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Send in the ROBOTS

To Meet the Challenge Offshore

Digital Twins
& Reduced Operating Costs

Market Report
Heavy Lift Vessels

Technology
Deck Machinery

VOL. 45 / NO. 4


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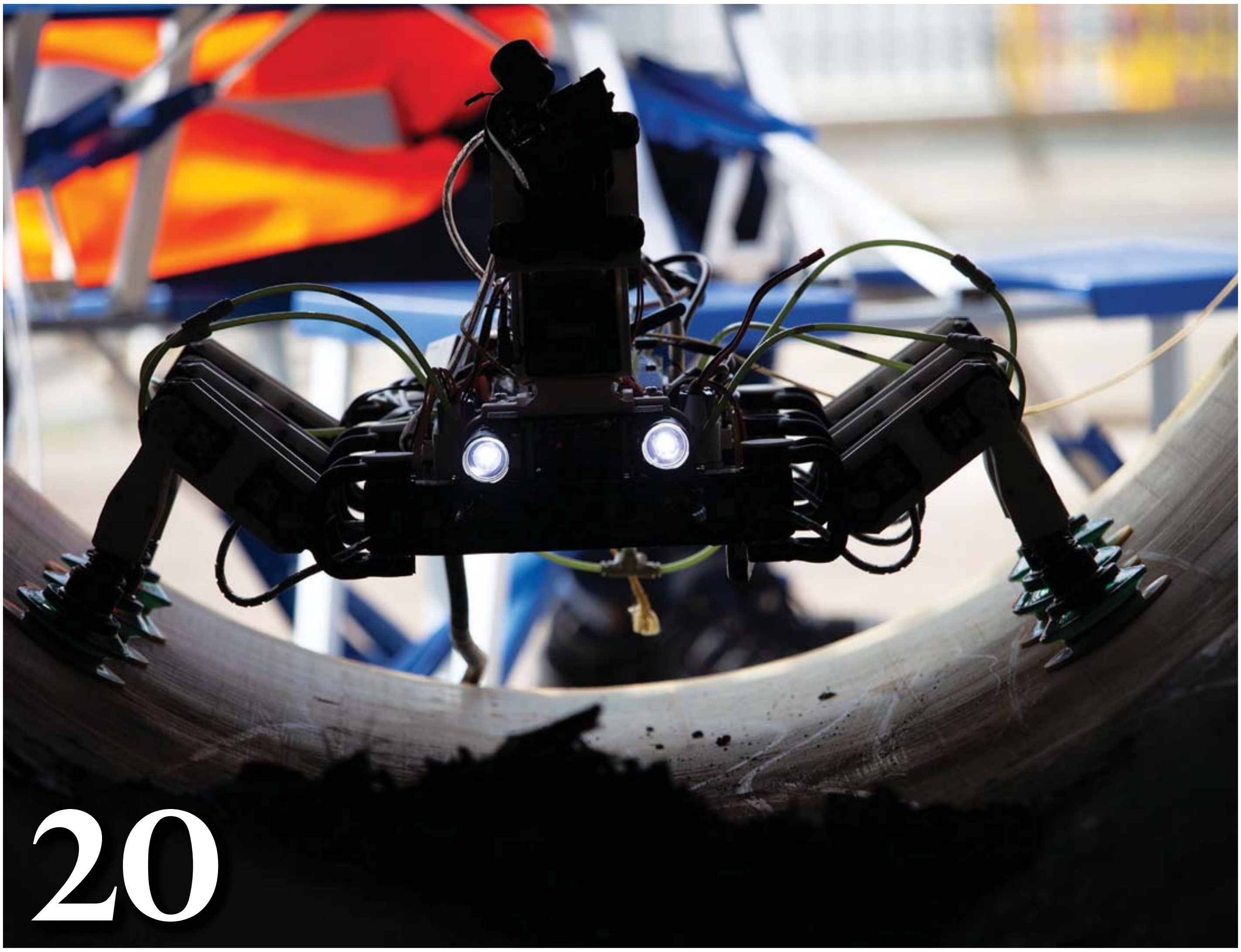
FEATURES



Source: ORE Catapult

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Send in the Robots

Robots and robotics have slowly been entering our lives, in various shapes and forms (and fictional characters), from self-driving household vacuum cleaners to highly automated manufacturing systems. Now they're heading for the offshore world – in just as many shapes and forms.

By Elaine Maslin

ON THE COVER: Image Source: Total

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Source: Bureau Veritas

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BY THE NUMBERS

RIGS

Worldwide

Rig Type	*Available*	*Contracted*	*Total*	*Utilization*
Drillship	25	54	79	68%
Jackup	130	315	445	71%
Semisub	28	60	88	68%

Africa

Rig Type	*Available*	*Contracted*	*Total*	*Utilization*
Drillship	3	9	12	75%
Jackup	14	21	35	60%
Semisub		1	1	100%

Asia

Rig Type	*Available*	*Contracted*	*Total*	*Utilization*
Drillship	5	6	11	55%
Jackup	48	99	147	67%
Semisub	9	15	24	63%

Europe

Rig Type	*Available*	*Contracted*	*Total*	*Utilization*
Drillship	6	3	9	33%
Jackup	19	28	47	60%
Semisub	11	22	33	67%

Latin America & the Caribbean

Rig Type	*Available*	*Contracted*	*Total*	*Utilization*
Drillship	2	18	20	90%
Jackup	2	2	4	50%
Semisub	2	9	11	82%

Middle East

Rig Type	*Available*	*Contracted*	*Total*	*Utilization*
Jackup	21	122	143	85%
Drillship	2		2	0%

North America

Rig Type	*Available*	*Contracted*	*Total*	*Utilization*
Drillship	5	17	22	77%
Jackup	23	34	57	60%
Semisub	5	4	9	44%

Oceania

Rig Type	*Available*	*Contracted*	*Total*	*Utilization*
Drillship		1	1	100%
Jackup		2	2	100%
Semisub		5	5	100%

Russia & Caspian

Rig Type	*Available*	*Contracted*	*Total*	*Utilization*
Jackup	3	7	10	70%
Semisub	1	4	5	80%

This data focuses on the marketed rig fleet and excludes assets that are under construction, retired, destroyed, deemed noncompetitive or cold stacked.

Data as of August 2020.
Source: Wood Mackenzie Offshore Rig Tracker

DISCOVERIES & RESERVES

Offshore New Discoveries

Water Depth	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*
Deepwater	25	12	16	16	19	7
Shallow water	85	65	74	50	80	16
Ultra-deepwater	19	16	12	17	17	2
Grand Total	**129**	**93**	**102**	**83**	**116**	**25**

Shallow water (1-399m)
Deepwater (400-1,499m)
Ultra-deepwater (1,500m+)

Offshore Undeveloped Recoverable Reserves

Water Depth	*Number of fields*	*Recoverable reserves liquids mbl*	*Recoverable reserves gas mboe*
Deepwater	553	40,827	20,355
Shallow water	3,211	412,847	144,549
Ultra-deepwater	325	39,488	26,306
Grand Total	**4,089**	**493,161**	**191,210**

Contingent, good technical, probable development.

The total proven and probably (2P) reserves which are deemed recoverable from the reservoir.

Offshore Onstream & Under Development Remaining Reserves

	Water Depth of fields	*Number reserves liquids mbl*	*Recoverable reserves gas mboe*
Africa	607	20,202	13,153
Asia	860	17,327	8,353
Europe	780	13,057	14,678
Latin America and the Caribbean	196	6,461	37,609
Middle East	119	91,409	148,213
North America	569	3,262	15,031
Oceania	89	12,040	1,507
Russia and the Caspian	58	11,124	13,819
Grand Total	**3,278**	**174,882**	**252,364**

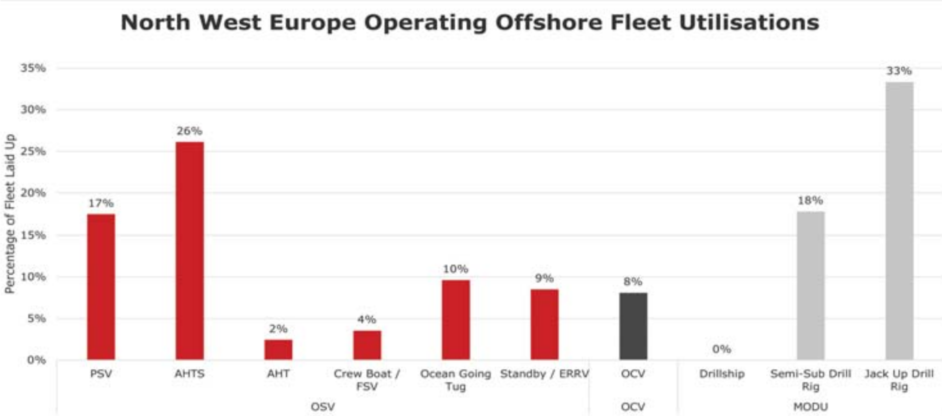
Onstream and under development.

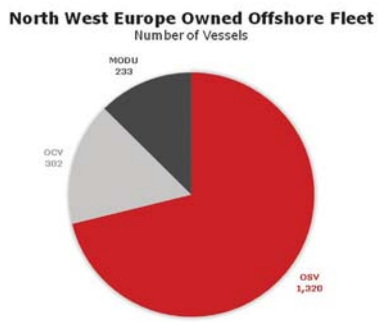
The portion of commercially recoverable 2P reserves yet to be recovered from the reservoir.

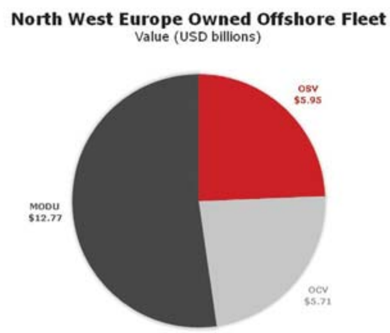
Source: Wood Mackenzie Lens Direct

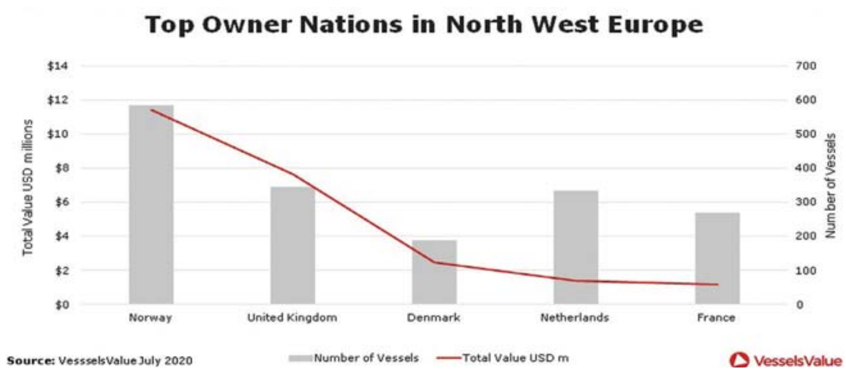
REGION IN FOCUS
NW EUROPE

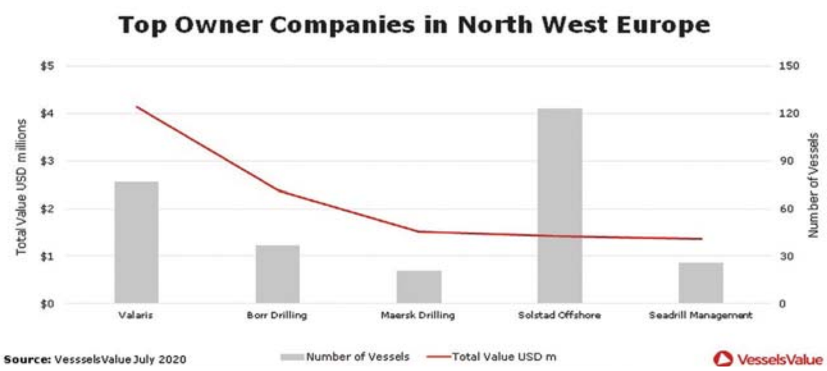
Data & Statistics powered by VesselsValue











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ROBO FUTURE

As we enter nearly half of a year under the haze and uncertainty brought about by COVID-19 and the raft of business challenges it presents, it is arguable that the offshore energy sector has been hit as hard as any other, as it was just starting to emerge from a four-year funk when the global demand for all energy products literally tanked in mid-March. While demand and energy pricing has modestly rebounded and stabilized, the damage has been done. This is a literal Black Swan event, and it will have a dramatic and ever-lasting impact on all walks of life, from entertainment to education to energy production.

While the picture for 2021 and beyond is still a bit hazy, and the pace of uptake on advanced automation and robotics technology is premised on the availability of funds to conduct research and development, it is clear that the future will be defined by robotics and the ability of machines to more rapidly take the place of humans in the jobs that are dull, dirty and dangerous.

With that, we dedicate in this edition more space than traditional to robots and robotics, all from the capable hands of Elaine Maslin.

Starting on page 20 with "Autobots … Transform", we look at how the evolution of robots and robotics in our personal, everyday lives are transforming into systems that increasingly will be found offshore. Make no mistake, the conditions found in the offshore environment are some of the most rigorous and demanding on the planet, and getting machines to work efficiently and effectively is not merely a flip of the 'on' switch. To this end, Maslin taps titans from industry and academia – from Equinor and Total to the UK's Offshore Renewable Energy (ORE) Catapult – to find out the direction and pace of development. While it is easy to declare that the age of the robot has arrived, it's much harder in practice as one executive summarizes: "The future vision is taking the human out of the loop. But we're 10-15 years from that. These early pilots at Shetland Gas Plant will (help to) understand the reliability of the robot. Right now, we don't know."

Immediately following the main feature, starting on page 28, Kris Kydd, Head of Robotics at Total E&P, UK, shares insights on the development of "Stevie the Robot", this month's cover feature. Total has been actively working on robotics since 2013 and the launch of the Argos challenge. Kidd and his team provide a wealth of practical information, including insights on why all non-critical processing has been moved from the robot and onto the cloud. The final story of our robotics trio is a look at robotic advances inside the Orca Hub in Edinburgh, a publicly funded project with some of the biggest names in UK academia signed on to pitch in.

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FIBERLINE INTERVENTION DELIVERS **RAPID INTEGRITY SURVEYS** FOR NORTH SEA P&A PROJECT

The UK's Oil and Gas Authority (OGA) has identified well integrity issues as the greatest cause of production losses in the UKCS1. In its latest Technology Insights Report, it selected Fiberline Intervention (FLI), a novel technology from Well-SENSE, as one solution to help overcome this continuing challenge.

Well integrity issues can progress at different rates and remain undiscovered for some time, impacting on production, safety, risk and reputation to varying degrees. Identifying casing annulus or production tubing leaks, for example, can be problematic and time-consuming, so investigation and resultant production shutdown, may often be deferred.

The traditional method to identify well leaks employs multiple passes of single-point sensors in a wireline tool. Passes are slow at a maximum of 30 ft/min and once leak depth has been estimated, stationary logs are carried out at that depth, and at 1-2 ft increments above and below, whilst well characteristics are being altered at the surface to maximise the leak profile. This process normally takes around 12-14 hours for each well.

SMARTER, FASTER DATA CAPTURE

FLI is an independent intervention and well surveillance system, with no requirement for third-party well control packages or wireline, slickline or coiled tubing. It deploys bare, single-use, fibre-optic line into the well to provide a distributed temperature or acoustic profile, from surface to total depth, rapidly identifying anomalies and capturing changes over time.

FLI is often used for leak detection and well integrity surveys, delivering quality data in a fraction of the time and cost of wireline methods. However, it can also assist with drilling, completion, production and other P&A applications. For example, running fibre through liquid cement can assess the integrity of cement plugs from the inside out.

As a smart, portable plug-and-play system FLI can be operated by just one engineer. It reduces personnel on site, HSE risk, complexity and the carbon footprint of each project. For some applications, FLI can be client deployed with remote support provided by Well-SENSE.

NOVEL APPROACH

The compact system comprises a pressure control launcher, which is connected to the wellhead, and a probe containing the fibre-optic line plus optional single-point sensors. (Figure 1.) The fibre is connected to a small surface data recorder prior to deployment, which can be powered by Well-SENSE's mobile solar panels.

When the probe is deployed into the well from the launcher it spools out bare fibre behind it as it descends to total depth (Figure 2). The fibre acts as a distributed sensing device, monitoring temperature or acoustic changes over time, from every location simultaneously. The fibre and probe are single-use and either sacrificial, to be left in the well at the end of the project, or fishable depending on the client's preference. It takes under an hour to 'rig-up' while 'rigging down' is almost immediate.

NORTH SEA P&A PREPARATIONS

FLI has been used in multiple leak detection and well integrity surveys for mature North Sea assets. One such project saw Well-SENSE engaged by Expro and Well-Safe Solutions to deliver a leak detection survey on two UKCS shut-in wells as part of a multi-contractor decommissioning project. As both were showing a sustained annulus pressure, the integrity of the wells required assessment before a decision could be made on the suitability and location of plugging.

For this campaign, Well-SENSE opted for distributed acoustic sensing (DAS) in combination with a distributed temperature gradient sensing survey (DTGS). Where DTS can provide both an absolute temperature reading and identify changing temperatures, the DTGS is limited to identifying differential changes in temperature, which was a requirement for this application.

The bottom-hole temperature in the two wells was high - approximately 160°C – and whilst FLI can be upgraded to suit high temperatures, in this case, the partners opted to use two standard tools one after the other. This allowed a cost-effective, extended logging period and a second data set to verify the first.

In the first well, the leak location was clearly pinpointed by FLI within one hour, negating the need for a second deployment. In the second well the leak signature was more subtle. After FLI's initial three-hour run, a second probe was launched to validate and verify the acoustic signatures from the first survey and this identified the leak's location within an hour.

The data also provided additional well insights and the rapid results enabled more efficient and reliable decision-making to identify the best location for plug placement.

THE FUTURE IS FLI

While other fibre-optic surveillance solutions are available, unlike FLI, they are either embedded in the completion or encased in a protective intervention medium such as a carbon rod. Compared with onshore data acquisition in the US, FLI could offer up to 75% cost savings or, dependent on the application, up to 90% in the offshore environment.

This is especially attractive for older, lower producing assets, likely to encounter more frequent integrity issues, and for operators looking for a cost-effective alternative to traditional surveillance.

FLI has been used to access deviated wells using a pump-down method and Well-SENSE is currently developing its own in-well conveyance system. To date, the technology has supported more than 30 commercial projects globally, both on and offshore.

Figure 1: FLI's fibre-optic surveillance is faster, more reliable and more accurate than single-point wireline logging.

Figure 2: FLI's bare fibre-optic line is run into the well, from surface to total depth, from a spool contained within a sacrificial probe.

Source: Well-SENSE

MARKET IN FOCUS: GLOBAL **HEAVY LIFT VESSEL** SECTOR

By Catherine MacFarlane, IHS Markit

The global heavy lift vessel market is a difficult place to be. Utilization for the fleet has remained depressingly low since the first oil and gas downturn in 2014, currently hovering around 33% for the global fleet with a lift capacity of over 800 tonnes, according to IHS Markit's ConstructionVesselBase.

Fixed platform installation work, the traditional market driver for the heavy-lift fleet in oil and gas, has seen demand fall significantly. According to global figures from IHS Markit's FieldsBase, 190 fixed platforms were installed in both 2013 and 2014, rising to 219 in 2015. The slowdown in field development activity since then has seen the number of fixed facilities installed slump to 118 in 2017, although this has improved to 147 installations in 2019.

ConstructionVesselBase tracks a total of 127 vessels worldwide with a lift capacity of 800 tonnes or more, with a further

Source: Saipem

12 vessels currently under construction.

However, this is a fleet which is heavily regionalized – 45% of these vessels are barges, capable only of working in benign waters in Asia Pacific, while a quarter are jack-up units, most of which have been purpose-built for the offshore wind market. The majority of the semi and ship-shaped units, meanwhile, are marketed for harsh and deep regions.

Over a quarter of the fleet (27%) has a lift capacity between 800 to 1,000 tonnes, while almost half of the fleet is capable of lifts between 1,001 to 3,000 tonnes.

Meanwhile, only nine vessels globally, are capable of lifts of 5,001 tonnes and over.

On a global level, comparing the fleet by their lift capacities, utilization has been weak across the board – ranging between 32% to 46% for 2019 for the four lift categories in the chart above. Age and hull type also throw up a few uncomfortable home truths. Vessels in this fleet aged 25 years or over had just 26% utilization last year. The vast majority of vessels in this age bracket are barges, suggesting that attrition at this end of the market is badly needed to bring back a more reasonable balance between contractor and operator.

Market conditions, however, have been universally tough and the prolonged contraction of the field development market has forced heavy lift vessel owners with capable units to look elsewhere – namely the decommissioning sector and offshore wind.

DECOMMISSIONING AND OFFSHORE WIND

Despite a sharp increase in the number of projects and platforms requiring removal – especially in Northwest Europe, where, according to FieldsBase, we have over 120 fixed platforms scheduled for removal, the decommissioning market comes with its own set of problems. Removal programs are often subject to budget cuts and delays and are low priority for operators looking to reign in expenditure during lean times. The over-supply of heavy lift vessels at the low end of the market – particularly for the removal of smaller wellhead facilities in shallow waters – has seen a competitive, cut-throat market emerge.

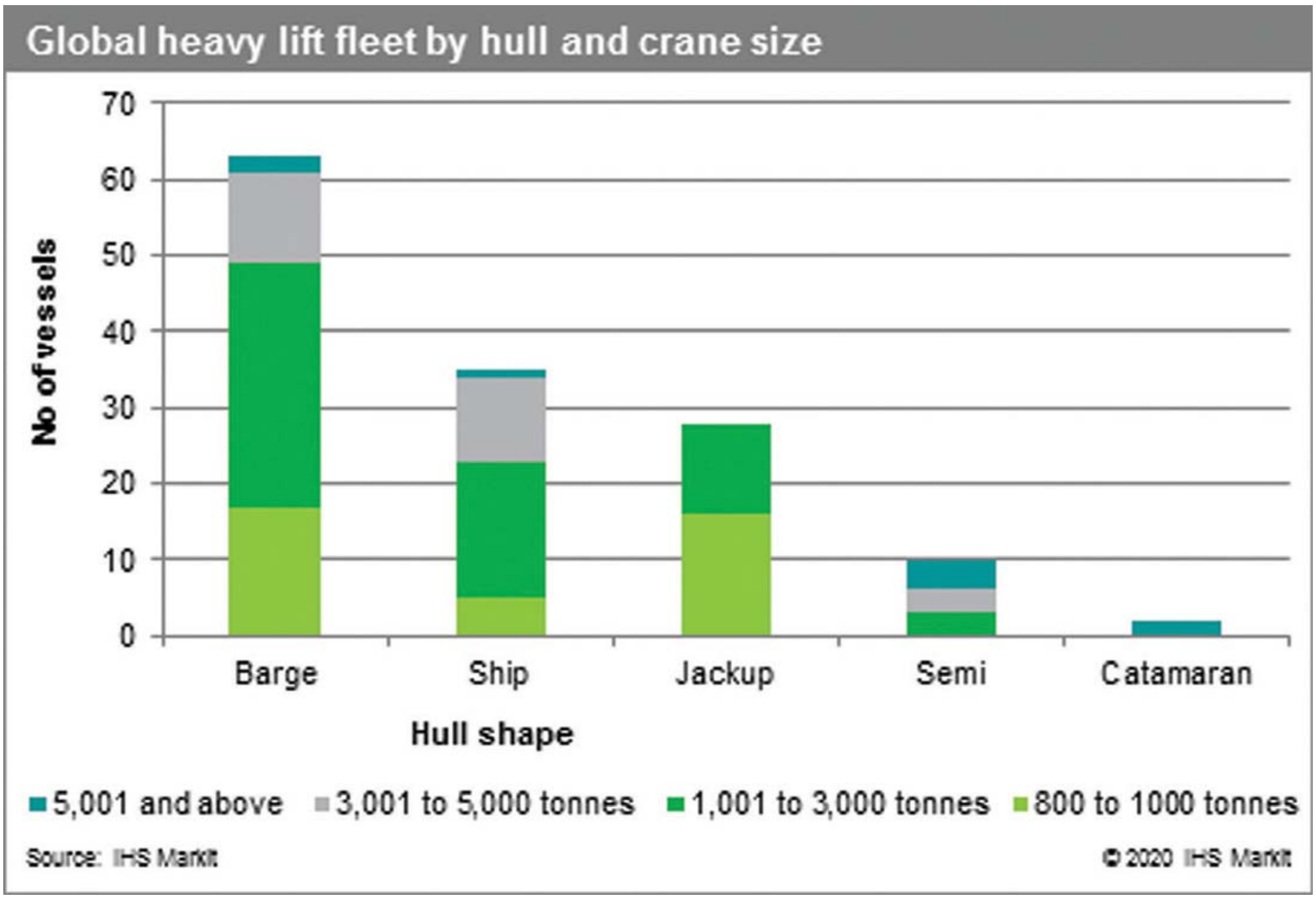
Meanwhile, although major contractors such as Seaway Heavy Lifting, Boskalis, Heerema Marine Contractors and Scaldis have long had some involvement in the offshore wind market, the lack of installation work in the oil and gas sector has expediated their move into the renewables market, where they have also now been joined by Saipem. The Italian contractor's 1987-built Saipem 7000 was first utilized in offshore wind for Equinor's floating Hywind project offshore Scotland in 2017.

Although it has since worked in offshore wind substation installation, the vessel, which is capable of heavy lift operations up to 14,000 tonnes, will start its first major foundation installation campaign in the sector next year, when it will be utilised for jacket installation at EDF Renewables' Neart na Gaoithe (NnG) project, offshore Scotland.

The action has not been confined to Europe either; in the Asia Pacific region, oil and gas contractor Sapura Offshore's LTS 3000's first foray in the offshore wind market was thwarted after the vessel's crane boom collapsed during a construction scope at ONGC's Cluster 8 marginal field development project in Mumbai High. The vessel had been due to undertake the transport and installation of 80 monopile foundations for the Yunlin offshore wind farm in Taiwan, but was replaced at the last minute by Seaway Heavy Lifting's Seaway Yudin.

The movement between markets, however, has not been a one-way street, with specialist wind contractors including Swire Blue Ocean, DEME, and Fred Olsen Windcarrier all recently completing decommissioning scopes within oil and gas. Swire Blue Ocean was the first pure offshore wind contractor to look the other way and dip its toes in the decommissioning market, with the removal of the H7 and B11 platforms in the German sector in 2013 and 2015 respectively, utilizing both of its six-legged jack-up vessels, Pacific Orca and Pacific Osprey. DEME Group followed suit, with the removal of Petrogas' Q1 Halfweg platform in the Dutch sector in 2019 with jack-up Apollo.

Meanwhile, at the start of this year, Fred Olsen Windcarrier's Blue Tern jack-up completed the removal of Perenco's Tyne and Guinevere platforms in the UK sector.



A DIFFICULT MARKET – BUT NEWBUILDS NONETHELESS

The global heavy lift vessel market is a difficult place to be, but it is also a contradictory one. Contractors have scrabbled to secure work within three sectors – field development, decommissioning and offshore wind – and utilization is a struggle. Yet, last year saw orders for five heavy-lift units being placed, and this year has so far seen a further two orders being placed, as well as Boskalis starting work on a former drillship to convert it into Bokalift 2.

In total, of the 12 heavy-lift vessels currently under construction, seven are destined for the offshore wind market. One of the main market drivers has been the rise of the offshore wind market in the Asia Pacific with two of these vessels being directed at the burgeoning Japanese wind sector, and with two directed at the Taiwanese market. The increasing size and scale of offshore wind foundations and turbines – with first orders for 12 MW and 15 MW models already secured – has also been a significant factor.

The pace at which turbine technology has moved, however, raises questions for the installation fleet. According to data from ConstructionVesselBase, excluding the Chinese market, and excluding vessels which are primarily used for substation installation, just over 20 vessels are currently involved in the installation of foundations and turbines. Nearly all of these vessels are less than 10 years old. Yet, the fact that nine of these vessels have lift capacities between 800 to 1,000 tonnes suggests that without significant upgrades, within a few short years, they could face relegation from wind installation work to maintenance work – or be forced into other markets.

Since 2018, utilization for this particular fleet has hovered at around 50%, and already it has become apparent that the smaller units are being overlooked in favor of those with larger deck spaces and cranes. Whilst the market drivers for the offshore wind installation fleet are obvious, the debris left in the wake of the recent glut of newbuilds could create further oversupply within oil and gas, decommissioning, and the wind maintenance market, in a vessel segment which is already clearly struggling.

NOC ON EFFECT: JACKUP RIG DEMAND AT THE MERCY OF NATIONAL OIL COMPANIES' PLAYBOOK

By Teresa Wilkie, Bassoe Analytics

Over the past four months we have been flooded by news of just how badly the offshore rig market has been hit during the double whammy of the Corona pandemic and oil price fallout. We witnessed what seemed like a never-ending wave of contract cancellations coupled with increasing numbers of contract options being declined, along with suspended drilling operations and a surge in deferrals to campaign start-ups. In addition, award activity has almost dried up, resulting in drilling contractor backlog quickly withering away.

Cancellations and suspensions have come from a mix of companies from small independents to supermajors, and almost all regions have been impacted in some form. However, as can be seen from Figure 1, there are currently several areas standing out as having higher levels of activity despite these challenges. These regions, which include the Middle East, Far East, India, Mexico, and Latin America, all have one common denominator – a prevalence of national oil companies (NOCs).

NOCS DISHING OUT FAIR SHARE OF TERMINATIONS

Now, this doesn't mean that these areas and their NOCs haven't been doing their fair share of terminating offshore rig deals, just not to the same extent as International oil companies (IOCs) and smaller independents – plus these regions also typically have some of the largest fleets. As can be seen from Figure 2 IOCs have, so far, cancelled over twice the amount of rig time that NOCs have, however NOCs have handed out more suspensions than the IOCs.

As already mentioned, new awards have been few and far between since March and IOCs and independents have actually awarded 20 deals in comparison to just 12 from the NOCs. However, NOCs may have made fewer deals since the latest market slump but they have still secured more rig time than any other operator type.

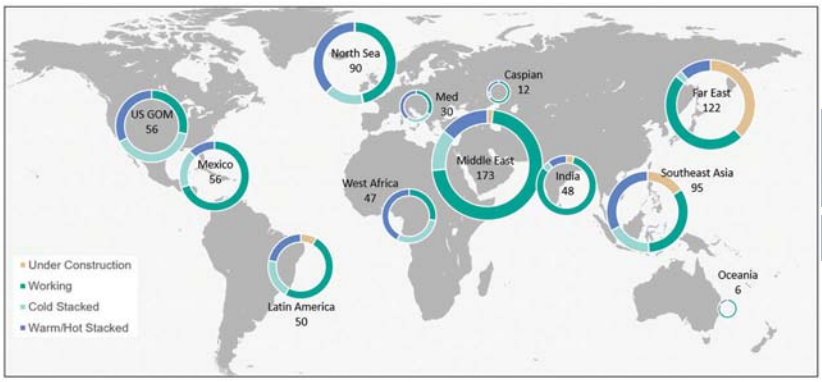


Figure 1: *Global Overview of current Jackup, Semi & Drillship Activity by Status*

Data from Bassoe Analytics

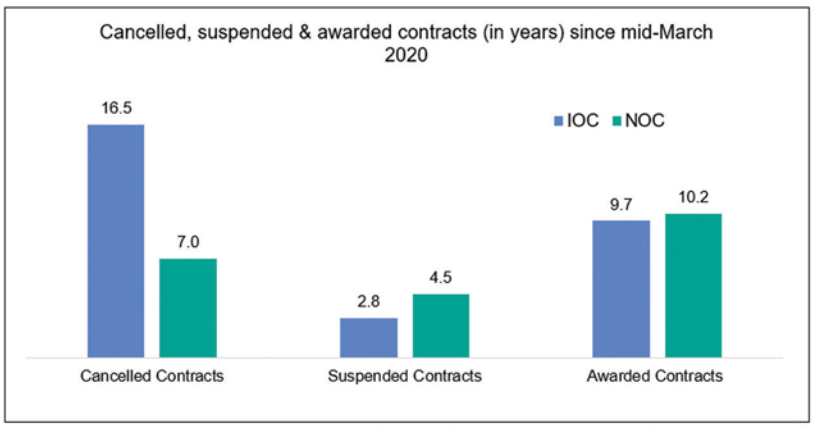


Figure 2: *Cancelled, Suspended & Awarded Contracts for Jackups, Semis & Drillships since mid-March 2020*

Data from Bassoe Analytics

SHALLOW OUTPACES DEEPWATER

During the last downturn, which took hold in 2014 and only started to gather recovery momentum during 2018, several trends were witnessed in the offshore rig market. One of these was a quicker and fuller recovery in the jackup segment in comparison to the floating rig segment (drillships and semisubs). And why was this? Well, excluding Petrobras in Latin America, most of NOC's operations are in shallow waters with the likes of Saudi Aramco, Pemex, ADNOC and ONGC all mass jackup users.

As can be seen from Figure 3, a total of 777 years of backlog was awarded between 2018 until July 2020, consisting of 430 years from the NOCs. Jackup awards account for 587 contract years and 75% of all backlog awarded. Nearly two out of every three jackup awards came from an NOC. International and smaller independent oil companies continue to lead the way in terms of deepwater-contracting activity, but because of its often high-capex nature and differing interests of such companies in comparison to NOCs, much fewer awards were made in this segment during the two-year interval.

NOCS & FIXING RIG TIME OVER PAST TWO YEARS

According to Bassoe Analytics, the top five operators responsible for adding the most backlog over the past two years consist of only NOCs, with Saudi Aramco far ahead of the curve.

The top four companies are virtually jackup only operators, however CNOOC has more of an even mix of shallow and deepwater rig time. There are various reasons behind this trend of hefty rig contracting activity amongst NOCs including a strong focus on maintaining domestic production, offsetting field depletion, being less dependent on imports and meeting state budgets.

On last check, global competitive utilization within the jackup market has fallen from 78% to 67% between February and July 2020, while floating rig competitive utilization has decreased from 60% to 50%.

That is one of the sharpest drops recorded in global rig utilization and it is not yet known when we will reach the trough in this cycle. There has been a slight increase in market optimism due to a bit more stability in the oil price, which could well spur E&P companies to start opening wallets again; however, a lot still hangs on how the Covid-19 pandemic plays out.

Although demand for offshore rigs is dormant at present, it is still there awaiting the right market conditions and when the time is right you can bet on national oil companies driving jackup demand once again.

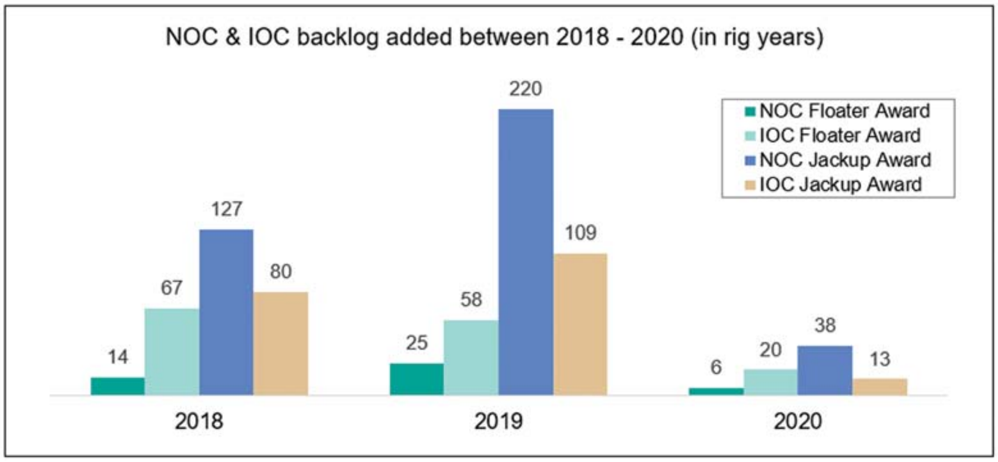


Figure 3: *NOC & IOC Backlog Added from Jan 2018 to July 2020 in Rig Years*

Data from Bassoe Analytics

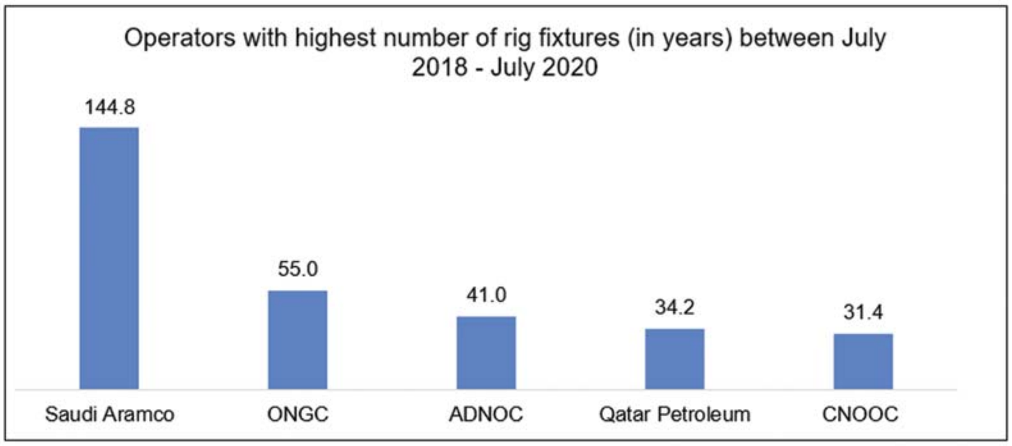


Figure 4: *Top 5 companies with highest numbers of rig fixtures in rig years between July 2018 and July 2020*

Data from Bassoe Analytics

BEARING SURFACE DAMAGE:
SHOULD ALARM BELLS BE RINGING?

SMB233 - *Designing for the offshore environment*

By Chris Johnson, Managing Director, SMB Bearings

Defect classification is a crucial step in determining if goods should pass or fail a quality control inspection. Minor defects usually don't affect the function or form of the item, whereas major defects could adversely affect the function, operational performance, or aesthetics. But, how do you determine when aesthetic surface damage needs action? Here, Chris Johnson, managing director of bearing specialist SMB Bearings, explains why not all bearing surface damage should cause alarm and future headaches for offshore oil and gas plant managers.

Bearing surface distress can take many forms and can result in problematic symptoms such as excessive heat, increased noise levels, increased vibration, or excessive shaft movement. However, not all external bearing flaws point to compromised internal machine performance.

One such form of bearing surface damage is corrosion. This is a naturally occurring phenomenon that offshore oil and gas plant managers must commonly confront. While there are ten primary forms of this pesky enemy, bearing corrosion usually falls into two broad categories — moisture corrosion or frictional corrosion.

Moisture corrosion is particularly commonplace in offshore drilling environments and worryingly, can appear on any component of the bearing. For example, if bearings are often exposed to moisture or mild alkalinity due to their contact with seawater, this could create an alarming oxide layer as a result of a chemical reaction with the metal surface. Mild corrosion may result in light surface stains, but in severe cases, it can lead to etching on the surface of the bearing, resulting in flakes of rusted material entering the raceway.

In these instances, corrosion can graduate from an aesthetic inconvenience to a very real drain on a business' bottom line. According to the IMPACT study conducted by NACE International, the world's leading corrosion control organization, it has been estimated that 15-35 percent of annual corrosion could have been saved if optimum corrosion management practices were followed. This equates to savings between

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$375 and $875 billion annually on a global basis.

The overall effect of corrosion is inherently damaging to offshore structures, as it weakens the structural integrity of the facility itself. What's more, it's impossible to ignore the significance of corrosion costs. However, corrosion resistance must be considered alongside other operating requirements, such as bearing longevity and load. After all, many external factors can prematurely affect a component's operating life.

For example, a marine riser tension system is required to operate with precision but must also operate in unforgiving conditions, which threaten contamination. Due to the extreme environment of oil and gas rigs, corrosion-resistant bearings would be recommended. If a design engineer were to opt for a highly corrosion resistant bearing fabricated from polyether ether ketone (PEEK), this would stop the corrosion in its tracks. Still, the precision of the machine would be compromised. In this scenario opting for a high precision stainless steel bearing with superior roundness, while allowing some superficial corrosion may be preferable.

In the fight against corrosion, ensuring the right equipment is selected is the first step — and this is imperative for both large-scale machinery and small components, such as bearings. So, what are the key bearing design considerations for offshore environments?

CHOOSE YOUR MATERIAL WITH CARE

For offshore oil and gas facilities, stainless steel is the most obvious bearing material choice. It offers corrosion resistance, but also benefits from other advantageous properties such as durability and heat resistance. The latter is particularly important, as rates of corrosion can increase in environments with pressure and heat.

For instance, 440 grade stainless steel is known for its resistance to damp environments. However, this grade has poor resistance to saltwater and many stronger chemicals. Consequently, for harsh offshore environments, 316 stainless steel may be considered. However, as 316 stainless steel cannot be thermally hardened, these bearings are only suitable for low load and low-speed applications. They should only be used in marine applications above the waterline, or in flowing, oxygenated water.

An alternative material option is ceramic. Full ceramic bearings made from zirconia or silicon nitride with PEEK cages can offer even higher levels of corrosion resistance and are often used fully submerged.

Similarly, plastic bearings, with 316 stainless steel or glass balls, provide very good resistance to corrosion. These are often made from acetal resin (POM) but other materials are available for stronger acids and alkalis such as PEEK, polytetrafluoroethylene (PTFE) and polyvinylidene fluoride (PVDF). Like 316 grade bearings, these should only be used in low load and low precision applications.

Another level of armor against corrosion is a protective coating. Chromium and nickel plating offer good corrosion resistance in highly corrosive environments. However, coatings will eventually separate from the bearing and need continual maintenance. For this reason, coatings aren't the most practical option for offshore environments. To protect machinery and equipment from failure, internal components must be high quality and preferably, low maintenance.

MATCH YOUR LUBRICANT TO THE APPLICATION

Surface roughness and lubrication affect whether surface distress will occur, so opting for the correct lubricant matters. A proper lubricant will reduce friction between the internal sliding surfaces of the bearing's components, dissipate heat and inhibit corrosion on the balls and raceways.

Superficial corrosion may occur on the outside of the bearing; however, it should not be allowed to occur on the inside. Opting for a sealed bearing with waterproof greases that contain corrosion inhibitors, is advised. These lubricants protect the internal surfaces of the bearing and can be matched to the specific offshore application environment. Full ceramic bearings are mostly specified without lubrication but can be lubricated with waterproof grease for extended life.

In harsh environments, contamination protection is of utmost importance, so opting for a contact seal is favorable to ensure contaminants do not enter the bearing. For equipment that may be exposed to moisture, a contact seal will also offer increased water resistance. This will stop grease washing out of the bearing, allowing it to do its job in lubricating and protecting the internal surfaces of the bearing. An alternative option is a metal shield, but this offers greatly reduced protection against moisture.

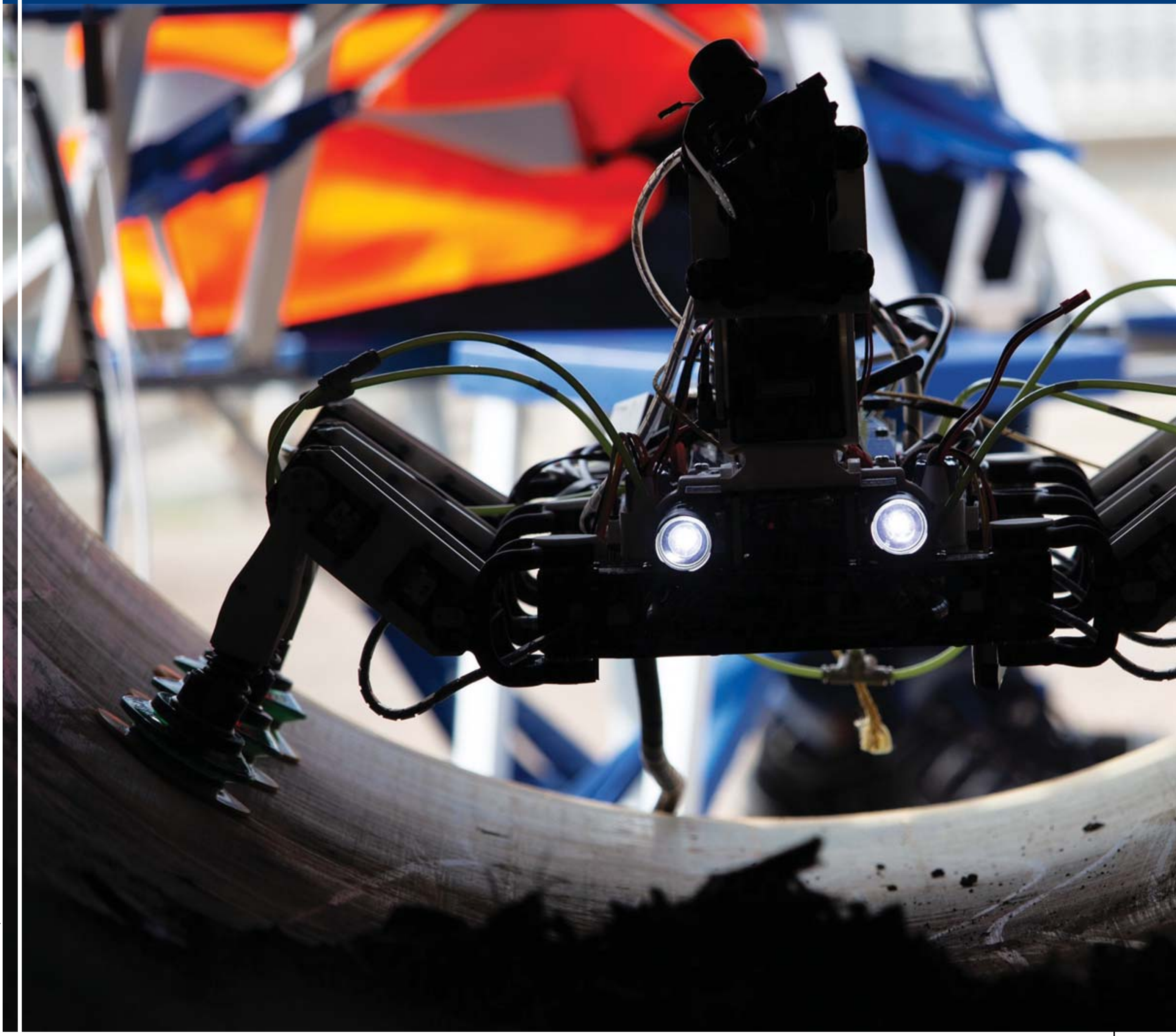
THE ENEMY OR A HARMLESS DISTRACTION?

Corrosion control is just one performance requirement, which doesn't necessarily equate to poor performance or affect the bearing's internal rollability. Downtime is one of the biggest challenges for offshore facilities, so a holistic design approach must be followed to increase equipment uptime and minimize maintenance.

Luckily, offshore facility managers can assess the operational environment, required longevity and loads that will be applied to the bearing and can weigh up whether opting for a corrosion control design feature will be the most cost effective, increase the bearing's lifespan and elevate a machine's performance. After all, the best bearing may not be the one that remains looking aesthetically pleasing for the longest.

showcase

AUTOBOTS ... T



Source: ORE Catapult

TRANSFORM

BY ELAINE MASLIN

ROBOTS & ROBOTICS

have slowly been entering our lives, in various shapes and forms (and fictional characters), from self-driving household vacuum cleaners to highly automated manufacturing systems. Now they're heading for the offshore world – in just as many shapes and forms.

BladeBUG is a blade walking inspection robot, focusing on leading edge erosion inspection.

There could be a lot to gain from robotics, but platforms and offshore wind turbine structures are also very challenging places to put them on. For oil and gas, key drivers are around safety and cost. For the offshore wind sector, the sheer volume of structures being installed is driving a push for robotic systems to do inspection, maintenance, and repair work safely, efficiently, and cost-effectively.

So, where are we today? Robotics, depending on how you define it, isn't entirely new to the offshore industry. Remotely operated vehicles with intricate manipulators have been used for decades, albeit in a fairly manual way, and are now becoming more sophisticated and specialized. Automated pipe handling systems and robotic roughnecks have been introduced to drill floors more recently (OE November 2016: Batteries not included). In the past few years, aerial drones and magnetic hull crawling robots have become part of the offshore inspection tool kit, also mostly with a human operator. In fact, this May saw the first delivery by drone to an offshore vessel (the Pioneering Spirit, in Rotterdam, by Dutch Drone Delta). (More on that here: **https://bit.ly/3cWQDuy**)

Some tentative steps have also been made into topside robotics, from quadrupeds to crawlers, some in response to concerns around hydrogen sulphide (H_2S), which is deadly to humans, and others in response to specific incidents - Total would have been able to act faster in response to the Elgin/Franklin gas leak in 2012 had it had a suitable robotic system on board, for example.

What's now underway is a drive to get those systems already being used able to do more themselves and for newer platforms to be more offshore ready, for tasks from internal inspection to grit-blasting and even X-rays and repairs on wind turbine blades. It's not an easy task and the challenges are not all robotic.

Reducing risk and emissions

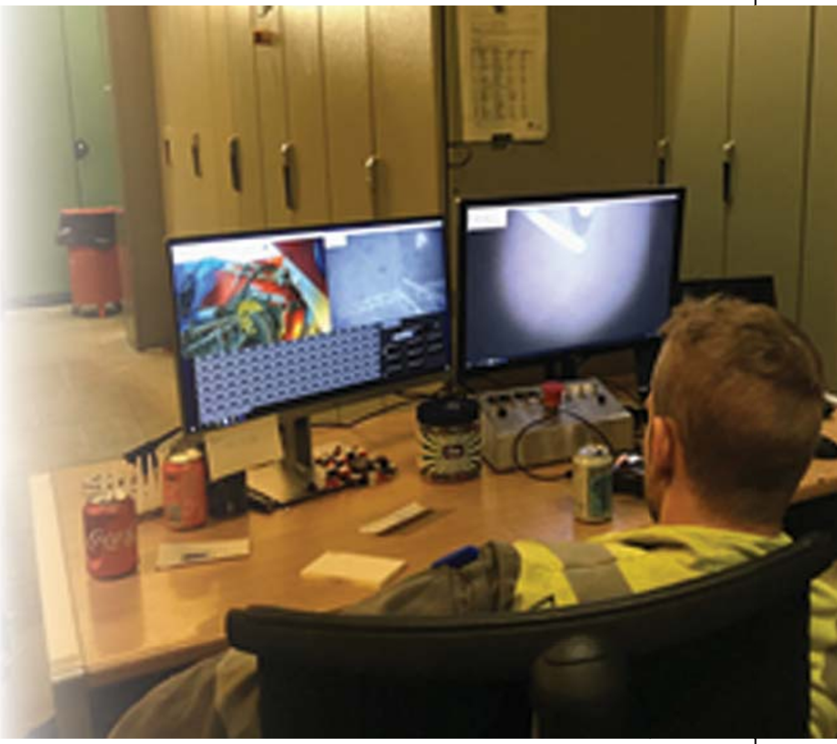
"Robotics take people out of harsh environments and could be more efficient," and they could also help meet net-zero emissions goals, reducing the need for helicopter flights, etc., says Andy Bell, Project Manager, Asset Integrity Solution Centre, at the publicly-funded Oil & Gas Technology Centre (OGTC). But offshore facilities weren't designed for robotics and robotics can't function as well as humans. "Simple things, like climbing stairs, we take for granted, robots can't," he says.

"In a production plant, everything is pretty static and controlled. It's easy to separate moving things from non-moving things and people from robotics," says Alex Loudon, the UK's Offshore Renewable Energy (ORE) Catapult. "Everything is linear, there's no wind, waves or currents to get in the way. It's so much easier to implement automation. When you think about offshore wind, it's a different beast entirely, because of the operating environment."

A raft of new systems

Still, there are plenty of ongoing projects. The OGTC has been working with drone firms Air Control Entech and Fly Logix on aerial systems. Air Control Entech developed three drones – one for flying in higher winds, one with laser scanning capability, and one with ultrasonic non-destructive testing capability, says Bell. In its first project with the OGTC, Fly Logix's worked on a drone capable of "beyond visual line of sight" (BVLOS). Its latest project with the OGTC is to develop a drone for methane monitoring, using long-distance fixed-wing drones. "There's not a one size fits all," says Bell, "there will be different solutions for different applications. I think the technology is there, we just need to start trialling it in the field

Source: Equinor



Equinor has been trialing System T, from Surface Dynamics, a portable robotic surface treatment system for sand or hydro-blasting ballast and other tanks.

and learning from the outcomes. Deployment is key to learning what these robotic systems can and can't do."

A similar ethos is likely to persist for topsides-based robotics – for oil and gas and offshore wind. Here, concepts are even more divergent. Some steps have been made in this area.

In 2017, OC Robotic's snake arm robot (a tracked vehicle with an arm able to enter pressure vessels), was billed as the first offshore robot when it was trialled on Chevron's Alba platform in 2017, then, in 2018, the quadruped ANYmal robot made a debut on a Dutch offshore wind converter station.

Time for trials

Total is now getting closer to trialling a robot co-developed with Taurob, initially for 12 months onshore at its Shetland Gas Plant (see Q&A on page 28), while in Norway Aker BP has plans to trial a number of systems, including a Boston Dynamics Spot quadruped, on the Skarv floating production vessel, and Oxford Robotics Institute has been testing an adapted ANYmal quadruped for its suitability offshore at a fire training center.

A lot of the work done to date has been enabling vehicles to navigate around a site – known and unknown, with visual aids, eg. cameras, lidar, inertial measurement units, artificial intelligence etc. Taurob's latest robot, developed with Total, will add gas detection capability, as well as microphones with algorithms to detect frequencies from valves and pumps to spot anomalies and enable preventative action. Another Taurob project, Offshore Work Class Robot, also currently in development and co-funded by the OGTC, Total and Equinor, is adding manipulator capability to the vehicle, says Bell.

Over in Norway, Aker BP and data

"Everything is linear, there's no wind, waves or currents to get in the way. It's so much easier to implement automation. When you think about offshore wind, it's a different beast entirely, because of the operating environment."

Source: ORCA Hub

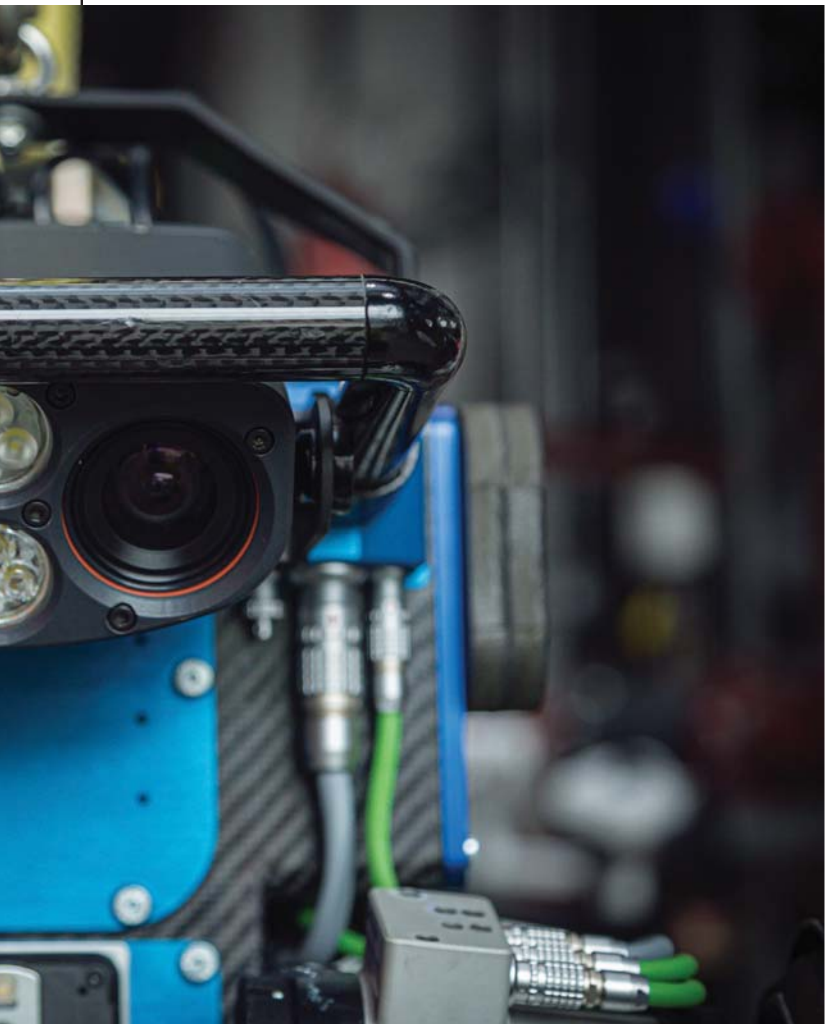
analytics firm Cognite are set to test Spot, a Boston Dynamics quadruped, offshore on the Skarv FPSO. Spot, which has been equipped with a precision acoustic sensor to identify nonconformities in offshore machinery, has been risk-assessed and approved for offshore use in non-classified areas, says Cognite. In the trials, Cognite staff will test the interface between various offshore operational systems and its Cognite Data Fusion platform, to test and verify how the robot can perform remote inspections supported by onshore personnel, for the likes of routine inspections, reducing travel, HSE risk and operational ability to detect anomalous situations, says Cognite.

Since 2017, Equinor has been using System T, from Surface Dynamics; a portable robotic surface treatment system for sand or hydro-blasting ballast and other tanks. It's set to test a treatment and painting system (System P) from the same company in full-scale trials later this year. Equinor is also trailing HXCI (Heat Exchanger Cleaning & Inspection), an in-situ cleaning and inspection system prototype due to tested on a site on land in 2021. Equinor is also working with Total on the Taurob robot.

Doing the dull & dirty work

Similar capability is being worked on in the UK. Quantum Leap Technology (QL Tech) is developing a robot to perform fabric maintenance, i.e. to detect a rusty surface and then prepare it by bristle blasting before applying a coating – a task that otherwise costs a typical UK offshore platform about £5-10 million a year, according to the OGTC.

Fabric inspection and maintenance is also a big challenge in offshore wind. There are already several systems being developed for specific tasks, with ORE Catapult support. InnoTecUK's iFROG, for example, is an amphibious non-destructive testing inspection robot climbing an internal and external monopile foundations, to help inspect welds and corrosion

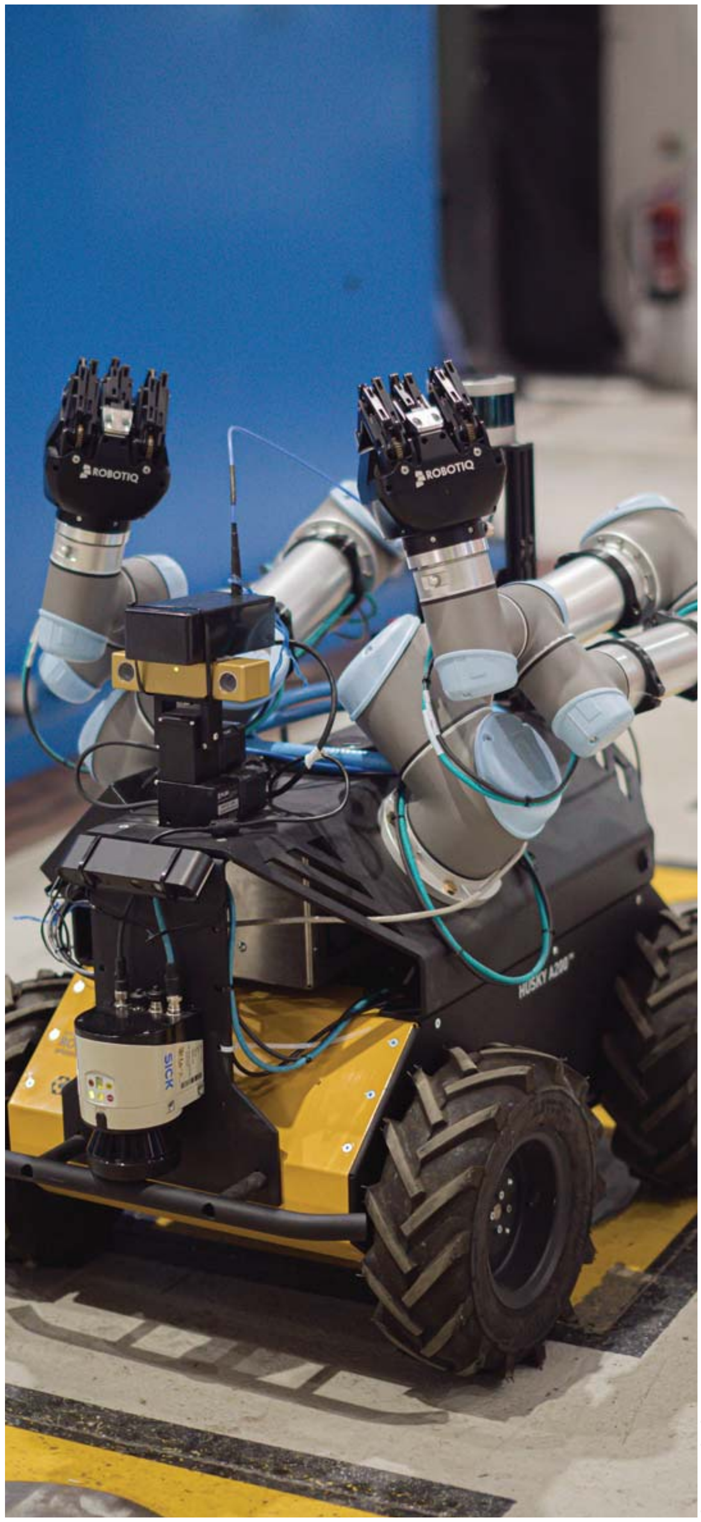


above and down to 60m below the waterline using ultrasonic testing. The procedure is currently done by divers or ROVs and is reliant on weather windows.

Another, RadBlad, by Innovotek working with London South Bank Innovation Centre, Forth Engineering, Renewable Advice and The Welding Institute, is looking to deploy a robotic system able to scale towers and perform radiography on blades to detect defects not possible to find at the factory. Around 3,800 blade failures per year are down to failures to inspect and maintain them at an early stage, according to ORE Catapult. Another, BladeBug, is a blade walking inspection robot, focusing on leading edge erosion inspection when it's too windy for drones.

Autonomy in offshore wind

But, the asset base in offshore wind is so vast, the challenge is also getting to each turbine safely and efficiently. Wind



Source: ORCA Hub

Hub-89: The Heriot-Watt University wheeled Husky robot used to demonstrate practical self-certification as part of an offshore inspection mission.

Prototypes of the OWCR have been trialed at onshore facilities that replicate offshore structures.

Source: Oil & Gas Technology Centre

turbine operators are focusing on smart and automated systems, that self-diagnose, but inspection will still be needed. So, a dual approach is being led by the ORE Catapult using unmanned surface vessels (USVs) through the MIMREE (Multi-Platform Inspection, Maintenance, and Repair in Extreme Environments). Basically, think all of the above in one system. Eight firms are involved in MIMREE using a Halcyon autonomous vessel from Thales, a BladeBug with a robotic repair arm from the Royal College of Art's Robotics Laboratory, a drone from the University of Bristol, an electronic skin developed by a tech start-up, Wootzana, to 'feel' surfaces. Others are working on systems to deploy these systems and human-machine interfaces.

A similar USV-drone pairing is being developed in Brazil by Repsol, the Universidade Federal do Rio de Janeiro, and USV firm Tidewise for oil spill detection. Their ARIEL project involves a USV deploying a drone (both with oil spill detectors; camera and thermal on the drone and fluorometer on the USV) to find and track oil spills.

These are just a few examples. There are other organizations working in this space, such as the Offshore Robotics for the Certification of Assets (ORCA) Hub, based in Edinburgh, and the more recent EU-funded Atlantis Test Centre for maritime robotics for offshore wind, in Portugal, which is focusing in inspection, maintenance and repair systems, and commercial enterprises doing their own work.

Moving beyond visual sight

A lot of what's been done to date is about robots making decisions based on visual cues, says Bell, so they understand and can navigate around their environment and react to obstacles. The next step is repair and maintenance. Louden agrees. "Inspection is the low hanging fruit," he says. "The next level is commercial repairs."

The challenges are communication and BVLOS – and reliability. Early testing of Taurob's robot highlighted communications as a challenge – and that's before you go offshore. The same will apply for aerial drones. There's a similar challenge in offshore wind. Systems could use satellite communications, says Loudon, but it costs a lot. All these systems will also need to be able to speak to one another to deliver efficiencies.

There's also a need to access power. While turbines appear a


ORE Catapult

Wootzano: An electronic skin developed by a tech start-up, Wootzana, to 'feel' surfaces.

ready source of power, there's no three-point plug for systems to tap into, and it's the same for communications. Power and communications cables (or private or 4G networks) would need to be run from converter stations to where power users need them, he says. Alternatively, wave or tidal power devices could be installed to support resident robotic systems, like underwater inspection vehicles.

Reliability and certification

Then there's the reliability of vehicles themselves. "For robotics to be fully integrated into commercial practice, barriers relating to their long-term reliability as well as their ability to operate safely with humans in the same environment need to be addressed," says an OTC 2020 paper from Heriot-Watt University, a member of the ORCA Hub. "The use of BVLOS robotics requires a new methodology in dynamic certification," it says, so it's been looking at self-certification, enabling robots to verify their health status and ability to deliver missions.

Future visions

"In the near term, there will be a hybrid approach, personnel working with robotics," he says. "The future vision is taking the human out of the loop. But we're 10-15 years from that. These early pilots at Shetland Gas Plant will (help to) understand the reliability of the robot. Right now, we don't know."

But advances are being made. Current operating and charging life of a Taurob type robot is 3-4 hours operating, then about double that for charging. An OGTC project with Taurob, Total, Equinor, and French battery maker SAFT is developing an ATEX approved battery that will enable four-hour operating then four-hour charging, so with two robots there would be 24-hour operations (so long as they were reliable, of course).

For greenfield sites, the vision could be very different – it could be unmanned automated facilities with crawlers or a rack-type system with a robotic arm that moves around. "These are questions being asked just now," says Bell.

Another challenge is technology adoption. Technology barriers are probably the easiest to overcome, says Bell, adoption could be harder, with concerns about jobs or disrupting incumbent markets – like the logistics and transportation for people and equipment currently shipped around.

Source: Total

Meet Total's "Stevie the Robot"

Total has been working on robotics for some years now, having launched the Argos challenge in 2013 and now getting ready to put the Taurob designed Stevie robot through its paces in a trial at Shetland Gas Plant. We spoke with **Kris Kydd, Head of Robotics, at Total E&P UK**.

What have been the main lessons learned to date around enabling these systems to operate in an offshore environment?

Total believes that robots have a huge amount to offer to our industry. We are pioneering their use on oil and gas sites, and the last seven years have seen progress, and lots of lessons learned! Robots offer immediate advantages such as increased safety and efficiency. In the long-term, they offer us new ways of working and are limited only by our imagination.

A major lesson learned is that the performance of any autonomous wireless robot is only as good as the quality of its surrounding digital architecture. We have taken this to heart and developed a digital architecture that is device agnostic and designed to be used with any robot system or mobile device. In the early stages, we had all the autonomous processing performed on board the robots. This led to issues with the battery power running down too quickly; it also limited storage space and processing power on the robot which we've upgraded by moving non-critical processing to the cloud. A reliable communications network is also essential. Available bandwidth and latency completely dictate what you can do.

We have also developed robot mission planning capabilities that can be run from the digital twin system. This is where users can indicate the inspection points of interest and this is then translated into robotic commands for the robot. It is this digital architecture that will allow us to extract maximum value from robots. Total now appreciates that using a robot to support operations does not mean keeping the robot on site. What is essential, however, is learning to make the best use of it; recognizing the changes to operations that robotics imply and updating operating philosophies accordingly.

Has anything changed in that period that would have been of benefit to the teams back in 2013?

Machine learning has taken off in a big way since Total launched the ARGOS challenge. If machine learning had been as prevalent then as it is now, then we would have included it from the beginning. If we'd had a digital architecture to interface with the robot, then we also could have tested the end-to-end functionalities.

A digital architecture means the robot gets all the data it requires to complete a mission from a digital twin, which is our single source of truth and contains the latest site data. Then,

of data transfer. During the ARGOS Challenge we experienced black spots with the Wi-Fi network even on small sites because of interference caused by metallic equipment. Our latest robot design has a dual router offering both 4G and WiFi capability.

You mention machine learning quite a lot. Could you explain what you mean by machine learning?

Machine learning, in this respect, allows for automated inspection capabilities. The robot captures images of various types of equipment, which allows us to generate a large data set upon which machine learning algorithms can be developed and tested. As the robot captures more images, the dataset grows, which can be re-fed into the machine learning model allowing the algorithms to be retested, which in turn allows its predictions to become increasingly accurate.

> *"Our major objective is for the robots to successfully operate autonomously in an ATEX environment. We will test robotic fundamentals such as mobility, navigation over a range of surfaces such as gratings, gravel, and stairs."*

either during or after its mission, the robot uploads its inspection data to the cloud data store in the machine learning module. This data is then processed through machine learning algorithms. It also means making the interface for the human operator as simple as possible, first through a mission planning app and second through a Dashboard for presenting the results of the mission.

4G/LTE is also much more standard these days. It's a more recent mobile broadband internet access offering higher capabilities in connectivity as it offers a higher rate

Are there any remaining technology gaps or areas where you see more advances can be made?

During the early stages, we focused more on the safety aspects of the hardware (e.g specifying that the design had to be capable of working in a potentially explosive atmosphere – ATEX) rather than the safety aspects of the software. We worked with Saft, Total's battery specialist affiliate, to meet this challenge. However, there is no point in specifying safety aspects for the hardware if you do not have the software equivalent. Assuring the safe behavior of an autonomous robot in a complex environment is of paramount importance for acceptability. The wider workforce needs to know they can trust these robots to make the correct decisions. In order to gain that trust, those autonomous decisions need to be transparent and explainable. We are currently working on this and recognize how important it is before we can deploy at scale.

When do you expect Stevie to head up to Shetland, and what are the trials going to involve?

Robotics for oil and gas is still in its infancy, so it's very exciting for Total to be starting site acceptance testing at the Shetland Gas Plant this September. Our major objective is for the robots to successfully operate autonomously in an ATEX environment. We will test robotic fundamentals such as mobility, navigation over a range of surfaces such as gratings, gravel, and stairs. It's important for us to stress-test the interface between the robot and the digital architecture. We will introduce two robots performing simultaneous autonomous navigation without collision with each other.

What's the initial goal and what's the longer-term vision?

The path for Total is to investigate how best to further develop and extend the use of robotics. Initially, we need to make the transition between a one-off week-long deployment to a 12-month continuous deployment. We need to assess the reliability and robustness of the robot. Repeatability needs to be monitored closely; can the robot perform the same missions day in day out? If so, we can build up datasets on how equipment potentially degrades over time and apply machine learning to that. In parallel to reliability and robustness, we want to perform missions that will bring value to the business, for example by targeting inspection tasks that need to be performed frequently.

Longer-term, we wish to remove the robot handler, the person in the immediate vicinity of the robot who is equipped with the remote emergency stop. For that, we need to prove high reliability in obstacle avoidance and collision detection. Adding manipulation functionality is also important to complement the inspection capabilities.

Is that likely to involve different types of robotics for different tasks and scenarios, eg. greenfield sites and brownfield sites?

In the near-term, Total will deploy robotics in human-engineered environments. We will work with operators on installations, building confidence and acceptance. The lessons learned from such deployments will enable "robotization" of future platform design. If we are to eventually achieve a fully unmanned platform, we will need further advances in robotics. That will require different locomotion systems that can perform a wider range of different tasks but all nevertheless communicating through the standard digital twin architecture.

How does robotics incorporate into Total's broader mission?

Robotics and autonomous systems will allow Total to reduce its Scope 1 and 2 emissions by increasing efficiency and reducing the amount of transportation of personnel that will be required. We are also participating in the recently approved OGTC project for accurate remote methane monitoring using beyond visual line of sight (BVLoS) unmanned aerial vehicles.

Robotics Advances Inside the ORCA Hub

Source: RCA Hub

The Imperial College London drone demonstrating autonomous UAV sensor placement at the ORE Catapult facility in Blyth. The drone is equipped with a winch-tethered magnet and passive wheels capable of perching on, and sliding along, both vertical and horizontal surfaces.

Many of the more advanced mechanics of robotic systems are being developed as part of the Offshore Robotics for Certification of Assets (ORCA) Hub in Edinburgh. It's a publicly funded project led by the Edinburgh Centre for Robotics (Heriot-Watt University and the University of Edinburgh), in collaboration with Imperial College London and the Universities of Oxford and Liverpool. We spoke with some of their specialists.

First of all, what is robotics? Does that include remotely operated vehicles and autonomous underwater vehicles, for example?

David Lane, Professor of Autonomous Systems Engineering, and Founding Director Edinburgh Centre for Robotics: "Yes, ROVs and AUVs are robots. They both have smart software to do different things - control, navigate, station keep for the ROV and much more for the AUV that must process its sensor data to understand where things are around it, e.g. from a sonar, and adapt its mission plan when the unexpected happens. It has to do this onboard (at the edge) because communication links are so poor in the ocean, without a cable. Autonomous vehicles have no choice but to control themselves, therefore. Similar to autonomous cars, only the underwater community of roboticists have been developing these systems since seriously for over 25 years."

Moving topside, aerial systems have become a part of the day-to-day offshore inspection toolbox, but is there more they can do, and how can that be achieved?

Ashutosh Choubey, Aerial Robotics Lab Program Manager at Imperial College London: "The development of aerial robots for the offshore industry is increasingly complex and challenging, due to missions at sea being faced with limited communication in hard-to-reach locations and a harsh environment, resulting in a risk to human safety. The solution requires advanced control mechanisms, autonomous manipulation, energy management, and data analytics. Nature acts as a source of inspiration for the design of novel artificial systems that better interact with complex environments. A team at Imperial College London, led by Dr. Mirko Kovac, Director of the Aerial Robotic laboratory, are developing aerial-aquatic robots that are biologically inspired, e.g. by gannets (which fly and dive), fish, spiders, birds perching, etc., that can perform monitoring and manufacturing tasks in such a challenging environment.

"Dr. Kovac's research group has developed a variety of robotic platforms that are capable of sensor placement and manipulation while airborne, covering a full suite of inspection and maintenance features, focusing on robustness within harsh environments, while decreasing energy consumption.

"One of these is an aerial system that can fix a tether to a surface, allowing for proximity or direct contact with a target surface. Perching is particularly valuable in windy conditions where free flight is dangerous or impossible. An autonomous flight control stack enables passive interaction with target surfaces, allowing it to safely place a sensor on infrastructure elements. Such sensors contain the ability to gather and transmit real-time IoT and non-destructive evaluation data and enable wireless communication frameworks. These aerial platforms can conduct wall-thickness scanning of a horizontal surface with continuous contact during operation, as well as various manipulation tasks.

"Another is an aquatic micro aerial vehicle that has the ability to transition autonomously from flight to water and vice versa. This underwater operation allows robots to perform many new applications, such as water sampling (e.g. to monitor disaster scenarios or perform scientific measurements), or inspection of underwater infrastructure."

The Imperial College London drone demonstrating autonomous UAV sensor placement on a wind turbine at the ORE Catapult facility in Blyth. The drone is equipped with a winch-tethered magnet and passive wheels capable of perching on, and sliding along, both vertical and horizontal surfaces.

Source: ORCA Hub

How do we deal with initial (or permanent) human/robot interaction where systems are deployed among the workforce?

Prof. Helen Hastie, ORCA Hub theme lead for Intelligent Human-Robot Interaction with Explainable AI, says: "In ORCA, techniques are being investigated for human-robot interaction (HRI) of systems with varying levels of autonomy. Transparent interaction that can explain what the system is doing and why, is key for situation awareness and human-robot teaming, ensuring safe operation, increased operator confidence and, as a result, increased adoption.

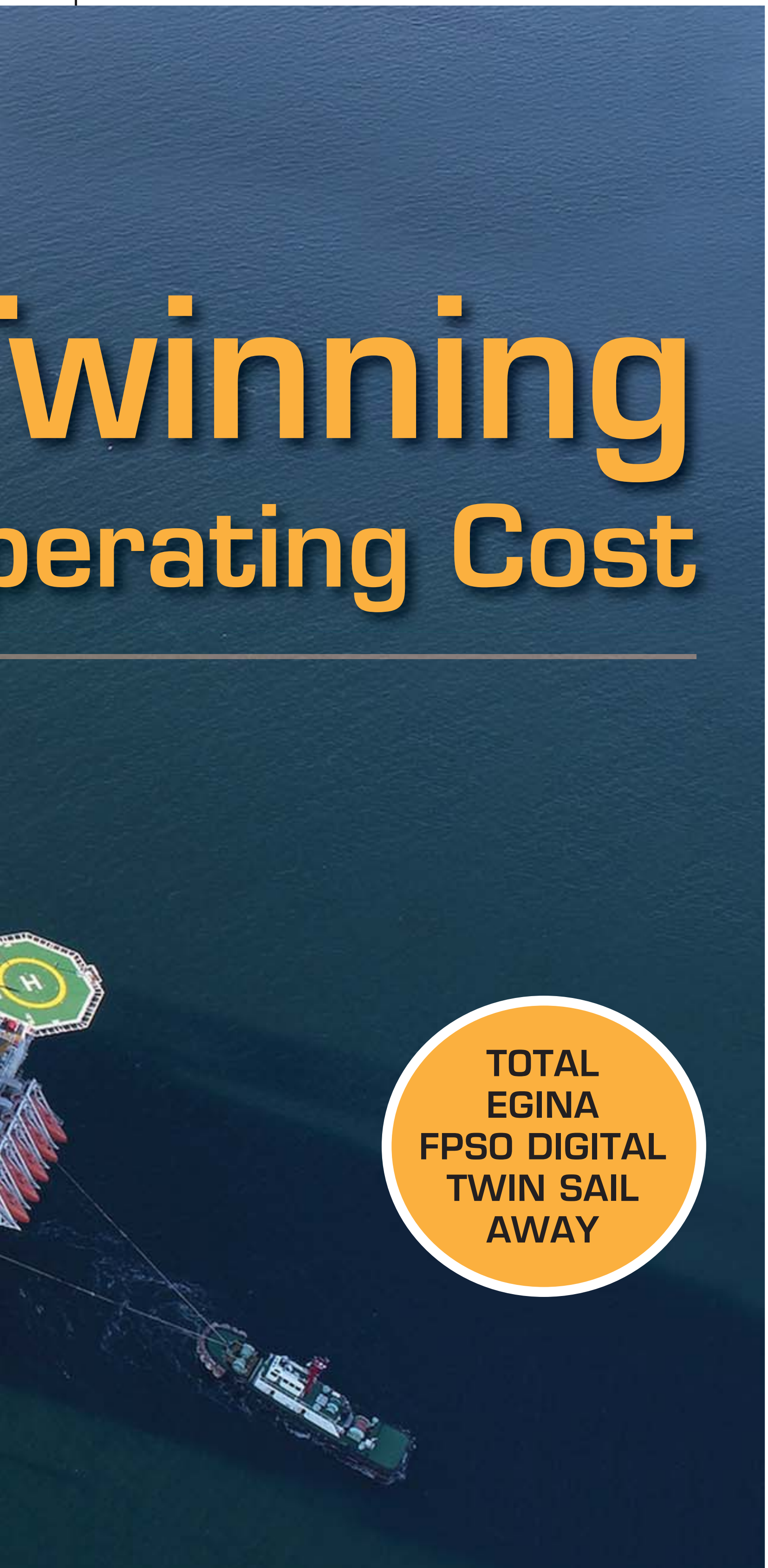
"In addition, it can provide an audit trail and, ideally, is designed into the system from inception, adhering to ethical best practices and rigorous standards, such as the emerging IEEE standards on transparency and ethical design (P7001/P7000). HRI techniques investigated on ORCA include sophisticated visualization of plans and an Amazon Alexa-style personal assistant, for real-time updates and explanations through voice.

"Prototypes have been demonstrated and tested with real operators for autonomous underwater vehicles and ground robots on offshore platforms, both with real robots and in simulation through digital twins. Furthermore, human factors studies have shown the readiness of operators to accept autonomous systems through such transparent interaction techniques."

Digital T
& Reduced Op

Source: Bureau Veritas

winning
perating Cost



TOTAL EGINA FPSO DIGITAL TWIN SAIL AWAY

By Dawn Robertson & Neil Pickering,
Bureau Veritas

The oil and gas industry is currently enduring one of the most challenging periods in its history. The impact of the COVID-19 pandemic significantly accelerated an existing decline in global demand for hydrocarbons, resulting in the lowest oil prices for 30 years. This has left the industry facing the dual challenge of ensuring successful and safe working conditions and practices for employees while maintaining the economic viability of assets.

How can operators maintain, or even raise, safety standards and address maintenance challenges while reducing cost?

One area that has the potential to present significant opportunities is a greater adoption of digital technology, most specifically in improved asset integrity management.

With attention increasingly on remote operations to maintain the economic viability of assets, increase safety and reduce risk, the current situation represents the perfect window for digitalization to make a quantum leap from a 'want' to a 'need'.

An aspect of this shift in focus is the growing adoption and recognition of the benefits of digital twinning i.e. the creation of a mirror image of an asset to support integrity management.

At the forefront of this cultural change is Bureau Veritas, a leader in testing, inspection and certification services, which has created a proven and 'boxed' digital twinning and smart data management system that is already helping to generate significant reductions in unit operating costs and capital expenditure.

The company's Veristar AIM3D system, developed in partnership with Dassault Systèmes, provides a true, as is, four-dimensional picture of an asset's condition instantly, everywhere on any platform or device, at any time.

Veristar AIM3D (VAIM3D) combines a digital twin of any marine or offshore asset with smart data. It improves visibility and understanding of the asset, allowing operators to make the right choices faster to improve efficiency, safety, integrity, performance, return on investment, and carbon footprint reduction.

The digital twin, linked to a comprehensive asset integrity management database and collaborative platform that will interface with any system the asset owner has - and is specifically designed not to replace existing infrastructure - can be accessed by all personnel.

The model, which provides a 360º view, is constantly updated throughout the asset's life. Any changes made within the systems it interfaces with are immediately reflected in the VAIM3D twin. Through its integral project management module capability, it allows shutdowns and turnarounds to be optimized, significantly reducing planning time, and it allows the preparation of maintenance and modification workpacks, to be done remotely.

It assists in the execution of, and preparation of maintenance and inspection reports, and the results are automatically visualized in the twin to reflect the asset's real condition.

Furthermore, it helps operators anticipate issues, easing the move toward predictive asset management, bringing with it reductions in operational costs, inspections, maintenance, and repairs. Bureau Veritas, with one of its clients, has estimated digital twinning is reducing hull maintenance costs (OPEX) by 25% over five years.

For remote operations or where assets have been demanned, the monitoring of equipment has traditionally been an expensive operation. However, the introduction of 4G or 5G connectivity has significantly reduced such costs allowing data to be fed back into the digital twin and enabling a rapid assessment of equipment or asset integrity.

With the benefits of a digital twin system well established in cutting maintenance costs, maintaining safety and performance, and extending asset life, Bureau Veritas then considered its benefits to the decommissioning sector.

It was assessed that the value from digital twinning could be realized across a range of spheres, including environmental, societal, wells, the asset, and regulatory requirements. Digital twinning was identified as a method of improving the definition of work scope, the quality of proposals, and execution efficiency while lowering estimated and actual costs.

Benefits for the supply chain include: the provision of a mirror image of an asset which everyone can view and estimate against the 'as it is' information; mitigation of inconsistency across tenders; the elimination of additional cost due to access and egress issues on site; a compilation of accurate engineering work packs with minimal requirement for site visits; more fixed price certainty, and time and opportunities to evaluate alternative scenarios, approaches and technologies.

From a safety perspective, digital twinning enables virtual simulation to run hazardous activity without a physical presence and thereby eliminate or mitigate risks; familiarisation with an asset prior to the mobilization of personnel; the laydown and storage of plant and equipment offshore; links into Permit to Work (PTW) systems and the simulation of access and egress from hazardous operations for personnel. In the UK, a rundown of the safety case through visualization reduces the requirement for the Health and Safety Executive to make on-site visits.

By providing a visualization of risks through simulation and respective mitigation, digital twinning can provide insurers and underwriters with a better understanding of the risks and control measures being taken. A greater appreciation of the decommissioning project may assist in driving down premiums. Indeed, insurers have suggested such increased visibility could remove a zero from the cost of premiums.

For operators, digital twinning represents an opportunity to reduce costs through optimization, efficiency gains, collaboration and the potential for improved relationships with regulators and the broader supply chain.

The broader values to the industry include standardization of approach and processes, a reduction in carbon footprint through fewer site visits and better scheduling of vessels, the ability to manage across a portfolio of assets simultaneously, potential economies of scale and the simulation of a range of infrastructure and topsides assets.

Bureau Veritas discovered that by using its digital twin and smart data system, operators could save between 9% and 15% on total decommissioning project costs. Data from the company, which was shared with the UK industry regulator the Oil and Gas Authority, showed operators could save more than £2 million on project costs for assets with topsides of 10,000 tonnes, increasing to more than £8.5 million for assets with topsides up to 40,000 tonnes.

A VERISTAR AIM3D DIGITAL TWIN

Furthermore, following several months of data gathering and refining, it was identified that savings from 9% to more than 30% could be made from a range of decommissioning activities including topsides and jacket removal (14% and 11% respectively), subsea infrastructure (19%), facilities de-energising (more than 30%), operator costs (15%), onshore recycling (10%) and site remediation and monitoring (10%) to deliver direct savings on total project costs.

Taking the figures for subsea infrastructure as an example of how the percentage reductions were achieved, the value generation on future deployments was identified as a 19% cost reduction on the work breakdown structure (WBS) for infrastructure removal.

This is based on a 15% reduction on vessel costs (typically these account for 80% of the WBS subsea infrastructure costs) and a 35% cost reduction in the remaining 20% of the subsea infrastructure WBS activities which includes planning, managing removal, weight assessments (CoGs), geographical positioning of subsea items, simulation of removal and seqencing optimization.

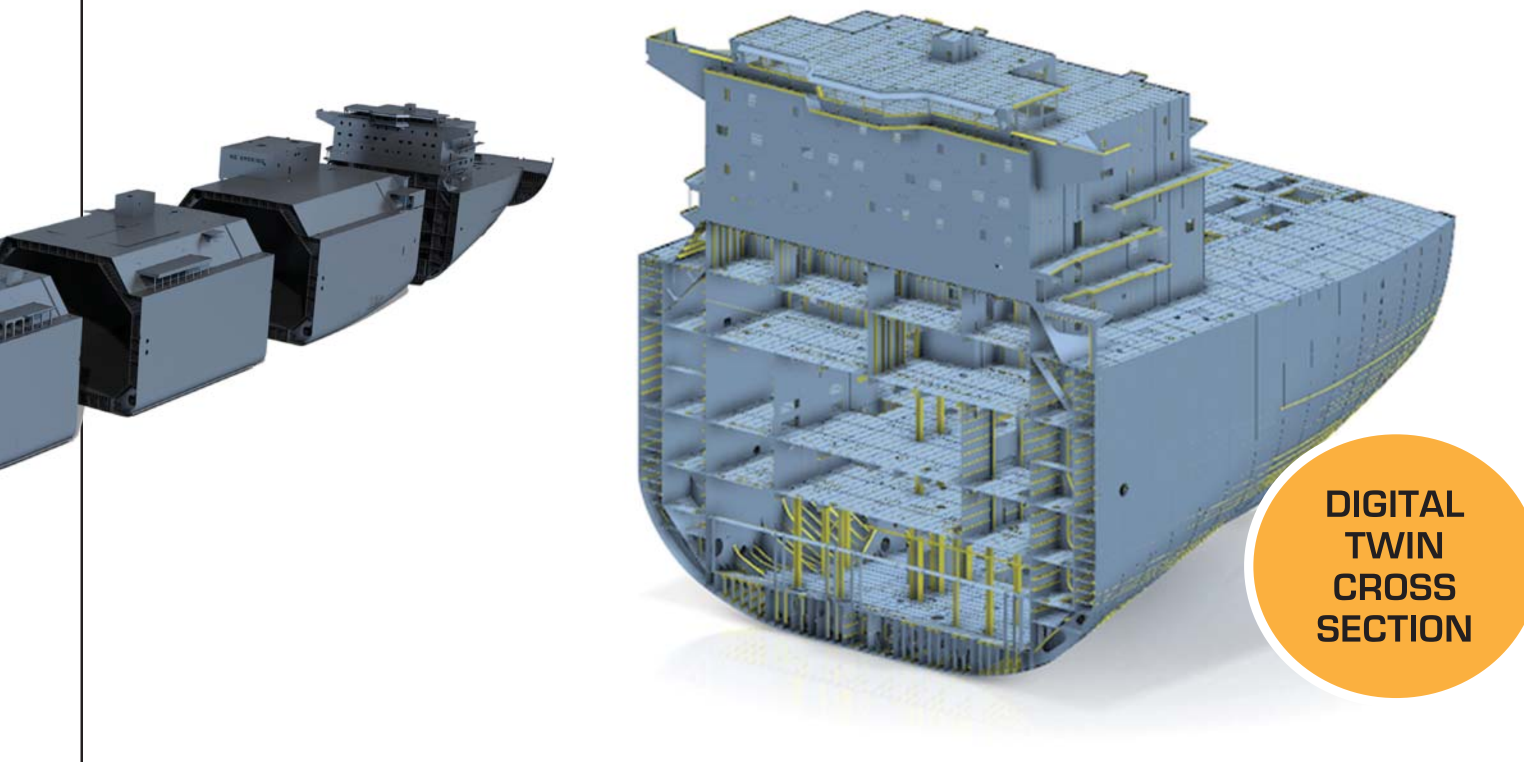
Bureau Veritas has identified a total of 54 North Sea assets with topsides of 10,000 - 40,000 tonnes that would benefit from using a digital twinning system to gain direct savings in decommissioning. It has also identified 35 assets of fewer than 10,000 tonnes that would benefit from the use of a digital twin in late-life operations through to decommissioning phases.

With decommissioning a hard cost on a balance sheet, the need for efficiencies and cost reduction is clear, as outlined in the UK Oil and Gas Authority's Decommissioning Strategy. The results from Bureau Veritas indicate digital twinning could save millions of pounds on overall project costs and enable operators to make smarter, more cost-effective choices.

The future for the greater adoption of digital twinning is positive, and demand is growing. Bureau Veritas has developed bespoke systems for several operators and is considering projects for the digital twinning of topsides decommissioning and an entire subsea field.

Like any system, a digital twin is only as good as the information fed into it. The technology deployed is well proven across a number of industries and generates operator trust by providing much greater visibility and understanding of the asset. One instant benefit of enhanced asset visibility is data rationalization. Where previously low-quality information could exist within a system for years, the construction of the twin allows poor data to be identified immediately. It also enables the identification of areas with insufficient or excessive data and an improvement in the type and quality of data available.

The common response from the industry to increased digitalization and the adoption of digital twins has been "I'm not sure our company is ready for this." Our response to this would be: "If not now, then when?" As the industry recoils from the double blow of COVID-19 and a low commodity price, and while we have a trusted and proven way to reduce unit operating costs, can companies continue to afford the luxury of indifference, particularly when their very survival may be at stake?



Source: Bureau Veritas

THE CASE FOR 3D PRINTING DOWNHOLE TOOLS

Advanced design software supports growth of additive manufacturing applications in the oil and gas industry

By Blake Perez, Ph.D.,
Design-for-Additive-Manufacturing Expert, nTopology Inc.

Additive manufacturing (AM, aka 3D printing) is beginning to impact product-development strategies in the oil and gas industry just as it already has in many other industries—by shifting the production paradigm in unexpected ways.

Particularly in the case of downhole tools, overall tool size is compatible with the range of part dimensions that today's AM systems are capable of manufacturing. Consider a common piece of equipment on any oil and gas rig: the tricone drill bit. Required to function within relatively narrow spaces, together with mechanical components that force drill mud down the well hole to carry rock, dirt, and clay back up, the bit is part of an intensely technical setup that undergoes extreme heat and pressure.

With AM, engineers could be given an extended ability to embed sensors practically anywhere within the drill head, or to control the design and manufacturing parameters of the components for maximum mud flow through the part. Advanced design-for-AM tools and 3D printing now make this possible. What if similar improvements could be made to the perforation tools for the fracking process, tailoring them for cleaner and deeper perforations? What effect would more efficient pumps have on these extraction methods? When driven by advanced design software capable of generating the component geometries that can answer such questions, additive manufacturing offers these capabilities and more. While not an end-use oil and gas product, the cutting tool image shown demonstrates how such tools could be redesigned.

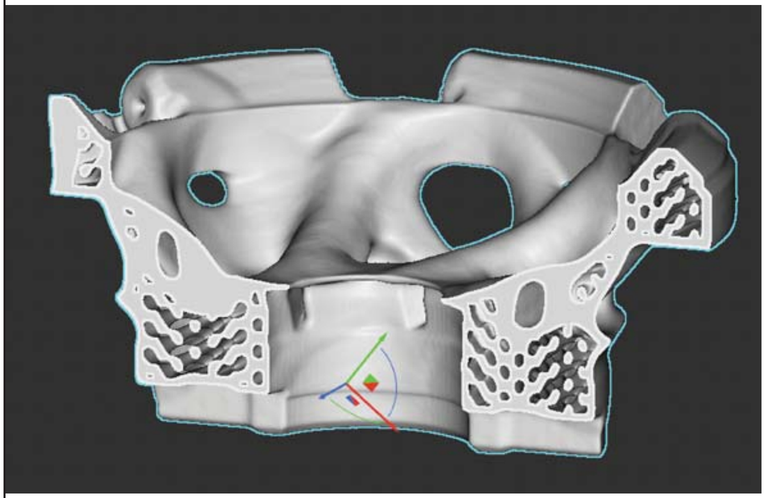
It's also important to note AM's broad range of material capabilities as well. Where the first 3D-printers were limited to prototypes made of simple polymers—suitable for testing form and fit but not function—today's machines print a wide range of engineering-grade plastics as well as fully-dense metals, including titanium, duplex and stainless steels, nickel and chromium-based superalloys. AM's ability to build complex, optimized part geometries from these and other high-grade materials means that less metal is needed to meet the oil and gas industry's stringent mechanical requirements, shortening manufacturing time, reducing costs, and helping streamline operations.

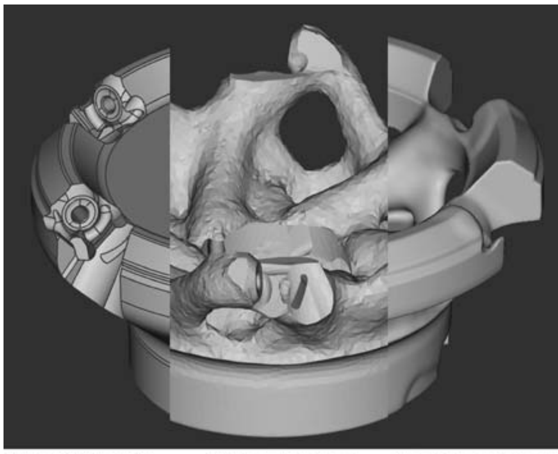
More efficient drilling and fracking operations are essential to industry growth, but so is an optimized supply chain. Here again, AM offers an array of benefits. Rather than the traditional manufacturing workflow—with multiple machining steps, significant tooling and fixturing investment, costly work-in-process, and typically lengthy lead-times—even the most complex component can be 3D printed in fewer operations far more quickly and with much less human intervention. For these reasons among others, MRO suppliers to the oil & gas industry are especially keen on additive manufacturing, since its ability to create replacement parts "on-demand" promises to reduce inventory levels without sacrificing customer service.

Granted, the actual AM "build" of a pump part or drill bit might require a day or two to complete, followed by another day or so of post-processing, but compared to the weeks or even months needed with conventional procurement methods, additive manufacturing serves to drastically compress lead-times and shorten the supply chain of certain components. And this can easily mean hundreds of thousands of dollars per day when critical systems are down, the well sits idle, the oil no longer flows.

Designing for both new and legacy parts

While using advanced design software in conjunction with AM promotes the creation of innovative, problem-solving oil and gas components it can also help improve the design and manufacturability of legacy parts.





For instance, a cast component can be less expensive to produce and more durable than one welded together from multiple pieces of steel. Computational engineering software such as nTop Platform not only provides Design for AM capabilities but also advanced part-consolidation and topology-optimization workflows that can quickly turn a welded design into one suitable for casting or forging, greatly automating otherwise cumbersome design procedures while decreasing development lead-times. This is why oil & gas industry engineers are beginning to take a deeper look at their product inventory and ask, "Can we run some of our legacy parts through a computational engineering workflow and find more effective, optimized ways to manufacture them?"

Such design-optimization workflows can also be applied to mold or forging dies used to make these redesigned components. Indeed, tooling-geometry generation is an integral part of the design process with the software, extending its uses well beyond the world of additive manufacturing. And since the software generates 3D objects mathematically—via a function called implicit modeling—rather than the boundary-based generation used with most engineering packages, multiple design iterations can be created and tested far more quickly, further reducing costs and product lead-time. Part consolidation through design optimization also offers the benefits of decreased assembly times and simpler supply chain logistics even for traditional process operations.

Developing the confidence to move forward with new technologies

Despite these robust capabilities, neither advanced computational engineering software nor additive manufacturing is going to "turn the oil and gas world on its head" anytime soon. Change doesn't happen overnight, especially in an industry with a rich, successful history, that is managed by decision-makers who tend to prefer the tried-and-true over the cutting edge.

That said, it's precisely those folks who can benefit from learning more about the tremendous potential of these new technologies.

It's important to understand that 3D printing has been in development since the mid-80s and is now a mature, well-understood manufacturing process; Boeing, Airbus, and many other industry leaders wouldn't be as invested in it as they are now it if it weren't proven, certified and cost-effective in the right applications.

Secondly, the powdered metals used with direct metal laser sintering (DMLS), electron beam melting (EBM), direct energy deposition (DED), and other metal AM technologies are nothing new. They are, in fact, the same metal powders—albeit on a finer, more well-controlled scale—used in metal injection molding, a process that gained popularity after World War II and is itself used to make diamond-coated oil and gas drilling tips (which themselves present opportunities for the generative design and topology optimization capabilities of advanced computational engineering software).

What's most notable about all this is the game-changing potential of these new technologies. Cutting heads, heat exchangers, pumping and filtration equipment, drill motors—pick an oil and gas component and chances are excellent that it can be improved through new digital redesign tools and either 3D-printed or produced via more traditional means. Further ahead, the integration of advanced sensors and other electronics into such components raises previously unimaginable prospects for finely tuned, real-time measurement and monitoring of drilling operations.

Software providers are beginning to work on creating specific toolkits, with input from oil and gas partners, that will provide automated, reusable design workflows that enhance collaboration and serve this specific market's needs best. These virtual tools will help speed optimization of the real-world ones.

Low Carbon Benefits of Processing Cuttings Offshore

By Gareth Innes, Chief Commercial Officer of TWMA

When it comes to defining the methodology for drill cuttings treatment, it is now possible to materially reduce costs, improve safety, and lower the carbon emissions of drilling projects. These benefits, associated with processing drill cuttings at the rig site, are now widely acknowledged by operators in the UK Continental Shelf (UKCS).

The largest waste streams generated from global offshore drilling operations are water-based and non-aqueous drilling fluids (NAF) and associated drill cuttings. Traditionally, the 'skip and ship' method is used to collect, contain, and transfer the drill cuttings by sea and road freight to a specialist processing facility onshore.

An alternative, and both financially and environmentally optimized solution, is thermal processing of drill cuttings at the rig site. TWMA's mobile TCC RotoMill unit separates drilling waste at the source, into its three constituent parts of oil, water, and solids for recycling, reuse, and safe disposal. This method eliminates the requirement to transport drilling waste long distances onshore.

An industry study highlighted significant health, safety, and operational benefits of a rig-based approach, such as a reduction in skip handling, waste handling, crane use, and weather exposure. Recently, with ever-increasing focus on the environmental impact of offshore operations, TWMA engaged environmental consultancy, Carbon Zero, to conduct a research study to determine the carbon footprint of both a rig site processing approach and a ship to shore-based cuttings treatment solution.

In line with PAS 2050, the UK specification for assessing product life cycle greenhouse gas emissions, Carbon Zero included and excluded various processes from the CO2e (carbon dioxide equivalent) calculation. For the processing of cuttings on an offshore rig, they included the transportation involved in commissioning and decommissioning a TCC RotoMill unit, and any direct emissions associated with the processing of cuttings.

For a 'skip and ship operation,' Carbon Zero studied the transportation of empty skips to the offshore platform and the transportation of full skips onshore. They also tracked any direct emissions associated with the treatment of cuttings and the transportation of all drilling wastes and any emissions associated with the further processing of water and oil.

Both onshore and offshore treatment methods use a similar treatment process, however, the main difference in carbon emissions between the two techniques is the transport and logistics associated with large volumes of material being shipped to shore when not processing at the rig site.

On a 'skip and ship' operation, drill cuttings are transported from offshore and treated at our Peterhead processing site. There, we deal with the three main waste products differently. Recovered oil is sent to a third party to be recycled, recovered water is treated onsite for discharge to SEPA requirements, and the

recovered powder is recycled for reuse in various applications.

In adopting TCC RotoMill treatment at the rig site, recovered oil can be reused onsite within the drilling fluid system, and water can safely and legally be discharged into the sea or used to dampen the rock dust powder before again being discharged to sea, where it disperses with marine currents.

Our research used three variables to establish the baseline data required to calculate the carbon footprint: average platform distance from Peterhead (263 km), average total well depth (7,664 ft.), and average total weight cuttings produced per well (582t).

In total, the data for nine wells from four different platforms was analyzed; five wells utilized the TCC RotoMill® to treat drill cuttings offshore with the remaining four using the alternative 'skip and ship' to shore method.

Three data scopes were measured and analyzed:

- *Emissions relating directly to engine fuel usage and company-owned vehicles were almost 43% less using the TCC RotoMill process*
- *Electrical emissions were around 37% less compared to 'skip and ship'*
- *Indirect emissions associated with third party road and ship transportation produced the greatest difference, with 98% less using the TCC RotoMill process*

The overall results revealed the carbon footprint of the TCC RotoMill utilized to treat drill cuttings at source on an offshore rig was approximately half of that of an equivalent 'skip and ship' operation. Furthermore, additional benefits include the diversion of waste powder from landfill, produced oil being re-used in the offshore drilling system, and wastewater requiring no further treatment.

This study really raised our awareness of the CO2e emissions associated with each process and highlighted where future savings may be made.

As HSE, cost-efficiency, and low carbon drilling continue to be the focus for all operators, I expect that the processing of drilling cuttings offshore will continue to be adopted as best practice and throughout the North Sea and beyond.

Source: TWMA

ELECTRIC ACCUMULATOR

HYBRID BOP POWER & CONTROL

With the prospect of deepwater operations positioning back into focus, operators and drilling contractors will continue to face subsea blowout preventer (BOP) stack size and weight challenges regarding the installation of subsea hydraulic accumulators, which must be sufficiently sized for emergency operations as required by regulations. Conventionally, gas-pre-charged accumulators have been relied on as the primary energy source for actuating emergency subsea BOP stack functions. The amount of accumulator volume required for these systems is driven by calculations within industry standards such as API 16D. Calculations take into account various factors, including the shearable material, wellbore pressure, sealing, closing ratios, and depth.

The impact of depth in these calculations is significant; greater wellhead depths require more accumulator volume to be available on the subsea BOP stack. In some cases, only 20% of energy at surface is available at the wellsite resulting in a significant increase in the number of accumulators required.

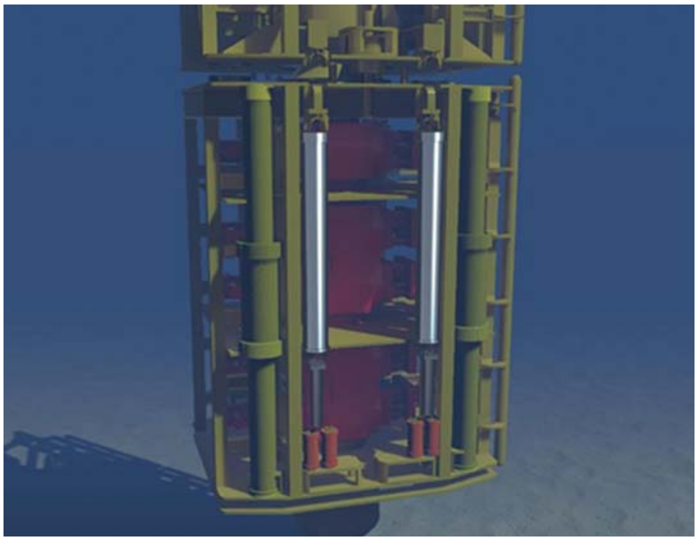
Deepwater operations are pushing required volumes beyond stack capacity. The industry has responded by providing higher pressures to existing accumulator skids with hotline or intensifier systems and accumulator mud mats, as well as direct bonnet operation of combustibles.

Electrification holds potential here. Batteries don't experience efficiency losses in the same way that conventional hydraulic power devices do. The core cost and performance of battery cell technology has also advanced significantly in recent years. While there have been steps towards all-electric production systems, drillers have understandably been slower than their production counterparts to move in that direction, particularly in respect of primary well control equipment.

Cameron, a Schlumberger Company, is proposing an intermediate step towards electrification; a hybrid approach using modern Lithium-ion batteries as the primary energy source. Electric energy in the battery assemblies can then be used to to drive subsea pumps or linear motion systems to provide on demand hydraulic power.

The system, the Electric Accumulator, reflects close collaboration with Aberdeen-based electronics specialist QL Tech which has a proprietary battery, inverter and control technology, all of which has been demonstrated at 11,000 ft. In addition to solving the energy challenges associated with deepwater wells, the technology will to support improved health diagnostics, higher reliability, reduced wear on the stack and lower CO2 emissions.

The Electric Accumulator is currently at prototype stage with a scale system recently assembled and tested to 5,000 psi of output pressure in Aberdeen. A field trial is targeted for 2021. It is expected that, through this hybrid approach, the industry can gain acceptance and confidence in the core electronic components, ultimately unlocking future electrification opportunities for deepwater drilling in the future.



Source: QL Tech

Source: SKF

BIG BEARINGS BOOST OFFSHORE PIPE LAYING

As the offshore industry struggles with depressed oil pricing for nearly six years running, more than ever it is taking a sharp eye to the bottom line, revitalizing equipment when practical instead of buying new. Recently in Norway, SKF helped offshore equipment manufacturer National Oilwell Varco (NOV) achieve just that by supplying it with a unique set of bearings … all told three different types of bearings totaling more than 28 tons.

Among other things, NOV builds handling and pipe-laying equipment for offshore vessels. In a recent upgrade, it needed to ensure that the bearings on two cable drums could withstand the tough conditions of unspooling pipe into the sea from a pipe-laying vessel. Conditions on pipe-layers are hugely challenging, as the bearings are under constant load, both radially (from the load itself) and axially (from the continuous motion of the ship on the sea). "It requires very complex engineering because of the uncertainty from the micro motions of the ship," said Daniel Ortaga, Senior Business Developer at SKF. The challenge for the bearings had nothing to do with speed, as the drums turn at around one-third of a revolution per minute. Instead, the difficulty was to design bearings that could take enormous loads while moving at such slow rotation speeds. As well as achieving this, SKF managed to design bearings in standard ISO dimensions, meaning they can be found within its catalogue. Strange as it may seem, these are standard bearings, the largest ISO-sized bearings that SKF has ever supplied. The order comprised six separate bearings in three different types: spherical roller bearings (SRBs); spherical roller thrust bearings (SRTBs); and self-aligning CARB bearings. The bearings were used on two different cable drums, one large and one small.

DECK MACHINERY

Offshore Engineer's ***previous edition's product feature focused on mooring systems. See more @:*** **https://bit.ly/MooringsOE**
Looking at the featured photo above, showing what appears to be a scarecrow - it is - it might be hard to guess the topic of this **Offshore Engineer's** ***product feature. It's*** **Deck Machinery, Equipment, Cranes** ***for offshore applications. So why is there a scarecrow in it?***
Well, it's on a deck, it's offshore, and it's a machine, sort of. Learn more reading to the right.

SCARETECH
SEABIRD POO BE GONE

Seabird poo or 'guano' is a huge problem for the global offshore wind industry as it poses a serious health risk, due to its highly carcinogenic qualities, and is extremely expensive to remove. Enter the Scaretech scarecrow. Designed to look like an offshore wind worker in full protective clothing, Scaretech is manufactured from steel, flexible foam and PVC and powered by solar panels. It can operate in extreme weather conditions and emits sporadic loud noises and high-intensity strobe lights which deters seabirds from landing on the structure. In one year since the installation on an offshore wind substation, it has reduced guano on the structure from approximately 50-60% coverage to virtually nothing.

KONGSBERG
HUGIN L&R

Kongsberg Maritime's new LARS (Launch and Recovery System) for the HUGIN range of Autonomous Underwater Vehicles (AUVs) permits midships operation, with release and capture occurring beneath the sea surface.

Operating from midships frees up valuable aft deck space, enhances safety by removing the need to work over the stern, and protects AUVs from damage by the launch vessel. Launching and recovering underwater – away from the splash zone – permits operation in higher sea states, reducing the risk of weather damage while boosting productivity to deliver significant cost savings. For deployment and recovery, the heave-compensated LARS cradle is lowered into the water,

whereupon HUGIN is released to start its mission. During recovery the AUV locates the cradle using the onboard navigation system and a KONGSBERG MicroPAP located in the LARS. Once nearby, HUGIN drives itself into the cradle and is locked in before it is lifted out of the water.

HENDRIK VEDER
5,000-TON CRANE

Hendrik Veder Group has recently tested a tub-mounted crane with a hoisting capacity of 5,000 tons on board the Allseas Pioneering Spirit. The crane passed the test, lifting successfully at 10 percent overload (5,500 tonnes). The 475-year-old an all-around service provider in the field of hoisting-equipment management now supplies its customers with a full-service, plug & play testing concept. The rigging and pontoons are custom-built for testing purposes and reusable, making testing cost-effective and sustainable.

MACGREGOR
WALK-TO-WORK

Offshore and marine equipment solutions provider MacGregor reports intense interest in its Horizon walk-to-work gangway and Colibri 3D motion-compensated crane, following an order covering four Edda Wind commissioning and service vessels. MacGregor now has six walk-to-work systems and five 3D compensated cranes under contract, with its energy-efficient solutions finding an especially receptive audience in the renewables sector. For Edda Wind, the all-electric handling solutions fully align with provision for the vessels to feature zero-emission propulsion technology in the future. MacGregor's integrated systems also allow a single operator to switch between gangway and crane operations from a bridge control station.

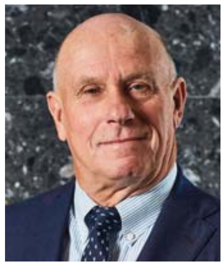
APPLETON
FPSO CRANES

Appleton Marine recently shipped ABS-certified large offshore knuckle and fixed boom crane to Singapore for installation on an FPSO. The cranes KB2000-105 - 25 metric tons at 32 meters; and SB750-87 - 15 metric tons at 26.5 meters – are electro-hydraulic and hazardous area classified. This FPSO will eventually be the second unit offshore Guyana utilizing Appleton Marine cranes. Manufactured to the customer's specifications, Appleton Marine specializes in engineered, project-specific equipment. All equipment is manufactured in the U.S.

Opedal

Schorn

Nauen



Hosking

Bøhn

Gattei

Pouroulis

Hetland

Holliday

Galloway

Ridder Olsen

Søe-Jensen

Equinor appointed **Anders Opedal** as its new president and CEO starting November 2, 2020. He succeeds **Eldar Sætre**, who will retire after six years as CEO and more than 40 years in the company.

Borr Drilling appointed former Schlumberger EVP **Patrick Schorn** as its new CEO effective September 8, 2020.

Siemens Gamesa Renewable Energy appointed **Andreas Nauen**, head of the company's offshore activities, as CEO replacing **Markus Tacke**.

Karoon Energy said that its founder and CEO **Robert Hosking** would step down after 16 years at the helm.

Axxis Geo Solutions appointed **Ronny Bøhn** as CEO.

Eni named **Francesco Gattei** as its CFO.

Chariot Oil & Gas said its CEO **Larry Bottomley** had stepped down. **Adonis Pouroulis**, Non-Executive Director and founder, takes over as acting CEO.

Ocean Installer established a new business branch called "developer of offshore wind," and has appointed **Olav Hetland** as Director Offshore Wind Farms.

Digre

Eikrem

Kawash

Hall

Harvey Gulf International Marine appointed **Ed Galloway** to manage Harvey Subsea Services.

Maersk Drilling's CFO **Jesper Ridder Olsen** will step down by January 2021.

Bladt appointed **Anders Søe-Jensen**, the former head of both Vestas Offshore Wind and GE Offshore Wind, as its new CEO.

Vattenfall's President and CEO **Magnus Hall** has decided to leave the company after nearly six years in the position.

Lloyd's Register appointed **Mike Holliday** as Marine & Offshore president for South Asia, the Middle East, and Africa.

Aker Solutions will merge with Kvaerner appointing **Kjetel Digre** as its new CEO to replace **Louis Araujo** from August 1. **Idar Eikrem**, CFO of Kvaerner, has been appointed CFO of Aker Solutions. Aker Solutions also will spin off its renewable and CCS tech business into two companies. The offshore wind spin-off will be headed by **Astrid Onsum** as CEO, while Aker Carbon Capture will be led by **Valborg Lundergarrd**.

McDermott International Ltd. appointed **Tareq Kawash** as SVP for its Europe, Middle East and Africa (EMEA) region.

UK-focused Hurricane Energy said its CEO **Robert Trice** had resigned. He will be replaced by **Beverley Smith**, who has been appointed Interim CEO.

OE OFFSHORE ENGINEER

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JANUARY - FEBRUARY

Ad Close: Feb 6

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Floating Production Outlook

DEPARTMENTS

Engineering, Procurement, Installation, Commissioning
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Subsea
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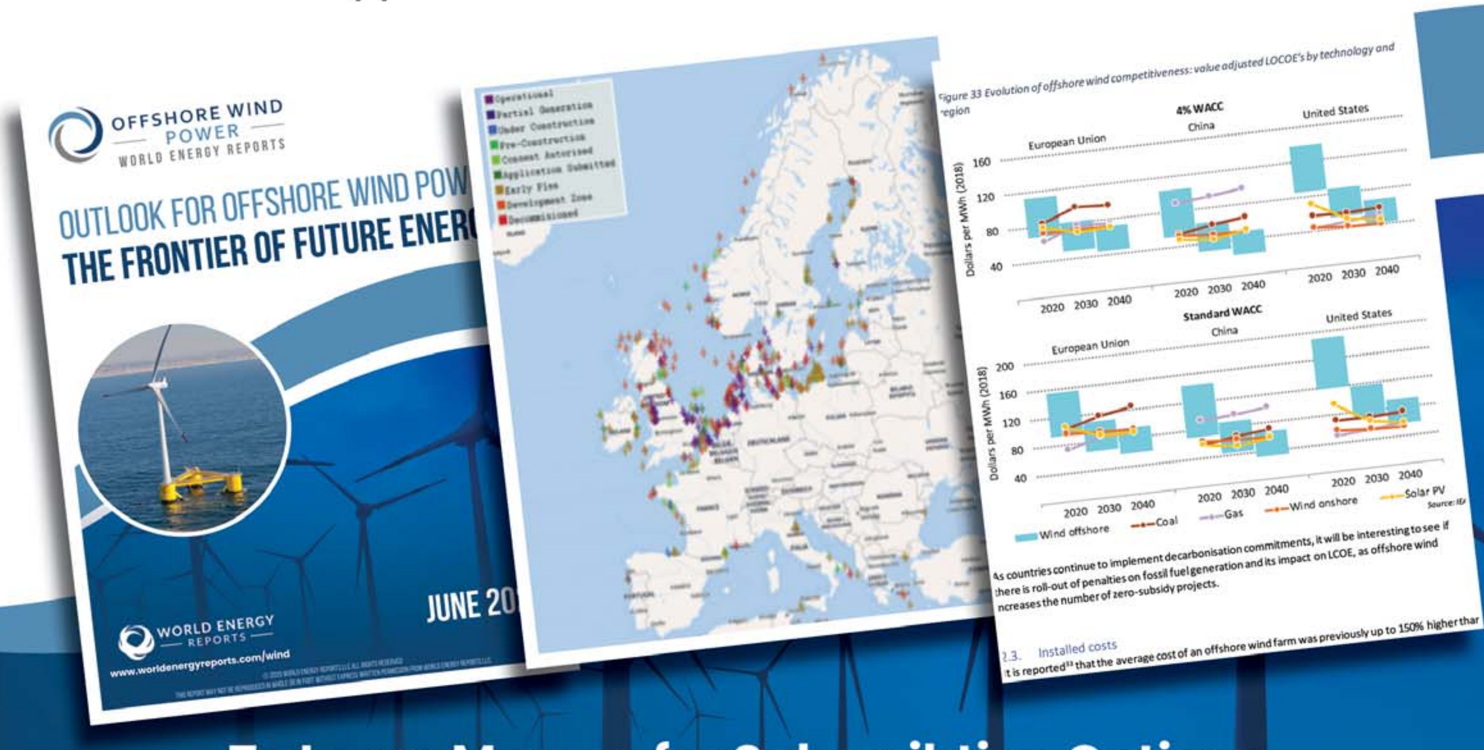

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