds, was to be able to drill faster: "The operational costs were very high, so the downhole tooling was number two on the list of priorities to improve. At the time it was all about steel. In that sense the deep-water market has stabilized. The challenges of yesterday are commodities today. The only real difference that can still be made, is how you operate the rigs, how you maintain them, and how well you are able to integrate operations. Thus, for new builds, digitalization is extremely important."

"A uniform standard of dataflow is the next big step we need to take," Van Kuilenburg says. "You can gather an enormous amount of data every day, but it is important to validate that data and to really make sense of it. This is still a challenging task." To give an example, one common problem has to do with the differences in time that are being used: "One person uses satellite time, someone else chooses to use local time on another device. This causes difficulties in synchronizing different data streams, which negatively influence the models. So, in this particular case, a standard time server would help."

Noble is evaluating technology for energy-peak shaving as well – not only for saving fuel, decreasing maintenance and lowering costs, but mainly to reduce emissions. These advances could enable rigs to be designed in a less conservative manner, to be less over-powered and less costly. It also helps by maintaining their social "license to operate", which is very important to the company and its stakeholders. Noble considers the use of LNG as a key technology to drastically reduce emissions and this is one of the drivers behind the peak shaving efforts.

With a mission in mind

McMullen: "Important for the transformation that we are undergoing as a company are our corporate culture and an enterprising yet down-to-earth attitude. We are constantly looking for ways to improve our processes and focus on

Adding value for clients

"Another useful market-driven tool is NOVOS (NOV Operating System). We are in the process of installing it on the Noble Lloyd Noble and the Noble Bob Douglas. Drilling automation, data analysis and baseline comparison is being used to monitor variations in performance. Adding value for clients means continuous optimization of the drilling process," according to van Kuilenburg. "NOVOS makes it possible to combine the valuable expertise of multiple drillers in one box, so we are able to come up with the best solutions for specific and different drilling situations."

To optimize the software, Noble is working closely with NOV. Van Kuilenburg: "As we speak, we are collaborating with NOV to optimize safety. It's not just about optimizing performance, we also need the system to be faultless and as safe as possible. This means that we have to exchange a lot of information, not only data but also the knowledge and experience of developers and drillers, between our companies."

Van Kuilenburg: "People don't fully realize the changes that are being brought about by tools such as NOVOS. The role of a driller is changing from a guy who literally puts his hands on the tool, to more of a process operator who adds value by focusing on productivity while responding to alarms and status indicators. It requires a different mindset: a driller cannot go out and make things right with his bare hands or sheer force of will; instead he will interact with the system and tweak a few parameters of the algorithm."

"It's not just about optimizing performance, we also need the system to be faultless and as safe as possible."

Robert van Kuilenburg



the 'direct' added value of using data. Digitalization makes this possible, while I immediately want to emphasize that the quality of data is crucial. We've already been using data for years, but the quality of data is a decisive factor for real success – also in the context of standardization and cooperation. That is the real driver of innovation."

According to Van Kuilenburg, "The rig of the future is not defined by steel, it is defined by how it adds value to the total process."

As another example of the progressive company culture, Van Kuilenburg stresses the importance of collaboration: "In close cooperation with GustoMSC, we have come up with a general concept for a 'rig of the future' – a self-propelled jack-up rig specifically designed for operating in the Arctic. It is mechanically simple but automation heavy. It can be retooled for different missions in remote arctic locations where resupply is difficult and on-site options for repair and maintenance are limited. This is where predictive maintenance comes into play. If you are 1,400 miles from the nearest shore base, it is nice to know three weeks in advance that you need a part, because three weeks is what it will take for that part to reach you. This concept can be very important in future rig design: execute the mission to the client's satisfaction, re-tool, maintain and mobilize for the next mission. The interesting fact is that we found out that this concept works surprisingly well in other remote areas of the world. In addition, research shows that there are approximately 10 billion barrels of oil locked in undeveloped fields located in remote, shallow water areas where this rig design could be an ideal solution."



Robert van Kuilenburg
Mechanical Engineering Manager, Noble

Robert van Kuilenburg graduated in 1996 from Delft University of Technology, Mechanical Engineering, on the use of neural networks in Condition Monitoring. After his graduation, he joined the development team at Innas B.V. developing and testing the linear motion diesel/hydraulic generator and hydraulic transformer. He joined Noble in 2012 as a member of the start-up team for the 4 HHI drilling rigs in Korea. He is currently Manager Mechanical Engineering, has presented and authored multiple papers and is a co-inventor of numerous patents.



Jason McMullen
Manager of Maintenance Systems, Noble

Jason McMullen was appointed Manager of Maintenance Systems in April 2014. In this capacity, Jason heads a team of specialists who oversee the mechanical, electrical, and subsea maintenance within the Noble Asset Maintenance & Planning System. He has developed and implemented a comprehensive maintenance review strategy, which has improved and continues to improve the maintenance on critical equipment. He has worked in the Offshore Drilling Industry for over 14 years now and has held various maintenance-related positions offshore and onshore with various types of rig experience."

OPERATING IN ITS ELEMENT

ASKEPOTT'S FIRST JOB

In January world's largest jack-up Askepott was moved to location for its first job. GustoMSC performed installation assessments and on-board assistance during jacking operations of this giant.

At the end of February, Askepott started drilling through the unmanned wellhead platform Oseberg H, which is Statoil's smallest platform and the first of its kind. Although the start of production drilling took somewhat longer than initially assumed, due to the weather situation in the North Sea, it will complete the project in accordance with the original plan.

Askepott is a GustoMSC CJ70 design that is able to operate in water depths of 70-150 meters and drill wells up to 10,000 meters deep. Together with its sister rig Askeladden, these two Cat-J rigs were tailor-made for operations in harsher environments and for wells in the shallow waters of the Norwegian continental shelf.

Cat-J Askepott's drilling activities on Oseberg Vestflanken 2 are planned to last for about 2.5 years. A total of nine wells are planned, of which Oseberg H is the first location.



THE PIONEERS OF OFFSHORE ENGINEERING



NG-8000X
SELF-PROPELLED
JACK-UP
FUTURE PROOF
& LEAN
WIND TURBINE
INSTALLATION



CJ70
CANTILEVER DRILLING
& PRODUCTION JACK-UP
MARGINAL
FIELD
PRODUCTION
SOLUTION



OCEAN1100-HE
DRILLING
SEMI-SUBMERSIBLE
COST EFFICIENT
HARSH
ENVIRONMENT



SCYLAX
WELL INTERVENTION
VESSEL
SUBSEA WELL
DEVELOPMENT
& INTERVENTION

GustoMSC

an NOV company

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