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Volume 81, Number 3

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COVER:
The semisubmersible rig *Maersk Discoverer* drills a well for bp offshore Egypt. *(Cover image courtesy bp)*

DEPARTMENTS

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The latest news is posted daily for the offshore oil and gas industry covering technology, companies, personnel moves, and products.

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Assessing the state of the offshore drilling market
Cinnamon Edralin and Justin Smith of IHS Markit provide an overview of the most active offshore drilling campaigns and an update on the changing rig contracting market and rig construction market. They also discuss the ways in which contractors are using new drilling technologies to improve their efficiencies and lower their carbon footprint.
www.offshore-mag.com/14202927

Redefining Operational Excellence and Building on Lessons from 2020
Industry experts discuss newly adopted offshore operational practices that were developed from lessons from a challenging year.
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Subsea Tiebacks in a Virtual World: Technologies and Behaviors Accelerated Due to the COVID-19 Pandemic
Industry experts discuss the latest digital technologies and processes that are improving the economics of subsea development.
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Floating Production Market: 2021-2025
David Boggs, managing director, Energy Maritime Associates, discusses recent floating production trends, the impact of COVID-19, the status of projects under construction, and a forecast for new orders.
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- 2021 Top 10 Drilling Contractors
- 2021 Status of US Gulf of Mexico Deepwater Discoveries
- 2021 Gulf of Mexico Map

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VP AND GROUP PUBLISHING DIRECTOR
Paul Westervelt *pwestervelt@endeavorb2b.com*

PUBLISHER
Danny Foster *dfoster@endeavorb2b.com*

CHIEF EDITOR/ CONFERENCES EDITORIAL DIRECTOR
David Paganie *dpaganie@endeavorb2b.com*

MANAGING EDITOR
Bruce A. Beaubouef *bbeaubouef@endeavorb2b.com*

EDITOR-EUROPE
Jeremy Beckman *jbeckman@endeavorb2b.com*

ASSISTANT EDITOR
Jessica Stump *jstump@endeavorb2b.com*

POSTER EDITOR
E. Kurt Albaugh, P.E. *Kurt.albaugh@yahoo.com*

ART DIRECTOR
Julie Whitty

PRODUCTION MANAGER
Shirley Gamboa *sgamboa@endeavorb2b.com*

AUDIENCE DEVELOPMENT MANAGER
Emily Martin *emartin@endeavorb2b.com*

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OFFSHORE
10300 Town Park Drive, Suite S1000,
Houston, TX 77072 U.S.A.
Tel: (01) 713 621-9720 • Fax: (01) 713 963-6296
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VERIFIED AUDIT
ABM

Industry response to COVID paves way to automated operations

THERE IS STILL MUCH to unpack and learn from the industry response to COVID. Many of the changes were rapidly implemented, short-term measures designed to protect personnel health and safety, and to protect business interests. While some have been and will be phased out, other measures are likely to be adopted permanently. One change that is likely to stick in some form is remote working. This includes personnel working from home; but for offshore personnel it also means remote operations, inspections, and maintenance.

It is perhaps unfortunate that it took a pandemic to force these changes, but the results have been mostly positive. These include savings in work commute and travel costs, higher staff productivity, improved communication and collaboration among internal and external teams, and gains in safety and sustainability. Many companies are allowing employees to work from home permanently, and others are offering a hybrid approach with a mix of remote and office time.

Two recent webinar panels, presented by *Offshore*, explored the technologies and behaviors that are evolving in the wake of COVID. One of the webinars, organized by the Deepwater Operations and Topsides, Platforms & Hulls advisory boards, asked the audience for its take on what is most essential for the industry to adopt coming out of pandemic and economic hardships seen last year. The respondents selected "adopt long-term remote work," followed by "industry collaboration for health-related emergency response." The webinar panelists discussed how the events of 2020 are serving as a catalyst for advancing remote operations. The next step in the move toward full automation is effectively predicting, planning, and prioritizing maintenance activities, the panel suggested. To facilitate this, sensors and cameras are being installed on equipment to feed information to personnel for inspection and verification. Traditionally, some of this equipment was verified in-person. The industry is also using more drones, robotics, and underwater ROVs and AUVs for monitoring and inspections, and eventually for operations and maintenance.

Most of the technology exists for automated operations, but behavior needs to change to accelerate uptake, the panel proposed. The webinar audience was asked as a follow-up for the expected percentage of operations that will be remote/automated by 2025. Survey respondents selected "about 25-50%" as their top choice.

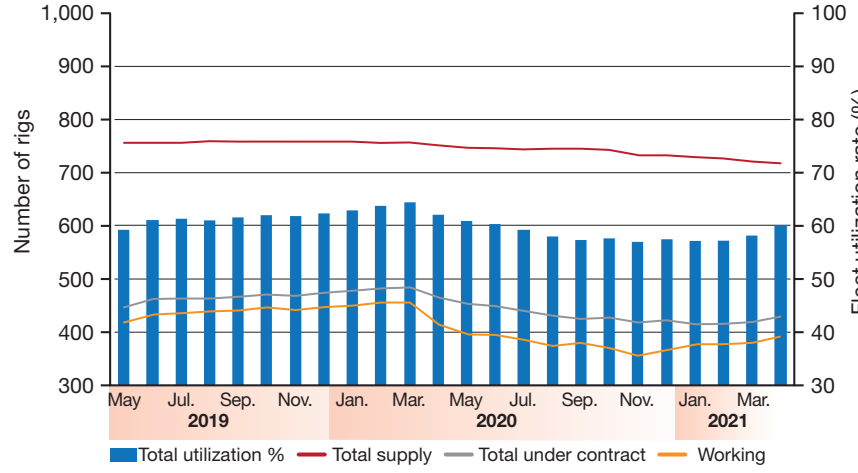
The industry's response to COVID proves it can connect and operate remotely. But more work is needed in the areas of offshore inspection and maintenance, and a collective behavioral change could accelerate the implementation of fully automated operations.

To respond to articles in Offshore, or to offer articles for publication, contact the editor by email (dpaganie@endeavorb2b.com).

Worldwide offshore rig count and utilization rate

While still a ways off from pre-COVID-19 levels of activity, the offshore drilling market has begun to make meaningful gains over the last couple of months. The total number of jackups, semis, and drillships under contract has climbed from 417 in January to 431 in April. Similarly, during that time span the global supply of units has been reduced from 729 in January to 717 through April. As such, utilization has jumped from 57.2% in January to 60.1% in April, the first time it has reached that level since June 2020. Meanwhile, the number of rigs working worldwide continues to improve, rising to 394 units in April from the 379 working in January.
– Justin Smith, Petrodata by IHS Markit

WORLDWIDE OFFSHORE RIG COUNT AND UTILIZATION RATE
MAY 2019 – APRIL 2021



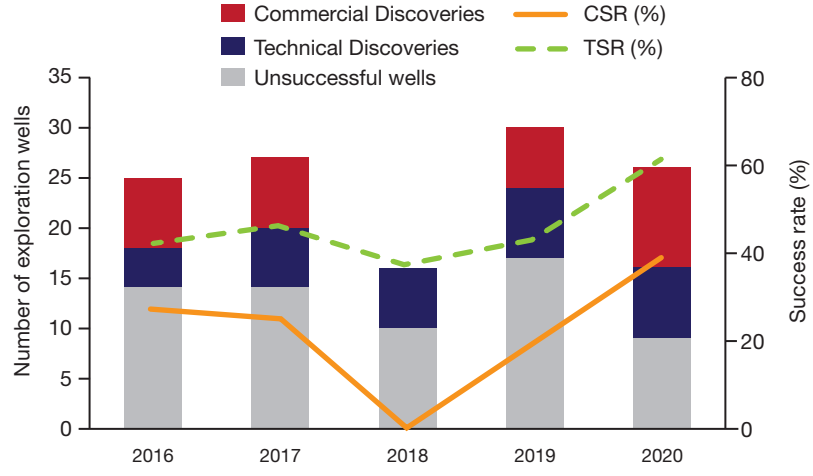
Notes: Rig types included are jackups, semis, and drillships

Source: RigPoint by IHS Markit

Farm-outs down but drilling success rates higher

Last year's oil price dip and COVID-19 pandemic led to a 56% decrease in E&P farm-out deals compared to 2019. The 29 exploration transactions completed represented the lowest of the past decade. Deepwater deals were down by 70%, with shallow water more resilient, only 24% lower. Total and Equinor traded out equity in six and four deals, respectively.
The commercial success rate from farm-out drilling in 2020 was 38%, a five-year high. Ten of the successes arose from the 26 wells that were drilled after equity transfers. The largest farm-out discovery was Maka Central-1 in block 58 off Suriname, where Total took a 50% stake from Apache.
– Vikesh Mistry, senior analyst, Westwood Energy

EXPLORATION PERFORMANCE FARM-OUT EXPLORATION WELLS
2016–2020



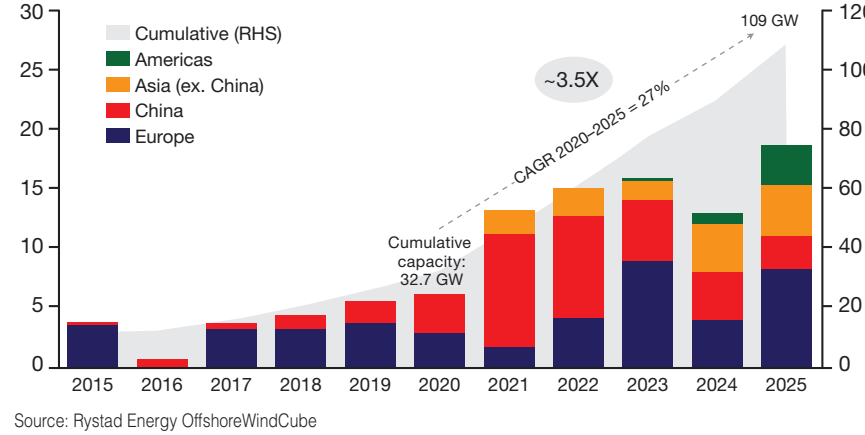
Source: Westwood Global Energy Group

Offshore wind capacity to more than triple

Global offshore wind capacity is expected to grow by about 27% annually on average to almost 110 GW by 2025, according to Rystad Energy. This constitutes more than a tripling of the current installed capacity. China is driving the global market in the short-to-medium term as developers are racing to reach full feed-in tariffs imposed by the Chinese authorities, which are set to be phased out after 2021. This is expected to lift annual capacity additions in 2021 to record levels above 13 GW, more than double the added capacity in 2020. While the activity in China is expected to slow down toward 2025, other Asian countries, the US, and Europe are expected to ramp up activity. This is forecast to surpass 15 GW of annual capacity additions in 2025.

GLOBAL OFFSHORE WIND CAPACITY ADDITIONS AND INSTALLED BASE

Gigawatts



Source: Rystad Energy OffshoreWindCube

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JEREMY BECKMAN
LONDON

CENTRAL/SOUTH AMERICA

BW LNG and Inveneregy have secured over $128 million from IDB Invest to finance the purchase and conversion of an LNG carrier into El Salvador's first floating storage and regasification unit. The vessel, with a re-gas capacity of 280 MMcf/d and an LNG storage capacity of 4.8 MMcf (137,000 cu m) will be moored at Acajutla Port, Sonsonate. The re-gasified LNG will be transported through a subsea pipeline to a 378-MW power plant onshore: the project, due to be completed next year, should supply 30% of the country's energy needs.

◆◆◆

First oil has flowed from BHP's shallow-water Ruby project in block 3a within the Greater Angostura field offshore Trinidad and Tobago. Five production wells and one gas injector in the Ruby and Delaware reservoirs will deliver at peak up to 16,000 b/d of oil and 80 MMcf/d of gas.

◆◆◆

ExxonMobil and its partners have achieved another commercial discovery in the prolific Stabroek block off Guyana. The Uaru-2 well, drilled in 5,659 ft (1,725 m) of water by the drillship *Noble Don Taylor*, penetrated 120 ft (36.7 m) of good-quality oil-bearing reservoirs, including newly identified intervals below the Uaru-1 discovery well, 6.8 mi (11 km) to the north. With more than 9 Bboe now proven across the block, ExxonMobil sees potential for up to 10 FPSOs, and six projects online by 2027.

◆◆◆

Petrobras has agreed to acquire bp's interests in six ultra-deepwater blocks in northern Brazil's equatorial margin region, all awarded in 2013 under the ANP's 11th bidding round. The concessions are 75 mi (120 km) from the state of Amapa: Petrobras also has an agreement to take on Total's operated stakes in the blocks, pending ANP approval.

In the presalt Santos basin off Brazil's south coast, the company is pressing ahead with plans to raise production from the giant Búzios field above 2 MMboe/d by the end of the decade. It has contracted Keppel Shipyard to build the field's seventh FPSO, due to be delivered in 2024. This will be connected to six producer and seven injector wells via a network of rigid and flexible pipelines, and with capacity to process 180,000 b/d of oil and 7.2 MMcm/d of gas. In addition, Petrobras is inviting bids for a ninth floater, *P-80*, designed to handle 225,000 b/d and 12 MMcm/d.

WEST AFRICA

ADM Energy and Eunisell have agreed to jointly explore opportunities to develop the Barracuda oilfield in swamp/shallow waters in Nigerian offshore lease OML 141. The scope could include an early production system producing 4,000 b/d later this year. With potential to raise output to 23,000 b/d by 2026 by drilling two further wells. A 7.5-mi (12-km) pipeline taking the oil to the Brass Export Terminal could lower opex costs to $12/bbl.

KBR is assisting the development of Nigeria's first FLNG vessel, a 1.2-MM metric ton/yr (1.32 MMt) facility. The company is responsible for a due diligence review of the pre-FEED, undertaken by Japanese company JGC. UTM Offshore is leading the project in collaboration with a subsidiary of state oil company NNPC, with a stated goal of decarbonization and monetization of Nigerian gas.

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VAALCO Energy may bring in an FSO at the Etame Marin oilfield offshore Gabon, once the present FPSO contract with BW Offshore expires in September 2022. Omni Offshore Terminals would operate the replacement vessel for up to 11 years: VAALCO estimates capex for the associated field configuration at $40-50 million, with payback of less than three years, and opex savings (compared with the FPSO) of up to $20 million/yr over the life of the new agreement.

◆◆◆

Total has produced first oil from its Zinia Phase 2 project in block 17, 93 mi (150 km) offshore Angola. The facilities, designed to recover an estimated 65 MMbbl, include nine new wells connected via subsea equipment to the Pazflor FPSO. Production should peak at 40,000 b/d by mid-2022.

Eni has made a further oil discovery in Angolan block 15/06. The drillship *Libongos* drilled the Cuica prospect in 1,640 ft (500 m) water depth, inside the Cabaça development area and close to the East Hub FPSO *Armada Olombendo*. The well encountered 38 API oil in Miocene sandstones, with reserves estimated at up to 250 MMbbl. The company has also been discussing with bp a potential combination of their full upstream interests in Angola.

The Sonadrill Holding drillship *Libongos* drilled the Cuica oil discovery. *(Courtesy Seadrill)*

NORTHWEST EUROPE

Equinor plans a $384-million subsea development for the 134-MMboe Askeladd Vest gas-condensate field in the Barents Sea. The project will involve a tieback of a subsea template over the structure to the Askeladd field via a pipeline and umbilical, with production sent 121 mi (195 km) through the Snøhvit pipeline system to the Hammerfest LNG complex on Melkoya Island off northern Norway. Aker Solutions will supply the subsea production system, including template and two christmas trees, with TechnipFMC installing the pipelines via the reel-lay method, and Nexans the umbilical, fiber-optic and power cables. Equinor and its partners are aiming for start-up in the first half of 2024.

◆◆◆

Worley is providing FEED services to support Phase 1 of Anasuria Hibiscus UK's Marigold development in the UK central North Sea, comprising the Marigold and Sunflower oil discoveries. Phase 1 involves re-purposing and upgrading of an FPSO, connected to three subsea production wells, to be followed by Phase 2 in late 2022.

JEREMY BECKMAN
LONDON

In the UK's Outer Moray Firth region off northeast Scotland, Ithaca Energy has committed to the Stage 2 enhanced oil recovery project, injecting polymerized water into the heavy-oil Captain reservoir with additional subsea wells and new topsides facilities.

BLACK SEA

OMV Petrom and Romanian gas distributor Romgaz are interested in jointly developing proven gas in the Neptun Deep block in the Romanian sector of the Black Sea. If current operator ExxonMobil accepts Romgaz's offer, OMV Petrom, the sole partner in the block, would take charge. The block includes Domino, Romania's first deepwater gas discovery.

MIDDLE EAST

Gas production has started from the Raven field offshore Egypt, the third stage of the $9-billion West Nile Delta (WND) project covering five fields across the North Alexandria and Mediterranean Deepwater offshore blocks. The fields have been developed via three long-distance subsea tiebacks to the shore, connecting 25 wells. Raven's gas is exported to a new onshore processing plant alongside the existing WND complex. Operator bp expects production to potentially reach 900 MMcf/d, with 30,000 b/d of condensate.

◆◆◆

Petropars will develop the Farzad B gas-condensate field in the Persian Gulf, under a $1.7-billion contract awarded by National Iranian Oil Co. The workscope includes construction and installation of three platforms; drilling eight wells with combined production of 28 MMcm/d of sour gas; and laying of export pipelines for the gas and condensate. The field is 12.4 mi (20 km) from Farsi Island.

ASIA/PACIFIC

Reliance Industries and bp have started operations at the Satellite Cluster gas field, the second of three deepwater developments in the KG D6 block off eastern India following R Cluster, which came onstream last December. Satellite Cluster will produce up to 6 MMcf/d from five wells across four reservoirs in up to 6,069 ft (1,850 m) of water, 37 mi (60 km) from the onshore terminal at Kakinada. All three projects will be connected to existing hub infrastructure.

◆◆◆

PTTEP has continued its run of recent drilling successes offshore Sarawak, Malaysia, proving gas in the Kulintang prospect in shallow-water block SK438, 67 mi (108 km) from the coast of Bintulu. The company expected to drill a follow-up well on the block, citing potential for a cluster development through nearby infrastructure. Previously the company found oil and gas with its Sirung-1 well in block SK405B, farther out from Bintulu.

Malaysia, via Petronas has formalized a unitization agreement with Brunei Darussalam that allows for joint development of the Gumusut-Kakap and Geronggong-Jahus East fields which overlap the two nations' maritime boundary. The Shell-operated Gumusut-Kakap field came onstream in late 2014.

◆◆◆

CNOOC has started gas production from the single-well Liuhua 29-2 field development, 186 mi (300 km) southeast of Hong Kong in 2,460 ft (750 m) water depth. Production is connected via a subsea wellhead to existing facilities serving Liwan 3-1 and other deepwater fields in the South China Sea.

◆◆◆

The Malampaya gas field complex. *(Courtesy Shell)*

Shell is exiting the deepwater Malampaya gas-condensate field after agreeing to sell Shell Philippines Exploration's 45% operated interest in the surrounding Service Contract 38 for an initial $380 million. The buyer is Malampaya Energy XP, a subsidiary of Udenna Corp, which is already a partner in the concession. The field has been producing since 2002 via subsea wells and flowlines and two platforms, with gas exported through a 313-mi (504-km) subsea pipeline to a gas plant in Batangas City. Shell could net further payments of up to $80 million depending in part on the field's future performance.

◆◆◆

Eni has produced first gas from the Merakes field in the East Sepinggan block offshore East Kalimantan, Indonesia, in a water depth of 4,921 ft (1,500 m). Up to 450 MMcf/d from five subsea wells will be gathered at a manifold for transmission 28 mi (45 km) through subsea pipelines to Eni's *Jangkrik* FPU; from there, the processed gas heads through further offshore pipelines to the onshore reception facility in Senipah.

AUSTRALASIA

Santos has awarded two of the main contracts for the $3.6-billion Barossa project in the Timor Sea, 186 mi (300 km) from Darwin. BW Offshore will supply the FPSO, based on the RapidFramework design previously applied to the Catcher field FPSO in the UK North Sea that allows for concurrent hull construction and topsides integration. The vessel, with a projected topsides weight of around 35,000 tons, will be built at yards in South Korea and Singapore, with capacity to process 800 MMcf/d of gas and 11,000 b/d of stabilized condensate. It should start operations (also entrusted to BW Offshore) in the first half of 2025, while the condensate will be stored on the FPSO for periodic offloading.

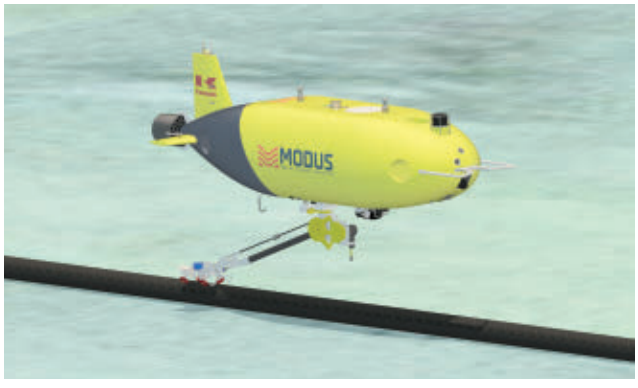
TechnipFMC will provide the subsea production system for the six subsea wells and associated controls. Gas will head through a pipeline connected to the Bayu Undan to Darwin pipeline system that send supplies to Darwin LNG.

JESSICA STUMP
HOUSTON

AUV/ROV ADVANCES IMPROVING EFFICIENCY

Modus Subsea Services Ltd. has acquired two SPICE (Subsea Precise Inspector with Close Eyes) autonomous underwater vehicle (AUV) systems from Kawasaki Heavy Industries Ltd. According to Kawasaki, SPICE is the world's first AUV equipped with a robot arm for performing subsea pipeline inspections. An inspection tool unit is fitted with close-range sensors at the end of the robot arm. SPICE controls the robot arm autonomously to track the pipeline and perform inspection operations.

The AUV is about 5.6 m (18.3 ft) long, 1.4 m (4.6 ft) wide, and 1.1 m (3.6 ft) tall. In addition, it is operated using a Kawasaki-developed docking station, which increases inspection operation efficiency and reduces cost requirements.



The SPICE AUV has a maximum depth rating of 3,000 m (9,842 ft). *(Courtesy Modus Subsea Services Ltd.)*

3D at Depth Inc. has purchased a Sabertooth hybrid AUV/ROV from Saab Seaeye. The hybrid AUV/ROV is equipped as a containerized spread to transform any vessel of opportunity into a survey and inspection platform in less than 18 hours. This allows deepwater assets and offshore wind operators to reduce their costs, risks, and carbon footprint.

Neil Manning, COO of 3D at Depth, said: "The hybrid AUV/ROV coupled with 3D at Depth's patented SL Subsea LiDAR laser with remote sensing technology adds an extra layer of measurement and repeatability."

The 3,000 m (9,842 ft)-rated dual-hull system features an inertial navigation package with fixed offsets to the sensor payload, which includes the company's SL3 LiDAR laser, ultra-high resolution multibeam echosounder, side scan sonar, multiple camera and light solutions, and a methane leak detection sensor.

MCS has introduced the mini-ROV MiniSpector, which is designed to cut the costs of subsea inspection and 3D metrology. The vehicle can be launched from a platform, which reduces the reliance on additional vessels and equipment.

MCS CEO Wael Bakr said: "The MiniSpector has been designed to be easily carried and deployed and contains built-in 3D Photo Realistic Cloud technology for precise 3D measurement…"

The system provides measurements subsea, up to fabrication accuracy, he added, with a claimed beneficial impact on overall project efficiency and duration, particularly in deepwater measurements.

"Example of tasks the MiniSpector can deliver seamlessly include HD general visual inspection and close video inspection, spool metrology, platform approaches, and riser installation.

"With seven horizontal and vertical thrusters [it] provides full control, increased vehicle maneuverability, stability, and payload capabilities to withstand higher currents than other mini ROVs on the market."

Blue Ocean Seismic Services (BOSS) has completed sea trials of a test prototype version of its AUV offshore Australia. BOSS' shareholders are Blue Ocean Monitoring, bp Ventures, and Woodside Energy.

The self-repositioning autonomous underwater nodes, designed for long endurance, will perform offshore seismic surveys for oil and gas exploration and reservoir optimization, also serving to identify and monitor potential carbon storage sites beneath the seabed.

During the trials, the testbed ocean bottom seismic robotic vehicle (tOBSrV) traversed a series of waypoints, while simultaneously providing status updates to a master vessel. It also logged flight and engineering data which is being used for further systems development.

The trials also validated BOSS' electronics and software system, confirming its efficacy underwater. Collected data collected will support the design and development of the final product ahead of commercialization.

The next priority will be the construction and testing of 10+ alpha prototypes, followed by a seismic sea trial in the North Sea.

Erin Hallock, managing partner, bp Ventures said: "Once in production, this vehicle will make global offshore oil and gas exploration, reservoir optimization and other marine seismic applications cheaper, faster, safer, and importantly, less carbon intensive."

PETROBRAS ORDERS MARLIM/VOADOR SUBSEA EQUIPMENT

Petrobras has awarded TechnipFMC and Baker Hughes contracts for the Marlim and Voador field-revitalization project in the Campos basin offshore Brazil.

TechnipFMC will supply up to eight manifolds for production and injection, using the all-electric robotic valve controller (RVC). The contract also includes associated tools, spares, and services. The RVC replaces traditional subsea hydraulics, as well as thousands of mechanical parts, while providing real-time data and analysis on system performance. This results in a manifold that is smaller, less complex and costly with a reduced carbon footprint. Also, the RVC's software can be remotely upgraded and maintained subsea.

Baker Hughes will provide up to five subsea production and injection manifold systems, featuring a lightweight and compact design that allows for installation from smaller vessels and integrated hydraulic connection systems and retrievable choke modules. The manifold systems, which will be fabricated, tested and assembled in Jandira, Brazil, will include the company's vertical mechanical clamp connection system. In addition, the company will deliver 32 Modpod subsea control modules powered by SemStar5 technology, and manufactured at its Nailsea facility in Bristol, UK.

BRUCE BEAUBOUEF
HOUSTON

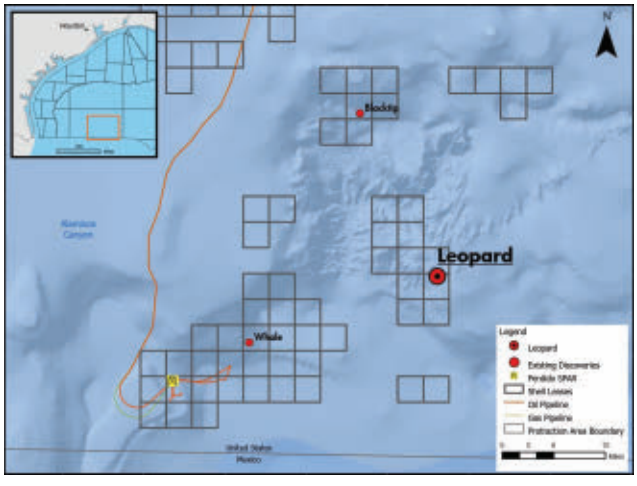
SHELL MAKES DEEPWATER DISCOVERY AT LEOPARD PROSPECT

Shell Offshore Inc. says it has made a significant oil discovery at the Leopard prospect in Alaminos Canyon block 691 in the deepwater US Gulf of Mexico.

The Leopard well encountered more than 600 ft (183 m) net oil pay at multiple levels. Evaluation is ongoing to further define development options, the company said.

Leopard is operated by Shell (50%) and co-owned by Chevron U.S.A. Inc. (50%).

Transocean's ultra-deepwater drillship *Deepwater Thalassa* drilled the discovery well in 6,800 ft (2,070 m) of water, Shell confirmed in an email to *Offshore*.



Location of the Leopard oil discovery in Alaminos Canyon block 691.
(Courtesy Shell)

Paul Goodfellow, Shell's Deepwater Executive Vice President, said: "Leopard expands our leading position in the Gulf of Mexico and is an exciting addition to our core portfolio, especially given its proximity to existing infrastructure and other discoveries in the Perdido Corridor."

Goodfellow continued: "With our US Gulf of Mexico production among the lowest GHG intensity in the world, Shell remains confident about the GoM and this latest discovery will help us deliver on our strategy to focus on valuable, high margin barrels as we sustain material Upstream cash flows into the 2030s."

According to the company, Leopard is an opportunity to increase production in the Perdido Corridor, where its Great White, Silvertip, and Tobago fields are already producing. The Whale discovery, also in the Perdido Corridor, is progressing toward a final investment decision in 2021.

Leopard is about 20 mi (32 km) east of the Whale discovery, 20 mi (32 km) south of the recently appraised Blacktip discovery, and 33 mi (53 km) from the Perdido host.

MCDERMOTT WINS TRION FPU FEED CONTRACT

BHP has awarded McDermott International Ltd. a front-end engineering design (FEED) contract for the deepwater Trion field development offshore Mexico.

The scope of the contract includes engineering tasks related to the configuration, sizing, and analysis of the semisubmersible floating production unit (FPU), including topsides, hull, risers, and mooring. McDermott was previously awarded and completed services under an initial pre-FEED contract.

The company will lead one integrated team to perform project management and execution planning.

The FPU will be designed for a water depth of about 8,200 ft (2,500 m). The Trion field is about 19 mi (30 km) south of the US/Mexico border and approximately 112 mi (180 km) off the Mexican coastline.

BHP is the operator and holds a 60% interest in Trion. PEMEX holds the remaining 40% interest.

BSEE INSPECTS MAD DOG 2 PRODUCTION PLATFORM

The Bureau of Safety and Environmental Enforcement (BSEE) inspectors and engineers have concluded a three-day pre-production inspection on the Argos, bp's new 60,000-ton platform slated for operation in the Gulf of Mexico.

The pre-production inspection team's goal is to verify that all safety equipment, components, and production processes aboard the structure have been constructed as planned, meet industry standards, and comply with federal regulations. BSEE's on-site inspection is one of the steps required to clear the platform for sailing to its planned destination in the deepwater Gulf of Mexico.

The inspection was conducted by a team of seven inspectors and engineers divided into two units, each simultaneously inspecting different areas of the facility for three consecutive days.

BSEE Houma District Manager Amy Pellegrin said: "During the pre-production inspection, we make certain that all safety devices are installed correctly and according to the facility drawings in the permit that bp originally submitted to BSEE. bp will subsequently be required to make revisions as necessary."

The Argos FPU arrived in Ingleside, Texas, in mid-April, in preparation for deployment on bp's $9-billion Mad Dog 2 project.
(Courtesy bp)

After the onshore pre-production process is complete, the Argos will sail to the Green Canyon area of the Gulf, about 190 mi (306 km) south of New Orleans. Water depth is about 4,500 ft (1,372 m). After the Argos is moved to its permanent location, BSEE engineers and inspectors will perform an additional inspection before production can begin.

"These regulatory inspections help ensure that the Argos meets all environmental compliance and applicable safety rules, regulations and practices," Pellegrin added.

The Argos is part of bp's Mad Dog 2 project, which is expected to begin production next year.

BRUCE BEAUBOUEF
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US GREENLIGHTS VINEYARD WIND 1 OFFSHORE MASSACHUSETTS

The Interior and Commerce departments have approved the construction and operation of the first commercial scale offshore wind project in the United States.

The 800-MW Vineyard Wind 1 project will be located 15 mi (24 km) off the coast of Martha's Vineyard.

The Vineyard Wind 1 project is expected to generate electricity to power more than 400,000 homes and businesses in Massachusetts.
(Courtesy Vineyard Wind)

Vineyard Wind, a joint venture between Avangrid Renewables and Copenhagen Infrastructure Partners, is expected to reach financial close in the second half of 2021.

The project will include 62 GE Haliade-X 13-MW wind turbines. First power is expected in 2023.

According to Vineyard Wind, it will generate electricity to power more than 400,000 homes and businesses in the Commonwealth of Massachusetts and reduce carbon emissions by more than 1.6 million tons per year.

The construction and operations plan was reviewed by more than two dozen federal, state, and local agencies over the course of more than three and a half years, the company said.

HIP PLANS WIND POWER EXPORTS TO UK FROM PODS OFFSHORE ICELAND

Hecate Independent Power (HIP) has initiated its HIP Atlantic wind power project. This involves installing 10,000 MW of fixed and floating wind turbines in the North Atlantic connected to the UK by long-length, high-capacity, high-voltage direct current (HVDC) submarine power transmission cables.

A specially designed, $277-million complex at a port in northeast England will manufacture the cables.

HIP estimates the total project cost at $30 billion. It has submitted four connection applications with National Grid Co. for an initial 4,000 MW of grid connections to the UK's 400-kV electricity transmission system across four connection sites.

Each wind farm – or pod – will be at a different location in the North Atlantic, and each will comprise 1,000 MW of wind turbines with a dedicated cable linked to the UK.

All the wind pods will be under the exclusive control of the UK electricity system operator making this Britain's first 'captive' wind farm in overseas territorial waters.

HIP Atlantic is aiming to have the initial 2,000 MW of generation capacity, from pods off the southern and eastern coasts of Iceland, commissioned in early 2025.

But the HIP Atlantic HVDC transmission cables will not connect to the Icelandic transmission system.

In addition, the planned pods in the North Atlantic will all be in a different meteorological area from current North Sea and Irish Sea wind farms, allowing the UK grid system to receive renewable electricity at times when existing UK wind farms are becalmed.

HIP also claims the project could create more long-term jobs across the UK than previous wind farms connected to the National Grid, with the initial 2,000 MW capacity alone resulting in around 15,000 new positions. Up to 500 new jobs are expected to be created in southern and eastern Iceland for the 2,000 MW pilot phase.

TRIO FORM ATIKA OFFSHORE WIND PARTNERSHIP

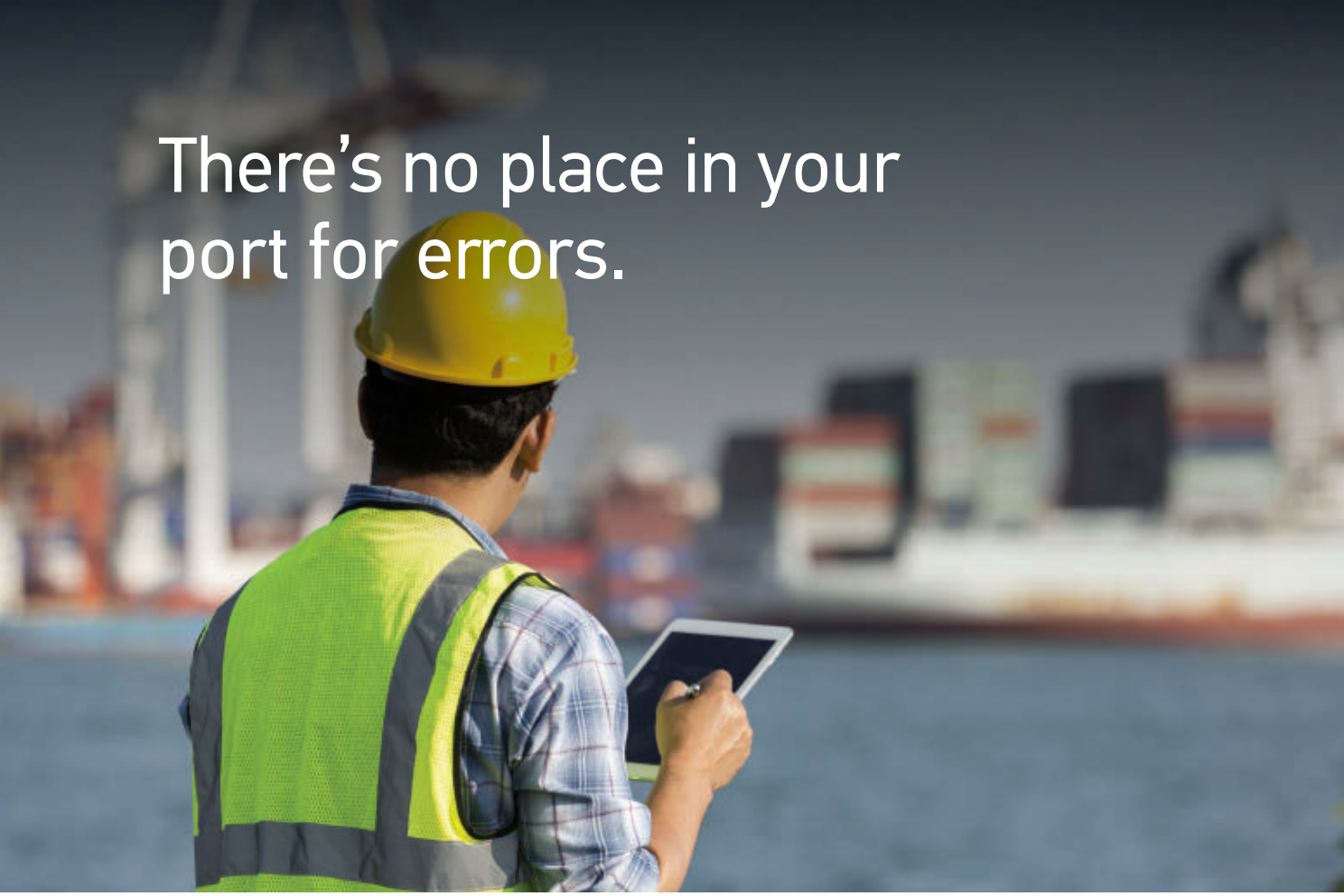
Ørsted, Japan Wind Development Co. (JWD), and Eurus Energy have partnered to jointly develop offshore wind projects in the Akita Prefecture.

The three companies have been developing two designated offshore wind sites under Japan's Offshore Renewable Energy Act of 2018, both of which are located off the coast of Akita: Noshiro/Mitane/Oga and Yurihonjo. Both projects are currently progressing with the necessary permitting, Ørsted said.

The consortium is prepared to participate in Japan's upcoming offshore wind auction round which closes on May 27, 2021.

The Atika offshore wind partnership is developing two offshore wind sites off the coast of Akita, Japan.
(Courtesy Ørsted)

Since 2017, JWD has conducted site investigations including wind measurements, seabed surveys, and environmental impact assessments at Noshiro and Yurihonjo. The turbines for both wind farms will be installed on bottom-fixed foundations.



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Proper planning allows Saudi Aramco to upgrade facilities in busy offshore area

Studies, mitigation measures enable Marjan & Zuluf Increments to move forward

MOHAMMED A. SADIQ, HAMAD S. SHAIBAN, ALI K. GHAMDI, *SAUDI ARAMCO*

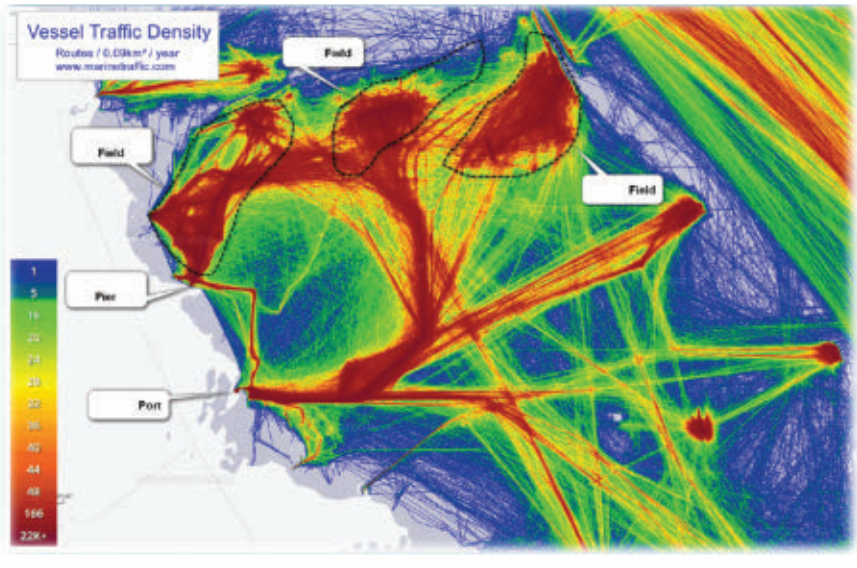
EXECUTING A MAJOR OFFSHORE construction project is a challenging task by itself. There are tremendous risks associated with the marine operations and installation work that must be mitigated every step of the way. The risks are much higher when the major offshore construction is taking place in an existing operational field.

Saudi Aramco's Marjan & Zuluf Increments are considered among the most ambitious programs worldwide. The programs will boost the country's position as a leading figure in providing reliable energy to the world. The fact that both programs are to be executed in these busy and congested mature offshore oil fields, while maintaining normal hydrocarbon production, is considered one of the most complex challenges ever taken by the company in the offshore projects execution sector.

Since the initiation stage of both programs, the offshore execution part has been identified as the biggest challenge that the programs have to manage. Multiple construction contractors will be working simultaneously in busy and congested oil fields—over and around live and operating subsea and above water facilities—mandating extraordinary mitigation measures to be adopted and implemented.

The project management team worked in close coordination with the operation and marine departments to properly plan and implement many mitigation measures addressing the huge challenge. The mitigation measures span over almost all project execution phases. Some of these measures have been implemented as part of the awarded contracts, while others are being implemented in the engineering and detail design phase; and the remaining will be implemented in the construction phase.

Through proper planning and front-end marine traffic and risk studies, the team identified and implemented multiple measures to mitigate the risks. These measures included utilizing only class 2 and 3 dynamic positioning systems; dedicated navigation channels and anchorage areas; implementation of renewable energy solutions; elimination of crossings; and other administrative measures associated with the fields' management and marine vessel control.



The marine vessel traffic study generated heat maps and risk areas for both the Marjan & Zuluf offshore oil fields. *(Courtesy Saudi Aramco)*

PROJECT EXECUTION CHALLENGES

Offshore and subsea construction work poses some of the greatest technical, logistical and safety risks in the construction world. The installation of the heavy offshore structures involves extreme heavy lifting operations (up to 5,000 tons); the installation of extra heavy structures that cannot be lifted (in the range of 10,000 to 20,000 tons); the laying of hundreds of kilometers of subsea pipelines and cables; and the execution of specialized diving operations.

The risks associated with each activity can be tremendous, and often pose real danger to properties and personnel working in these offshore oil and gas fields. Such risks multiply drastically when working within existing operational fields that are already producing

and busy with ongoing drilling and maintenance activities.

The Marjan & Zuluf offshore oil fields are the second and third largest offshore fields in the Arabian Gulf. Both fields currently produce oil from around 100 offshore platforms, six offshore gas oil separation plants, and hundreds of kilometers of subsea pipelines and cables. Each year, both fields receive additional facilities to maintain field potential and replace aged facilities.

In addition to the ongoing maintain potential programs, the fields are due for substantial increment projects, which are part of Saudi Aramco's continuous plan to strengthen its position as one of the world's leading producers of oil and gas. Through the Marjan Increment Program that has already commenced, and the upcoming Zuluf Increment Program, the two offshore fields will receive tens of additional offshore oil, gas, and water injection platforms, and additional hundreds of kilometers of subsea pipelines and cables.

Executing these increments in busy, producing offshore fields pose great challenges and risks. These can be narrowed into three main categories:

Marine traffic and logistics. Both of the Marjan & Zuluf fields are operating fields. The fields currently run a busy production operation with a heavy presence of boats to support operation, maintenance and security personnel roaming around the fields. In addition, the ongoing maintain potential projects also add a substantial number of marine vessels to support drilling and workover rigs and the construction of the maintain potential facilities. It is estimated that both fields have an average daily presence of 100 boats/barges a day, ranging between heavy lift construction barges, jackup barges, cargo barges, field service boats, work/maintenance boats, crew transfer boats and supply/fuel/water boats. Organizing such heavy marine vessels presence within the limited boundaries of the fields, and ensuring the safety of the personnel and existing subsea and topsides assets, is already a huge undertaking by the Saudi Aramco marine department.

Executing significant increment programs and adding tens of offshore facilities, drilling tens of wells and installation of hundreds of kilometers of subsea pipelines and cables will at least double the number of marine vessels and barges present in both fields. Thorough risk analyses and mitigation plans will need to be proactively put together to properly manage the marine traffic and logistics, ensure safe ongoing operation and execution of the drilling and construction activities that will accompany the increment programs.

Interface with subsea assets. Another challenge that is associated with the busy offshore fields is the presence of a complex mesh of subsea pipelines and cables connecting the existing/producing facilities. To put things in perspective, the Marjan field, for example, is an area of 20 km wide and 30 km long. Having hundreds of kilometers of subsea pipelines and subsea cables connected in a small geographical area is a remarkable achievement already. Now, adding hundreds of kilometers of additional subsea pipelines and cables within the same area is a logistic and safety challenge. The new lines will need to cross over the existing/producing subsea pipelines and live subsea cables and any miscommunication or faulty installation operation can lead to subsea pipeline damage or interruption of ongoing operations.

Offshore construction cost and logistics. Executing normal offshore construction work in a completely green field area is a very expensive business. The cost of the offshore specialized construction resources is extremely higher than similar construction activities in onshore. Many of the required resources are specialized barges that are rare around the world. For example, there are only a small number of heavy lift barges that can lift an excess of 5,000 tons, and only three or four cable lay barges that can lay the required length of cable in one run between the coast line and Marjan field. The cost and logistic challenges grew even bigger when trying to execute these offshore construction projects in busy fields with the required safety and precaution measures.

The project management team within Saudi Aramco realized the above challenges at the early stages of planning for the increment programs. The Marjan & Zuluf increment projects department worked with the integrated project team members from all relevant Saudi Aramco organizations to properly plan and mitigate the above identified risk categories. The teams conducted thorough analysis and came up with early mitigation measures, and utilized the latest technologies to ensure safe execution of the offshore construction activities with no interruption to the ongoing production and drilling operations.

STUDIES AND MITIGATION MEASURES

Realizing the challenges ahead, the team kicked-off a study to model and analyze the marine traffic, taking in consideration the ongoing operation and the forecasted increase in activities during the execution of the increment programs. The study utilized the latest computer modeling to generate heat maps and risk areas for both offshore oil fields.

The heat maps were then utilized to identify the major contributors to such increase in traffic and risk factors. The team then conducted brainstorming sessions to identify the measures that can be implemented to reduce the risks. When identifying these measures, the latest technologies in marine vessels management and facilities design played a major role in the reduction of risks.

Some of the major implemented measures were as follows:

Utilization of renewable energy. The increment projects department analyzed the power requirements of the programs' relatively low-power consuming facilities (such as the water injection platforms) and adapted the utilization of solar panels in lieu of running new subsea cables. The decision led to eliminating tens of kilometers of subsea cables required to power the offshore platforms. As such, this design directly addressed and mitigated all three risk categories by significantly lowering the number of subsea cables (reducing the subsea interfaces and crossings), reduced the number of required cable lay vessels (contributing to lowering the marine traffic) and provided more cost-effective design. As an

added bonus, the design is more environmentally-friendly with the utilization of renewable solar energy instead of the traditional subsea cable approach.

Subsea pipeline design. The traditional design of offshore production platforms is using a direct subsea pipeline from each production platform to a collecting platform known as a tie-in platform. The tie-in platform collects the production from multiple (eight-10) production platforms and send the gathered production to the gas oil separation plants for processing. This typical arrangement requires hundreds of kilometers of pipelines to transfer the produced hydrocarbon to the processing facilities. Moreover, each pipeline requires continuous maintenance and scraping operations to preserve and prevent corrosion. The Marjan & Zuluf increment projects department capitalized on this offshore best practice approach to design the subsea pipelines configuration with a multilateral approach requiring only one pipeline for every group of platforms. The pipeline starts from a leading platform while the others connect join-ins using a lateral approach.

The project has also adapted the utilization of flexible lines for the lateral connection. The flexible lines technology provides an excellent nonmetallic alternative to the traditional rigid carbon steel pipelines. Although flexible lines may have limitations in length and size for longer runs, they work perfectly in lateral connection and provide scraping free corrosion resistance product for oil production.

Utilizing this laterals approach significantly eliminated tens of kilometers of subsea pipelines and crossings between the new pipelines and the existing subsea pipelines and cables. The number of marine vessels required to install the pipelines was also reduced, in addition to the reduction in marine traffic during normal field operations (with the elimination of scraping requirements for the flexible pipelines).

Contracting strategies. The project team has also taken several steps to properly plan the construction activities and reduce or eliminate risks during the construction phases. From a planning perspective, the contracting strategies of the projects has taken into consideration the marine traffic and crossing risks, and adapted a geographical-area zoning strategy. This contracting strategy is designed to reduce overlapping and interfacing between construction contractors, and to allow each construction contractor full access to his construction site independently, with a dedicated marine channel without the need to cross the busy field center.

Construction simplification. The selection of the platforms locations and the routing of the subsea pipelines and subsea cables has been planned/selected to

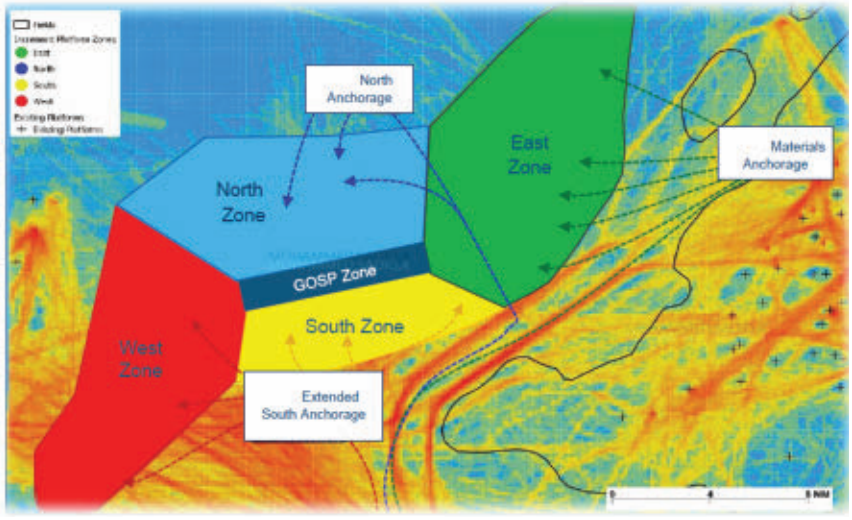
provide the lowest possible number of crossings. Wherever possible, the team has also utilized the design of double subsea crossings, where one crossing structure is deployed on the seabed to protect the existing adjacent subsea pipelines and cables before crossing them with new ones. As a result, the number of overall crossings has been significantly reduced, providing cost and risk avoidance during offshore construction.

Moreover, the design of all heavy, large and complex facilities has been planned with the purpose of simplifying offshore construction. The team designed the extra-heavy platforms (weighing 5,000 tons or more) to be installed using float-over techniques. The float-over installation eliminates the need for the rare, expensive and massive extra-heavy lift barges. These barges usually come with a fleet supporting vessels, tug boats and anchor handling operations. The float-over installation method is a much simpler installation technique that uses fewer marine resources.

On the pipelay, cable lay and diving fronts, Marjan & Zuluf projects adapted the utilization of DP vessels in all construction operations. The DP vessels utilization eliminates the need to deploy anchors to control the movement of the barges and the installation work. Instead, DP systems use satellite GPS technology to control the barge's thrusters, and adjust the position and movement of the barge automatically. This in turn eliminated massive anchoring work on the already congested seabeds of both fields and significantly reduced the risk of dropping anchors on live subsea pipelines and cables, and causing damage to personnel, assets, and the environment. The marine traffic concern has also been mitigated with the elimination of the anchor handling tugs and continuous deployment, recovery and movement of anchors from one location to another.

Marine management and mitigations. Realizing the challenges associated with the execution of these two major increments and as part of the integrated project team, the Saudi Aramco marine department has also proactively implemented several operational control measures to ease the movement and reduce the traffic in the busy offshore fields. The marine department increased the number of anchorage areas in both fields from two to four, providing safe designated areas for the vessels/barges to shelter during bad weather periods, and avoid the risk of damage to existing (or new) subsea and topsides facilities.

Moreover, the marine department adapted and approved additional designated navigation channels for vessels to move between fields and back-and-forth from shore. These channels work like super highways and control the marine traffic through known, safe, and



By assigning the color codes to the various offshore sectors, vessels can be routed into and out of the fields as needed. *(Courtesy Saudi Aramco)*

continuously monitored lanes, to avoid scattered traffic all over the fields in the Arabian Gulf.

Other implemented measures also included:

Increased vessel traffic. The existing VTS systems supporting the field are undergoing review, and will possibly be upgraded to IALA Level 2 Traffic Organization Service. This will provide more advanced operational management techniques and decision support tools that will play a major role in managing and mitigating navigation risks. These techniques and tools can include:

- One-way vessel transit in defined areas
- No passing/meeting of vessels in defined areas
- No overtaking in defined areas
- Use of escort tugs for large barges/vessel move
- Maximum speed limits
- Maximum draught requirement
- Daylight operations only
- Prohibited areas to be avoided
- Safety and exclusion zones
- Maximum tow lengths
- Prohibited anchorages
- Restricted operations in certain weather conditions
- Time, distance and geographical separation of vessels
- Mandate routes to be followed
- Traffic separation schemes/reporting schemes.

Enhanced master training. Saudi Aramco realized the need to focus on the vessels' masters and make them appreciate the changes taking place in the offshore fields. Therefore, an enhanced training scheme is being put in place for the masters and mates of vessels engaged in the increment programs. The training will allow these key vessels' personnel to make better decisions, and improve situational awareness of increment and baseline vessel traffic activities. The training will be similar to the harbor pilots' general scheme in aspects related to navigational features/obstructions and details of the navigation safety during the construction phases.

Enhanced vessel specifications. In addition to the mandate of using DP vessels as explained earlier in the paper, Saudi Aramco is also looking into mandating other specifications for the vessels that will be involved during the construction phase of the increments. Examples include Electronic Chart and Display Information System (ECDIS) to provide collision avoidance warnings. The ECDIS displays the ship's position on the electronic charts in real time and takes feeds from the ship's GPS, radar, log, compass and AIS systems. It can provide fused traffic image, bring all sensors together, and use collision algorithms to identify and warn the bridge team of impending collision situations that can be avoided.

Declaration of information. Declaration or promulgation of construction information is important to ensure that vessels transiting (or planning to transit) in the fields are familiar with the planned operations. The following forms of declarations are being adapted:

- Regular notices to vessels – created by a dedicated hydrographic survey unit and issued by the company's marine department
- Marine information broadcasts
- Provision of projects' specific mapping files and chart plotters.

Routing measures. The completed studies showed that there are cases of 300 vessels/day moving in the two fields during the peak periods of the construction work. This is a substantial increase from the average 90 vessels/day during regular operations. As a mitigation measure aimed toward reducing vessel density, mandatory routing measures are being introduced. By implementing special routing measures, the fields can be split into color-coded sectors; and then, vessels can be routed into, out of and around the field, as needed and mandated.

PATH FORWARD

During the construction of the increment programs facilities, the Saudi Aramco project management team, along with Marine and Operations Departments, are planning to deploy a state-of-the-art Marine Control Center (MCC) to continuously monitor, control and direct the marine traffic associated with ongoing operations and new drilling and construction activities.

Similar to flight control systems in busy airports, the MCC will be directly connected to the vessel's tracking system that will be mandated on all marine vessels working on Saudi Aramco fields. The human-computer integrated staff will be planning and monitoring all marine traffic, and will have live-feed on the subsea construction/laying activities, heavy lift and float-over installations and diving operations.

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Offshore drilling market adapting through consolidation, collaboration

Rig scrapping expected to accelerate

JESSICA STUMP, *ASSISTANT EDITOR*

THE OFFSHORE DRILLING MARKET is slowly recovering from the COVID-19 pandemic and oil price crash. Several drilling rig contractors and analysts have reported seeing early signs of a recovery and pickup in activity as the year goes on. Operators are said to be accelerating drilling programs in order to take advantage of low rig rates in anticipation of a tighter supply/demand balance.

Meanwhile, rig contractors and managers are still working to pare back their fleets to be in line with market demand. According to Rystad Energy, an evaluation of active rigs in the global floater fleet (as of late 2020) revealed that up to 59 of the 213 units are potential candidates for retirement. This equates to one-quarter of the floater segment, or 22 drillships and 37 semisubmersibles.

The *Noble Clyde Boudreaux* is the only semisubmersible in the drilling contractor's fleet. *(Courtesy Noble Corp.)*

Jo Friedmann, vice president, Energy Service Research, at Rystad, said: "Capacity attrition can set the stage for a comeback in utilization and play a key role as the offshore drilling industry seeks to shore up its finances."

Rig supply needs to tighten for drilling contractors to regain pricing power, Friedmann added.

From corporate and asset M&A transactions, to joint ventures and rig management and operating partnerships, consolidation is under way in the offshore drilling market.

A CHANGING LANDSCAPE

As many offshore drilling contractors emerge from Chapter 11 bankruptcy, long-term stacked and older rig retirements are expected to increase.

In April, Noble Corp. acquired Pacific Drilling Co. LLC in an all-stock transaction. According to Noble, the acquisition facilitates its reentry into the growing West Africa and Mexico regions and strengthens its presence in the US Gulf of Mexico. Also, it is hoped that the addition of Pacific's ultra-deepwater drillships will allow participation in key tendering activity. The company immediately retired the *Pacific Bora* and *Pacific Mistral*.

The drilling contractor now owns and operates a high-specification fleet of 24 offshore drilling rigs: 11 drillships, one semisubmersible, and 12 jackups.

Last year, the company retired the 1981-built jackup *Noble Joe Beall*, and sold the cold-stacked drillships *Noble Bully I* and *Noble Bully II* and the semisubmersibles *Noble Jim Day*, *Noble Danny Adkins*, and *Noble Paul Romano*.

Terry Childs, Head of Westwood Energy's RigLogix, said: "Whether any other deals take place remains to be seen, but it is possible that the changing landscape could mark the end of some of the biggest names in the history of the offshore rig market, joining the likes of Rowan, ENSCO, and GlobalSantaFe."

As for other rig contractors, Diamond Offshore Drilling Inc. and Valaris both completed financial restructuring in April and May 2021, respectively.

Valaris has sold and retired three drillships (*DS-3*, *DS-5*, and *DS-6*), five semisubmersibles (*5004*, *8500*, *8501*, *8502*, and *8504*), and six jackups (*JU-71*, *JU-84*, *JU-87*, *JU-88*, *JU-101*, and *JU-105*). Its fleet now consists of 11 drillships, five semisubmersibles, and 44 jackups.

Seadrill and some of its consolidated subsidiaries filed for Chapter 11 bankruptcy in February 2021.

Last year Seadrill announced it would scrap or offer for sale up to 10 rigs. As part of this initiative, the company sold the cold-stacked jackup *West Epsilon* to Well-Safe Solutions.

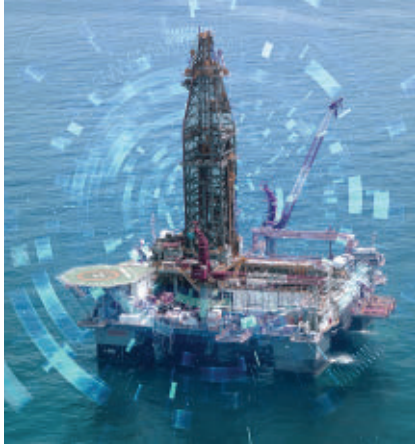
Vantage Drilling International has entered into a framework agreement and related management and marketing agreements with Seadrill Partners. Vantage will provide operating, management, and marketing services for the drillships *West Polaris* and *West Capella* and the semisubmersibles *West Leo* and *West Sirius*.

Vantage also sold the drillship *Titanium Explorer*, and it is expected to be recycled soon.

In addition, Transocean has retired the semisubmersible *Leiv Eiriksson*, and Shelf Drilling has sold the jackups *Trident 15*, *Galveston Key*, and *Key Hawaii*.

Maersk Drilling has sold the warm-stacked jackup *Maersk Guardian* (now re-named *Guardian*) to New Fortress Energy, and is close to an agreement to sell the cold-stacked jackup *Mærsk Gallant* to the same buyer. Total sales price for the two rigs is $31 million. New Fortress Energy plans to use the rigs for non-drilling purposes, as part of its planned Fast LNG project.

Once the two transactions have closed, Maersk Drilling's fleet will consist of 12 jackups, 11 of which are suited for harsh-environment operations, and eight floaters.



The integrated offering is said to enable the automation of manual workflows, improving safety and drilling efficiency. *(Courtesy Schlumberger)*

COLLABORATION HEATS UP

Downhole service providers are also adapting to the new environment, mainly through consolidation and collaboration.

Baker Hughes and Akastor ASA have agreed to create a 50/50 joint venture company that is expected to deliver a global full-service offshore drilling equipment offering. The company will bring together Baker Hughes' Subsea Drilling Systems business with Akastor's wholly owned subsidiary MHWirth AS. The closing of the transaction is subject to customary conditions, including regulatory approvals, and is expected to occur in the second half of 2021.

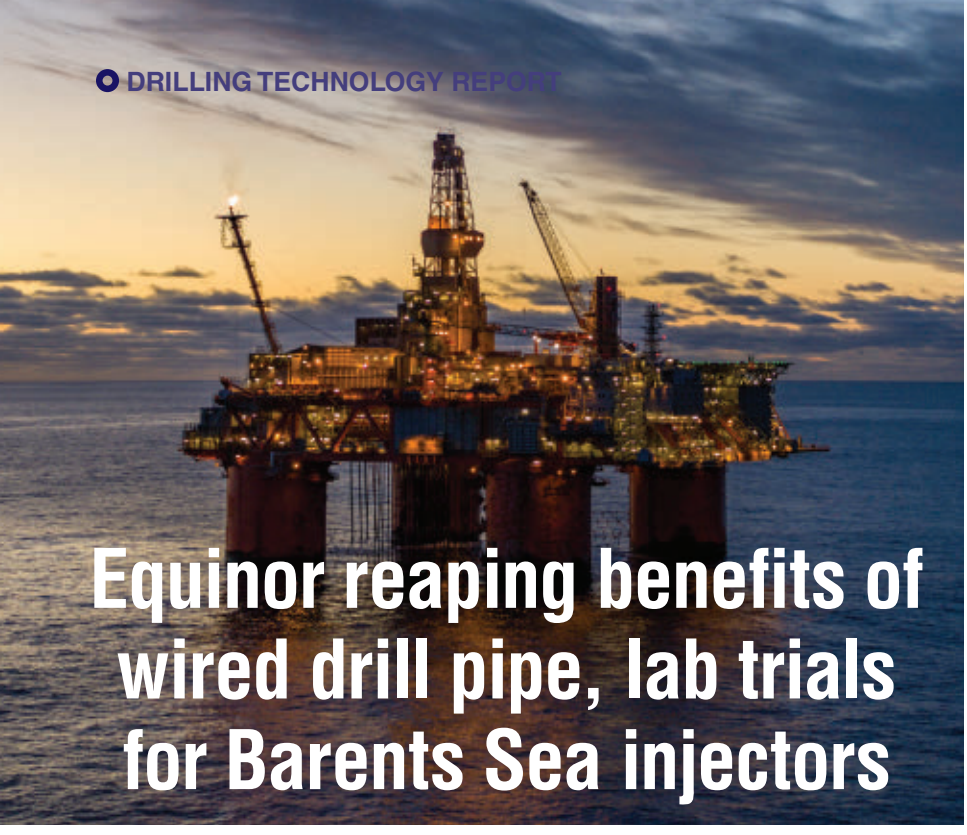
Schlumberger and NOV have agreed to collaborate to accelerate automated drilling solutions adoption by oil and gas operators and drilling contractors. The agreement will enable customers to combine Schlumberger's surface and downhole drilling automation solutions with NOV's rig automation platform. This integrated offering is said to enable the automation of manual workflows, improving safety, decision making, consistency, and efficiency in drilling.

The combined solution leverages advanced AI from the Schlumberger DrillOps on-target well delivery solution, while NOV's NOVOS process-automation platform controls all the company's rig equipment within the operational envelope. The two technologies will work together to manage compliance to procedure and to reach best-in-class operational performance, the companies claimed.

Also, Weatherford has teamed up with Safe Influx to offer automated downhole solutions. Under a recent memorandum of understanding, the companies say they will cooperate to bring to market the first-ever integration of managed pressure drilling (MPD) solutions and automated well control technology.

As part of the MoU, Safe Influx will combine its automated well control technology with Weatherford's portfolio of MPD products and services.

The companies recently completed the rig trial of what they claimed is the industry's first ever integration of MPD and automated well control technology. The combination of Weatherford's Victus intelligent MPD and Safe Influx's technology is said to provide automated secondary well control which is expected to allow wells to be drilled and constructed more efficiently.



Snorre A platform in the Norwegian North Sea.
(Courtesy Bo B Randulff/Even Kleppa/Woldcam/Equinor)

Equinor reaping benefits of wired drill pipe, lab trials for Barents Sea injectors

Improved well productivity, integrity management

JEREMY BECKMAN, *EDITOR, EUROPE*

NORWAY'S OFFSHORE OPERATORS were strongly represented at the SPE/IADC Virtual International Drilling Conference earlier this year. Among those submitting multiple presentations were Equinor, with updates on technical developments at various fields on the Norwegian continental shelf that have continued throughout the pandemic.

Børge Nygård, Lead Advisor, Drilling Technology at Equinor, related some of the improvements to the company's drilling operations since the introduction in 2017 of wired drill pipe (WDP) and along-string measurement (ASMs), a co-development with NOV. The WDP extends from the surface through to the bottomhole assembly (BHA), with measurements taken regularly along the string and at the BHA, such as temperature, pressure, vibration, torque, tension, and bending moments.

The ASM tools are typically placed in the open-hole: the signals require electrical power to travel up and down the pipe, so repeater subs with batteries are also placed at 300-m (984-ft) intervals along the drillstring. The bi-directional telemetry provides 56 kbits/s and is independent of flow. On reaching the surface, the data travels underneath the top drive, through cables and down to the drill floor where it is distributed through a controller unit to different users of the telemetry. Surface, network and computer systems at various positions on the rig and in the driller's cabin allow multiple personnel to visualize the WDP data.

Another feature of the process is a data while tripping (DWT) device, a remotely-operated retractable system mounted on the base of the top drive. This enables a connection to the WDP when the pipe is held by the elevators and not screwed into the top drive, during tripping. The DWT is engaged from the driller's panel by a yellow arm sliding down into the box, creating a connection, but this is only done when there is sufficient weight hanging in the elevators. Benefits include improved safety, with fewer personnel needed on the rig floor when testing the WDP, and reduced testing time. In addition, the DWT provides options for collecting information from the BHA and the along-string sensors while tripping.

Equinor has used WDP extensively in the North Sea, and on five different rigs to drill in total more than 130,000 m (426,508 ft) and over 160 well sections, in hole sizes from 26-in. to 8½-in. On one rig it has helped to more than double average net ROP, from 35 m/hr to 75 m/hr (115 ft to 246 ft), with telemetry savings on the same rig of around 200 hr during 16 months of operations. The company has also used WDP to retrieve an 81-m (266-ft) core in one run from a floating rig in the Barents Sea, and to potentially save difficult sections from technical side tracks.

To get the most out of WDP, however, the operations team must get into the habit of taking decisions based on the new data, Nygård cautioned, rather than fall back on established drilling practice, and do so while drilling and monitoring the effects in real time. When implementing WDP, he added, it is important to identify all required components early to ensure compatibility with planned operations. And the operator, drilling contractor, drilling service company, and WDP provider must all be continuously involved in a One Team Approach.

At the same time, not everything is plain sailing. Equinor has encountered issues with the inductive couplers installed in the connections, which can cause the WDP to function only as a conventional pipe. But this type of situation can also be forestalled through ensuring a strong focus on handling by all personnel involved both prior to and during operation, with frequent testing performed on connections to mitigate such issues. The DWT is useful in allowing faulty connections to be identified early.

As for the gains, for one large, phased North Sea drilling campaign, Equinor drilled three wells in the first phase using conventional pipe, and the nine that followed in Phase 2 with WDP. The second phase wells achieved increased section length and significantly higher rate of penetration (ROP) in all the 17½-in., 7¼-in. and reservoir sections. However, the ROP gains were not down to WDP alone, but also other actions on the rig, and a general effort to improve drilling efficiency. In addition, the ASM tools made it possible to continuously evaluate

the downhole conditions. The pressure along the string determined if the hole was being cleaned while drilling or if ROP needed to be reduced.

For the Phase 1 wells the average time spent circulating hole clean-out at section TD was 10.3 hr, while for seven of the Phase 2 WDP wells, on average 6.5 hr was saved on this operation alone, i.e. a 63% reduction in circulation times to TD. And the 12¼-in., sections were around 23% longer in Phase 2.

So how does WDP increase efficiency? Equinor employs ASM tools to deliver an increased volume of data: visualization needs to be put in place widely to allow for fast and easy interpretation so that individuals can decide on appropriate operational changes where needed, via a system that combines time, depth and real-time measurements. As an example, for the phase drilling campaign seawater and pills were used to clean the hole, while at the same time, the team sought to increase ROP. Color coding was used to show changes in hole cleaning during this process, until the time came to reduce ROP and regain hole cleaning. As for shortening circulation time, this decision was based on actual downhole data instead of standard hole cleaning practices, with a range of colors used to show that the hole section was already clean 1½ hr earlier.

Equinor has also used WDP data to assess drillstring vibration mitigation when drilling challenging hole sections, with favorable results. Further benefits could be expected when applying the telemetry to improve well placement, Nygård concluded.

WELL INTEGRITY MANAGEMENT

Claas van der Zwaag, Lead Engineer, Drilling and Well Operations at Equinor, spoke of how the repercussions of the P-31 A well blowout on the Snorre A TLP in late November 2004 are still influencing the company's well integrity management today. Saga Petroleum, the original developer of the Snorre field, first drilled the well in 1995. While cementing in the reservoir section, the drillstring became stuck in cement, necessitating a long fishing/milling operation. This caused extensive wear and holes in the 9⅝-in. production casing: Saga opted to install a scab liner on the inside of the casing to cover the holes and areas of wear, but production was not as expected, so the well was converted to a water-alternating-gas injector.

After taking over as operator, Statoil (now Equinor) decided to perform a wireline operation in late 2003 to qualify the well for a recompletion. A plug was installed in the tail pipe below the production packer, but the A-annulus did not pass a leak test, with indications that the well could leak through the scab liner and holes in the casing. When the well was deemed unfit for requalification, a new plan was put together to P&A and side track to recover the well slot. But when the Snorre A rig skidded onto the slot in November 2004 to start the operation, changes to the plan – one being to squeeze cement – had not been processed properly. Statoil chose to perforate the tail pipe beneath the production packer in order to secure access to the reservoir for performing the cement squeeze. But this meant the scab liner and holes in the casing were no longer mechanically isolated from the reservoir while pulling the tubing and scab liner.

On Nov. 28, when operations were under way, there were indications of swabbing and unstable well conditions. All the mud was bullheaded to stabilize the well, while the rig crew continued to pull the scab liner. When the top of the liner was in the rotary table, a well control situation arose, leading to shut-in of the well on the annular preventer; overnight, the crew encountered difficulties stripping back the liner to the hole, and gas escape was then reported both beneath and on the platform, triggering an emergency shutdown of the rig. Containing the incident became a struggle when the rig crew ran out of mud, although they were eventually able to mix sufficient water-based mud mixed with chemicals to plug the leak from the well to the seafloor and kill the well.

Statoil was hit with a fine and censured for inadequate risk assessment and management involvement and for failing to comply with well barrier requirements. According to van der Zwaag, the incident served to amplify attentiveness to well integrity in the industry and formed the basis for key measures that are in use today. In Equinor's case, this includes connecting highest-level HSE via Norway's NORSOK D-010 industry standard for well integrity in drilling and well operations to the company's well integrity management principles. Complementing NORSOK D-010 are the NOROG 117 guidelines issued by the Norwegian Oil and Gas Association, which define the essential elements of well integrity and management systems, such as well integrity training, well handover documentation, use of well barrier schematics in the operational phase, and a well integrity categorization system.

The two most important organizational changes at Equinor following the incident were the establishment of a) a subsurface support center for drilling and well operations, supporting assets across the company with the latest best practice; and b) a well integrity management organization. At the same time, the company's management system transitioned from a library-based steering system to today's workflow-based steering system. This includes clearly defined work processes related to well integrity management, and roles and responsibilities for various tasks throughout the well's lifecycle.

After Snorre A, Equinor developed a substantial professional workforce within the well integrity discipline with job positions created for what today is known as well integrity engineering, van der Zwaag said. The company has also established various competence management activities since 2004, with attendance at an annual two-day well integrity seminar mandatory for all drilling and well personnel in operations positions. And offshore/onshore staff working with wells handed over from Drilling & Well to Production Operations must attend well integrity courses and seminars every five years.

JOHAN CASTBERG INJECTION STUDIES

Charlotte Eliasson, Principal Engineer Well Operations Completions at Equinor, recounted the reservoir drilling and

breaker fluids qualification process for direct injection wells on the Johan Castberg project in the Barents Sea, based on a paper co-presented with Halliburton. This is a large subsea development taking in the Skrugard, Havis and Drivis structures, all featuring shallow reservoirs with hydrostatic pressure and low temperatures. The field is being developed via a combination of long horizontal producer wells, single and multilateral; horizontal gas injectors for pressure support and gas disposal; and deviated water injectors for pressure support and accelerated production.

Equinor identified injectivity of the water injectors as one of the development's top 10 risks. Water will be injected under matrix conditions, cooling the formations and creating fractures that will propagate over time, securing high injection rates over the lifetime of the wells. But injection pressures that are too high could cause out-of-zone injection, with the fracture growing outside the reservoir zone and potentially spreading through the overburden right up to the seabed. To contain fractures within the reservoir, injection pressures must be maintained below the minimum horizontal stress of the overburden.

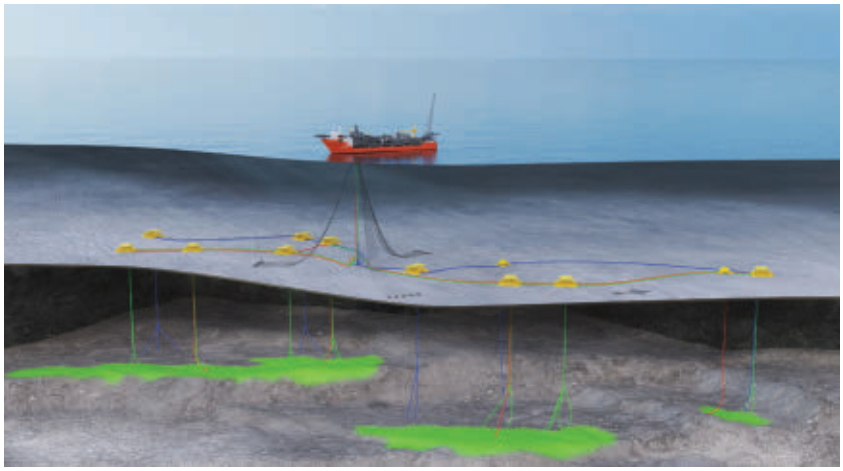
Johan Castberg's combination of shallow reservoirs and low pressures means that the water injectors cannot be cleaned prior to initiating water injection, hence the need for direct injection wells. The reservoir completion and fluid design are both vital to secure injectivity. For the fluid qualification, Equinor assembled a multi-disciplinary team of drilling fluids, production technology and completions specialists, working with chemists at fluid laboratories to qualify the drilling and completion fluids. The main considerations for this type of program, Eliasson noted, are whether the fluids should be water or oil-based; the type of bridging material; the concentration of polymer; and the compatibility with the reservoir fluid to avoid emulsion and precipitation occurring. For the completion fluids, the plan was to run the lower completion via screen-driven fluid, displace for brine, and place a breaker. But how should the breaker be placed in the reservoirs, and how should the configuration be set up to ensure operational success?

The team identified a wish-list for securing injectivity. These included a water-based drilling fluid, to ensure compatibility with the reservoir fluid; use of sized salt as a bridging material that would be soluble in the injection water; deployment of an acid pre-cursor in the breaker formulation; and keeping the concentration of polymer low. Other aims were breakthrough times (contact with the reservoir) of less than 2 hr, and to leave no residues that might at some point impact the injectivity of the water injectors. As for the breaker fluid design, it was important for the fluid to develop a formic acid when mixed with water and exposed to the reservoir temperatures.

Equinor decided to use new mud for each well to avoid contamination of the filter cake and drilling materials while drilling several water injectors back-to-back. The team also sought to verify the interaction between the breaker and filter cake; check the breaker's chemical capabilities with the filter cake; and to verify the minimum possible interaction with reservoir fluids. For the completion design, a priority was to ensure and even and effective breaker placement along the entire injection interval. Johan Castberg's wells will have open-hole completions, with pre-drilled liner in the reservoir sections. By using a simplified gravel pack system, with a gravel pack port and a wash pipe, the breaker can be placed throughout the injection interval before being activated, with the entire filter cake exposed to the breaker fluid.

The wash pipe is run on the inside of the pre-drilled liner through to the toe of the well. The breaker fluid is circulated down the wash pipe, out into the reservoir annulus and up the full reservoir section. After pulling out the wash pipe the entire reservoir is filled with breaker fluid: during the pulling procedure, the wash pipe is placed directly under the reservoir barrier valve, and once losses are confirmed, it is completely pulled out and the barrier valve is closed. By being able to confirm losses while at the same time retaining well control, "the set-up allows us to go down with the wash pipe again to the toe of the well and create new, fresh breaker fluid if needed," Eliasson explained.

The test campaign at Halliburton's fluid laboratory in Tananger started with standard qualification which was used for the further breaker qualification. Checks were performed of rheology, sag, mobility and fluid loss. "It was an iterative process, during which we observed starch and polymer concentrations, both important for success. We revisited the formulations



The Johan Castberg field development in the Barents Sea. *(Courtesy Equinor)*

many time and optimized the results to deliver a fit for purpose drilling fluid."

For the rheology, the set-up replicated seabed conditions at 4°C (39°F) and flowline conditions at 20°C (68°F). Fluid losses increased with temperature and decreased with the addition of HPC, a clay material, to simulate drilling materials. Results were as expected, and also corresponded with experiences at the field. For the filter cake solubility, a chemical suitability test was performed to verify that the breaker worked on the filter cake – the latter was created on a ceramic dish, then lifted off and placed in a breaker solution at reservoir temperature for five days. Two different temperatures were applied – one at 44°C (111°F) to simulate conditions at Skrugard, another at 71°C (160°F) representing Havis. The filter cakes dissolved completely in both tests after five days, indicating that no residuals will be left in the reservoir that might plug it and reduce injectivity.

The breakthrough test was designed to provide the time taken for the breaker fluid to break through and penetrate the filter cake and establish contact with the reservoir. Dissolving of the polymer in the filter cake left a lunar-type surface, which showed that breakthrough had been achieved and that the reservoir would be accessed. At higher temperatures the process proved to be faster, the breakthrough time of 71°C being 1.25 hr compared with 2.7 hr at 44°C. Although the latter was longer than the 2 hr targeted, it was still seen as acceptable.

The test results, Eliasson concluded, showed that the reservoir drilling fluid has been optimized to create a filter cake that can be easily removed using the breaker fluid. The completion design and operational procedures have been customized and optimized to ensure maximum reservoir exposure of the breaker fluid system. Development drilling started on the field last August: for the first water injectors there have been indications of losses, which means that the fluid and breaker systems do work. Actual injection is due to start in 2023 when the FPSO is in place.

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Transition to remote operations underscores need for robust barrier management

Automated managed pressure drilling systems can play key role

ANDREW MCLENNAN, *HALLIBURTON*

TO THRIVE IN TODAY'S ECONOMIC ENVIRONMENT, major oil and gas companies are embracing automated systems that can consistently accomplish drilling activities with higher speed, increased accuracy, and less human intervention. The automation of barrier management and managed pressure drilling (MPD) operations is a prime example of new technology solutions to meet such demands.

MOVING TOWARD REMOTE OPERATIONS

Operators worldwide are driven to find ways to reduce the cost and risks associated with drilling in order to maximize returns. This quest, combined with the effects of the global pandemic, has thrust "remote operations" into the forefront of the drilling services industry. Advances in digital technology, software tools, global connectivity, and improved data transfer rates allow us to effectively monitor operations through remote operations centers (ROCs), requiring fewer resources at the rig site. These ROCs shift reliance upon highly trained subject matter experts (SMEs) in the field to a small team of cross-disciplined SMEs working remotely to safely support several wells at a time.

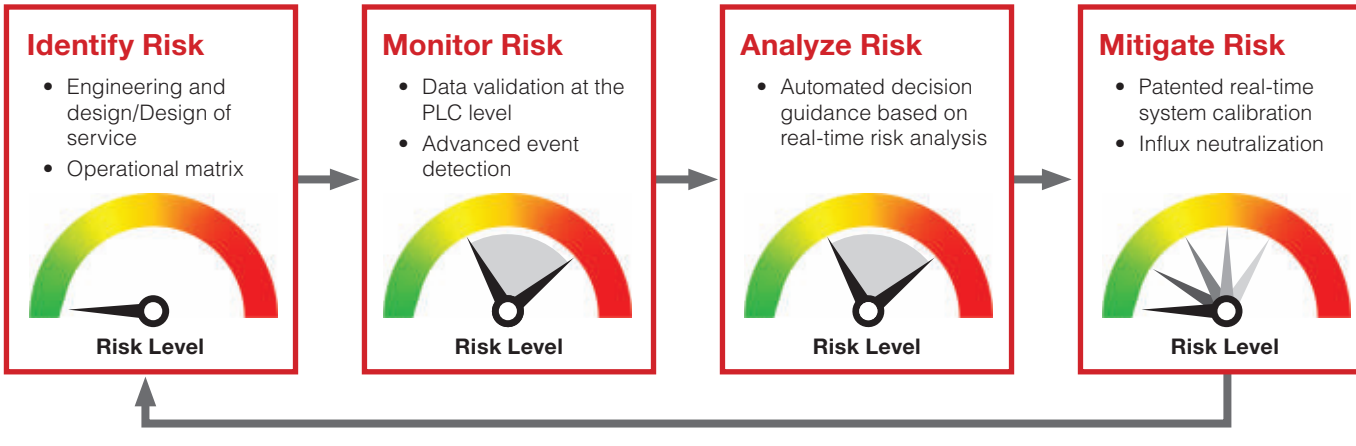
This transition to remote operations depends heavily on the reliable automation of all drilling processes, and the automated response of the system to abnormal events in real time. Such systems will have to diagnose a compromised situation and respond accordingly to bring that situation back into an ideal or controlled state. This is particularly important when talking about remote MPD operations, because the MPD system becomes a critical part of the rig's primary well control barriers. Ultimately, to truly have an automated MPD system capable of remote operations, it is going to require a robust and extremely dependable barrier management system.

BARRIER MANAGEMENT SYSTEM

Barrier management is about understanding what barriers exist, what their critical controls are, and how their status is assessed and monitored in daily operations. Simply put, barrier management involves both risk management and mitigation. To safely manage and mitigate risk during live operations, the control system must be incorporated into a larger, integrated barrier management system that can do everything from identifying risk to monitoring, analyzing, and mitigating it.

MPD CHALLENGES AND RISKS

The first challenge with any barrier management system occurs in the planning and design phase, when the barriers and their limits must be clearly identified. While barrier management is by no means a new concept to the industry, the classification of risk and identification of different barriers vary from company to company. For conventional drilling operations, these



risks and barriers are well defined and generally well-regulated with documented industry best practices and minimum safety requirements.

A challenge with accurately defining the software and control barriers is that they both have a large variance in capability and functionality across the industry. To complicate things further, both rely on a combination of different components to make up their barriers. When combined, these individual components and variables create what is commonly called the "MPD primary barrier envelope." The condition of each element contributes to the overall health of the primary barrier and well.

MONITORING RISK

After the barrier envelope and all its elements have their limits clearly defined, they need to be monitored. In conventional operations, the primary well control barrier is monitored through simple, single-input limit or bandwidth alarms on the pit volume or flow out. Due to the dynamic nature of drilling operations, single-point alarms often result in repeated false alarms as operations change between different drilling states. These false alarms are compounded with an extensive list of variables that affect the volume and flow throughout operations. It is these repeated false alarms that often lead to the rig personnel disabling them and ultimately missing the true influx and loss events.

With MPD and the addition of Coriolis flow meters, the accuracy and ability to quickly detect changes in flow and density has increased drastically. This has allowed MPD systems to become a critical tool in early event detection. However, if the enhanced flow and density data is only used in simple, single-variable alarms, the increased accuracy will only lead to more false alarms and, again, result in operators disabling the alarms. In this scenario, the MPD specialist or rig personnel is still required to manually monitor and understand when the quality of the primary barrier is deteriorating.

Advanced trends analysis and multiple variable alarms have helped reduce false alarms, but most of these also require manual user input and monitoring as drilling states or monitored values change. More advanced, signature-based detection algorithms and holistic barrier health monitoring systems are needed for true drilling automation—where event detection is done through monitoring the entire barrier envelope, and how the quality of all its individual barrier components influence the entire barrier's overall health. Yet, these advanced algorithms are only going to be as accurate and reliable as the data they are monitoring. Therefore, any fully automated system must be able to understand and compensate when its monitored values or inputs deteriorate.

ANALYZING RISK

The next part of barrier management is to analyze the risk or health of the primary barrier. Using the hydraulic model as an example, as drilling progresses, user-configured variables, like pump efficiency, fluid properties, cuttings load, and most importantly fluid densities, can change. As those variables change, the accuracy of the model will drift; and this change in the model's accuracy can be a very strong indicator of the health of the primary barrier or current level of risk to the well. Understanding that the barrier quality is degrading allows for further analyses and early diagnoses of potential well events before they become critical, such as:

- Influxes that result from trip gas, connection gas, or multiple pump-off events in wellbore
- Poor hole cleaning
- Fluid properties changes – thermal effects, evaporation, etc.
- Poor mud weight control
- Losses
- Pump efficiency
- Wash outs.

MITIGATING RISK

This final part of barrier management is where the MPD systems can really shine. With the ability to manipulate the pressures in the well, using SBP, automated MPD systems can actively maintain, and even improve, the barrier's health as it weakens.

Returning to the hydraulic model example, as the drilling parameters drift, the quality of the barrier drifts; and if no correction is made to the model, the BHP will eventually exceed the operational window, resulting in losses or an influx. This is where an auto-calibrating MPD system will self-adjust and always ensure BHP control, even while inputs deteriorate. Or, looking at things that would traditionally damage the barrier's health, like tripping as pipe is pulled from the hole, the bottomhole pressure is reduced because of the swab effect. Having an automated MPD system that can actively calculate and compensate for the pressure reduction keeps the barrier's health in check. MPD systems can also take this a step further, with the ability to safely detect and circulate out small influxes while maintaining primary pressure barrier.

CONCLUSION

Ultimately, when talking about barrier management, MPD should be looked upon as a critical tool, especially with regards to rig automation and remote operations. The challenge is that it cannot just be an advanced early-kick-detection system, or an automated influx circulation system. To be truly automated, it needs to be able to:

- Clearly identify all barriers and the individual components that define them.
- Understand and define the limits of the entire system, its barriers, and each component.
- Monitor those barriers, both as single parameters and in a holistic view for complex events, such as influxes or losses.
- Identify missing or degraded barriers and automate the implementation of corrections.
- Proactively implement better controls and mitigations to minimize risks of events.

Rethinking intelligent completions: the future is here

Today's systems incorporate remote operational tools

JULIO BELLO, *WEATHERFORD*

The TR1P system, developed by Weatherford in collaboration with SNEPCO (Shell Nigeria), has helped reduce completion time by up to 60%. *(Courtesy Weatherford)*

THE INDUSTRY IS FINALLY ON THE VERGE OF AN INTEL-ligent completion. After 30 years of intermittent progress, the promise that we made to ourselves throughout most of our careers is nearing fruition. But now that it is here, it is rather different than we imagined. Rather than an intelligent completion, we have created an intelligent oilfield asset.

Rather than viewing completion technology as a whole, the industry has instead focused on parts of the system. Essentially what has been improved are downhole components that we called intelligent. The real challenge is to rethink what defines a completion. It is far more than just a process that follows drilling. It is the mechanism by which an asset is produced for two or three decades. It is the single item that supports well revenue for life. To create an intelligent completion, we must think like our production teams and develop integrated intelligent systems that seamlessly spans from the drilling phase into production.

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EARLY ADVANCES

In August 2014, a colleague shared a presentation entitled "What's New in the World of Completion?" The main themes explored the rise of unconventional wells, sleeve developments, the daily new-and-improved composite plugs, and some interesting coil/frac applications.

By this time, intelligent components had reached maturity and their 20-year installation anniversary of the first intelligent well was near. All the majors had tested the intelligent-well technology. It grew steadily between inception and 2014, but how much the technology had advanced was debatable. The industry shuffled between controlling producers and controlling injectors, or both. Then we focused on ever-longer lateral sections with multiple zones or multiple reservoir-layers with the puzzling question of how many inlets to control. Then came highly deviated wells and then the effort to reduce the number of zones through hydraulic selector technologies.

In short, our activity and advancement track record through 2014 was one of chasing the latest shiny object. We failed to see the forest for the trees and apply these advances to completion.

COMPLETION INTELLIGENCE TODAY

Today we have a strong case for electronic control. Having control using a single line or multiple lines in one bundle is appealing, as losing one valve does not mean you lose them all. Like many of our peer companies, Weatherford is developing electronically controlled completions technology. Ours will include technical features such as direct actuation to close position from any other sleeve flow setting, which is necessary for water injectors, but also move 90% of the electronic components to the surface to heed lessons from the past.

The true test of intelligence, however, is data. To gather downhole intelligence, we can instrument the well with either electronic or optical pressure and temperature gauges joined by a fiber-optic cable to enable DTS and DAS (distributed temperature and distributed acoustic sensing), in addition to well-contribution and flow-fraction measurement with downhole optical flowmeter. This intelligent system can command node points and optimize sleeve position by identifying the maximum production contribution zones.

More importantly, completion engineers focus beyond plumbing a well left by the drilling team; they seek production performance for the life of that well, which can potentially influence the placement, configuration, completion design and requirements of the next. We are trending toward a symbiotic relationship between the driller, the completion engineer, and the production engineer.

NEEDS CHANGE, EVOLVE

"There is nothing more important in petroleum engineering than a definite knowledge of the pressure at the bottom of an oil well at an existing operating condition, and the relation of this pressure to the pressure within the producing formation. A knowledge of the bottom hole pressure is fundamental in determining the most efficient methods of recovery and the most efficient lift procedures. Yet there is less information about these pressures than about any other part of the general problem of producing oil."

Charles Millikan spoke these words in 1931. What was true then, remains true today.

Well instrumentation delivers reams of data the help us understand the downhole environment, but the challenge is doing something meaningful with it. To help meet this need, Weatherford introduced the ForeSite production optimization platform in 2017. This platform integrates reservoir data, downhole flow and production measurements, surface production data, production-optimization workflows, and even plant data into one ecosystem.

So rather than filing away disparate reams of data, we moved away from compiling reports to look for behavior anomalies, problems, and even opportunities to be a bit less conservative. One example could be to draw down a well beyond the practical rule without risk. Among other findings, we discovered that we can detect water breakthrough, coning, or interference from an adjacent injector earlier. We can detect anomalous flow, precursor of sand production, scale production, and screen plugging. We can detect water-hammer effects in injectors and cross flow in addition to interference and mapping pressure support mechanisms.

In short, we are learning to predict the future. This includes the impact on different phases of asset development, well placement, an evolved completion design or technique. We can identify—through managed pressure drilling and completions—future hazards like over- or under-pressured layers, fractures, and provide warning before it happens.

LOOKING TO THE FUTURE

Completion technology has moved on to remote operational tools, surface-controlled or remotely operated RFID, and other telemetry systems. Whether it is openhole over cased hole, step changes in equipment reliability, deeper wells, deeper waters, longer laterals—these all pose challenges that the industry must address.

It is perhaps outside the complex but narrowing completion discipline that we are seeing the greatest improvements. We are working with our drilling colleagues to deliver a better hole. We are instrumenting wells that provide information—and not just data—to better influence how that well and future wells are managed. We are far more cognizant of the fact that those weeks or months of drilling and completing can and dictate how a well will produce for years into the future and how the asset must live with the consequences of decisions made during construction.

THE AUTHOR

Julio Bello is Global Product Line Manager, Reservoir Monitoring, Weatherford

New rotary steerable systems improve drilling efficiency

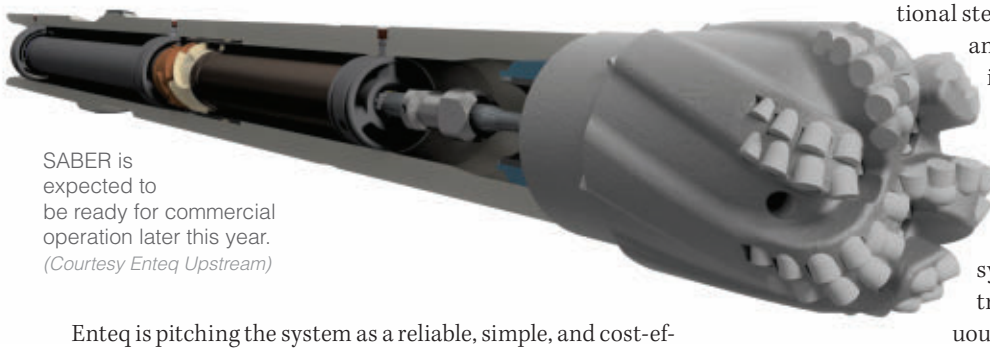
Latest tools offer greater precision, reliability

JESSICA STUMP, *ASSISTANT EDITOR*

AS THE OFFSHORE DRILLING MARKET RECOVERS, downhole service providers are introducing and advancing rotary steerable systems (RSS) that enhance efficiency and deliver accurate wellbore placement and quality.

Enteq Upstream, the newest company to *Offshore*'s annual RSS directory, has introduced the SABER (Steer-At-Bit Enteq Rotary) tool for directional drilling. Shell has proven and tested an evolution of the concept, and the system is now ready for next-stage field trials.

SABER uses an internally directed pressure differential system to steer from the drill bit face, which is said to provide true 'at-bit' geosteering. The mechanically simple design, the company said, avoids the need for traditional pistons and pads susceptible to rapid wear and reliability issues, resulting in a smoother, more precise wellbore with easy to manage directional control.



SABER is expected to be ready for commercial operation later this year. *(Courtesy Enteq Upstream)*

Enteq is pitching the system as a reliable, simple, and cost-effective directional drilling alternative to current RSS options. The company licensed the designs and intellectual property from Shell in September 2019 following successful initial trials. Its technical team has since re-engineered the concept.

Baker Hughes has added the Lucida rotary steerable service to its directional drilling offerings.

According to the company, drilling performance is optimized through an integrated bottomhole assembly that features a customized drill bit, real-time dynamics sensors, and multi-chip module electronics. The near-bit dynamic sensors measure downhole weight-on-bit, torque, bending moment and direction, while the accelerometers in the primary electronics measure axial and lateral vibration as well as high-frequency torsional oscillations. The real-time bending moment and direction measurements are said to enhance directional control and can also be used for stringer detection. The multi-chip module electronics are said to increase reliability and operating range.

The new RSS enables drillers to hit their geological targets the first time, with no side tracks, the company claimed. Located near the bit, 16-sector gamma-ray sensors provide real-time formation data that enable quick decisions to geo-steer or geo-stop.

Lucida is said to enhance wellbore quality through a combination of automated well path trajectory control and continuous proportional steering that automatically corrects wellbore course for any formation trends. The integration and automation in these systems, the company said, reduces wellbore tortuosity, providing a corresponding reduction in torque and drag, to drill better curve sections and longer and faster lateral sections. The automated well path trajectory control system is said to deliver precise control, even at very high penetration rates, with near-bit directional sensors that check azimuth and inclination every millisecond. The continuous proportional steering system addresses formation and drilling challenges by optimizing the drill bit and hydraulics program with precision-controlled pads that operate independently of bit pressure, flow rates, and drilling fluid properties.

According to the company, this system uses three precision-controlled pads to maintain a continuous proportional steering vector that drills a smooth, in-gauge hole. Steering control is not affected by drilling dynamics because the independent ribs are powered by internal hydraulic power on the decoupled slow rotating sleeve.

The new RSS is fully enabled for the company's remote operations services.

Schlumberger's PowerDrive Orbit G2 RSS is said to deliver higher abrasion resistance and dogleg severity (DLS) for tougher, longer runs. Its pad design increases abrasion resistance with metal-to-metal sealing to handle aggressive drilling fluids and severe downhole conditions for longer runs.

The system includes six-axis continuous hold inclination and azimuth measurements to enable precise well positioning. This feature, along with closed-loop automation, the company said, provides smoother tangents with minimized tortuosity. Near-bit extended-range gamma ray measurements transmit additional well positioning data for improved real-time decision making.

The PowerDrive Orbit G2 RSS recently drilled the horizontal section of a complex well offshore Indonesia in one run.

Interbedded and fractured carbonates posed a challenge for drilling the horizontal section of wells in the East Java basin. To drill the horizontal, the operator needed to overcome the constant microdoglegs observed in offset wells that resulted in unstable DLS, severe shock and vibration, and stick/slip conditions, compromising directional control and ROP. Conventional RSS tools had difficulties precisely and consistently landing offset wells inside the reservoir with sufficient DLS, the company said.

In concert with the MicroScope HD resistivity and high-definition imaging-while drilling service to better navigate the well trajectory, the RSS was used to deliver higher DLS and wear resistance in harsh downhole conditions for longer runs with greater trajectory control.

According to the company, the system increased the maximum DLS by 50% and the average DLS by 80% while maintaining

2021 Rotary Steerable Systems Directory

Product trade name	Point-the-bit or Push-the-bit	Length (ft)	O. D.& I. D. (in.)	Hole size (in.)	Max DLS capability (°/100')	Automated closed loop deviation control (yes/no) (+/-degrees)	Build rate increment	Is deviation force continuous?	Max temp (°C /°F)	Max internal pressure (psi)	Other special pressure limitations
APS Technology											
SureSteer-RSM (Rotary Steerable Motor) RSM675	Push	Steering Section (14.5'), Power Section (17.2')	OD: 7.78 ID: 1.5	8.375" to 8.75" nominal	5.5	Yes, Inclination and MTF to within 0.1°	Configurable	Yes and variable	150/302	20,000	None
SureSteer-RSS RSS475	Push	Steering Head - 10.6'	Nominal OD - 4.75" Steering Pad Upset OD - 5.75" ID 2.7 - 3.1"	6.0" to 6.75"	12.0	Yes, Inclination and MTF to within 0.1°	Configurable	Yes and variable	150/302 175/347 (option)	20,000	None
Baker Hughes • www.bakerhughes.com											
6.75" AutoTrak Curve (conventional motor can be added)	Continuous Proportional Steering	38 (fully inclusive of steering system & MWD) Steering head length = 9.3	OD: 6.75 ID: N/A	8.375 - 9.875	15	Yes Precise to within 0.2°	Build Force programmable from surface via downlink. Target inclination in 0.125° increments	Yes	150/302	20,000	None
9.5" AutoTrak G3	Continuous Proportional Steering	58 (fully inclusive of steering system & MWD/LWD) Steering head length = 8.2	OD: 9.5 ID: N/A	12.00 - 28.00	6.5	Yes Precise to within 0.1°	Build Force programmable from surface via downlink. Target inclination in 0.125° increments	Yes	150/302 (175/347 on request)	20,000 (25,000 & 30,000 on request)	None
6.75" AutoTrak G3	Continuous Proportional Steering	50 (fully inclusive of steering system & MWD/LWD) Steering head length = 7.2	OD: 6.75 ID: N/A	8.375 - 10.625	6.5	Yes Precise to within 0.1°	Build Force programmable from surface via downlink. Target inclination in 0.125° increments	Yes	150/302 (175/347 on request)	20,000 (25,000 & 30,000 on request)	None
9.5" AutoTrak X-treme (Adds Integrated pre-contoured drilling motor)	Continuous Proportional Steering	88 (fully inclusive of steering system, motor power section & MWD/ LWD) Steering head length = 8.2	OD: 9.5 ID: N/A	12.00 - 28	6.5	Yes Precise to within 0.1°	Build Force programmable from surface via downlink. Target inclination in 0.125° increments	Yes	150/302 (175/347 on request)	20,000 (25,000 & 30,000 on request)	None
6.75" AutoTrak X-treme (Adds Integrated pre-contoured drilling motor)	Continuous Proportional Steering	76 fully inclusive of steering system, motor power section & MWD/ LWD) Steering head length = 7.2	OD: 6.75 ID: N/A	8.375 - 10.625	6.5	Yes Precise to within 0.1°	Build Force programmable from surface via downlink. Target inclination in 0.125° increments	Yes	150/302 (175/347 on request)	20,000 (25,000 & 30,000 on request)	None

a constant steering ratio and reducing wellbore tortuosity and microdoglegs.

Earlier this year, Weatherford deployed its Magnus RSS in the North Sea for the first time. A major operator in the UK decided to replace technology from the incumbent to drill re-entries in an existing field and boost production. According to the company, the Magnus system not only surpassed the technical limit set by the customer, but also drilled the first three re-entry wells an average of 33% faster than planned. This success led to contracts with two more customers in the region.

Key features of the push-the-bit tool include fully independent pad control, a fully rotating bias unit with minimal bottomhole assembly (BHA) stabilization, real-time BHA diagnostics, and autopilot functionality. The system comprises several modular components to facilitate quick and easy maintenance, even in remote locations.

The 2021 Rotary Steerable Systems Directory provides a detailed listing of the technology available on the market.

	Does tool require configuration based on anticipated flow rate?	Sensor distance (ft) Inc/Azm/GR/ Res	Control from surface (Downlink) (Y / N)	If yes, tool control method	Rig time req'd to communicate change in target (minutes)	Minimum kickoff inclination (degrees)	Max RPM / WOB	Min flow rate (gpm)	Max flow rate (gpm)	LCM limits	Power source	Bit requirements	Integrated LWD?
	No	4' Inc/Mag ToolFacE	Y	Mud Pumps and Rotary	3.5 to 8 min	0	80 RPM, 50 klb	300	600	None	Alternator driven off motor	Per APS Bit Recommen-dations	No - Can be operated below any LWD/MWD
	Yes	Inc (RSS) - 14.1' Gamma - 17.2' MWD Dir - 21.6'	Y	Mud Pumps and Rotary	3.5 to 8 min	0	200 RPM, 30 klb	150	350	None	Turbine Alternator driven by Mud flow	Per APS Bit Recommen-dations	MWD & LWD can be intergrated with steer-ing head
	Steering system: No MWD system: No	5.9 / 21.6 / 11.5 / NA	Y	Negative pulse from surface skid unit	While drilling ahead	0	400RPM 56 klbf	300	750	50 lb/bbl medium nutplug, Cedar Fiber	Turbine generator	Application specific	No
	Steering system: No MWD system: Yes	Inc: 3.9 Others BHA dependent	Y	Negative pulse from surface skid unit	While drilling ahead	0	300 RPM 100 klbf	300	1,600	Steering system: None MWD system: 40 lb/bbl fine nutplug (higher conc. on request)	Turbine generator	Application specific	Yes
	Steering system: No MWD system: Yes	Inc: 3.1 Others BHA dependent	Y	Negative pulse from surface skid unit	While drilling ahead	0	400 RPM 57 klbf	200	900	Steering system: None MWD system: 40 lb/bbl fine nutplug (higher conc. on request)	Turbine generator	Application specific	Yes
	Steering system: No MWD system: Yes	Inc: 3.9 Others BHA dependent	Y	Negative pulse from surface skid unit	While drilling ahead	0	300 RPM 60 klbf	530	1,600	Steering system: None MWD system: 40 lb/bbl fine nutplug (higher conc. on request)	Turbine generator	Application specific	Yes
	Steering system: No MWD system: Yes	Inc: 3.1 Others BHA dependent	Y	Negative pulse from surface skid unit	While drilling ahead	0	400 RPM 36 klbf	265	660	Steering system: None MWD system: 40 lb/bbl fine nutplug (higher conc. on request)	Turbine generator	Application specific	Yes

2021 ROTARY STEERABLE DRILLING SYSTEMS DIRECTORY

Product trade name	Point-the-bit or Push-the-bit	Length (ft)	O. D.& I. D. (in.)	Hole size (in.)	Max DLS capability (°/100')	Automated closed loop deviation control (yes/no) (+/-degrees)	Build rate increment	Is deviation force continuous?	Max temp (°C /°F)	Max internal pressure (psi)	Other special pressure limitations
9.5" AutoTrak eXpress (Base level RSS service)	Continuous Proportional Steering	64.6 (fully inclusive of steering system & MWD) Steering head length = 8.2	OD: 9.5 ID: N/A	12.00 - 28.00	6.5	Yes Precise to within 0.1°	Programmable from surface via downlink from 0-6.5° /100 ft	Yes	150/302	20,000	None
6.75" AutoTrak eXpress (Base level RSS service)	Continuous Proportional Steering	58.2 (fully inclusive of steering system & MWD) Steering head length = 7.2	OD: 6.75 ID: N/A	8.375 - 10.625	8	Yes Precise to within 0.1°	Programmable from surface via downlink from 0-8° /100 ft	Yes	150/302	20,000	None
9.5" AutoTrak V (RSS for vertical drilling)	Continuous Proportional Steering	24 fully inclusive. Steering head = 8.2	OD: 9.5 ID: N/A	12.00 - 28.00	Vertical Drilling	Yes Precise to within 0.1°	Vertical Drilling	Yes	150/302	20,000 (25,000 & 30,000 on request)	None
6.75" AutoTrak V (RSS for vertical drilling)	Continuous Proportional Steering	21 fully inclusive. Steering head = 7.2	OD: 6.75 ID: N/A	8.375 - 10.625	Vertical Drilling	Yes Precise to within 0.1°	Vertical Drilling	Yes	150/302	20,000 (25,000 & 30,000 on request)	None
6.75" AutoTrak eXact	Continuous Proportional Steering	38 (fully inclusive of steering system & MWD) Steering head length = 9.3	OD: 6.75 ID: N/A	8.375 - 9.875	15	Yes Precise to within 0.2°	Build Force programmable from surface via downlink. Target inclination in 0.125° increments	Yes	150/302	20,000	None
4.75" AutoTrak eXact (can be integrated with pre-contoured drilling motor)	Continuous Proportional Steering	39 (fully inclusive of steering system & MWD) Steering head length = 9.62	OD: 4.75 ID: N/A	5.75 - 6.75	15	Yes Precise to within 0.1°	Build Force programmable from surface via downlink. Target inclination in 0.125° increments	Yes	165/329	30,000	None
6.75" AutoTrak Curve Pro (conventional motor can be added)	Continuous Proportional Steering	38 (fully inclusive of steering system & MWD) Steering head length = 9.3	OD: 6.75 ID: N/A	8.375 - 9.875	15	Yes Precise to within 0.2°	Build Force programmable from surface via downlink. Target inclination in 0.125° increments	Yes	150/302	20,000	None
4.75" AutoTrak eXact Pro (can be integrated with pre-contoured drilling motor)	Continuous Proportional Steering	39 (fully inclusive of steering system & MWD) Steering head length = 9.62	OD: 4.75 ID: N/A	5.75 - 6.75	15	Yes Precise to within 0.1°	Build Force programmable from surface via downlink. Target inclination in 0.125° increments	Yes	165/329	30,000	None
Lucida Rotatry Steerable Service	Continuous Proportional Steering	13.2 ft, RSS	OD: 4.75 ID: N/A	5.75 - 6.75	15	Yes Precise to within 0.1°	Build Force programmable from surface via downlink. Target inclination in 0.125° increments	Yes	175/350	30,000	None
Lucida Heavy Duty Rotatry Steerable Service	Continuous Proportional Steering	13.2 ft, RSS	OD:5.23" ID: N/A	*6.75 *variation in size being introduced	15	Yes Precise to within 0.1°	Build Force programmable from surface via downlink. Target inclination in 0.125° increments	Yes	175/350	30,000	None

	Does tool require configuration based on anticipated flow rate?	Sensor distance (ft) Inc/Azm/GR/ Res	Control from surface (Downlink) (Y / N)	If yes, tool control method	Rig time req'd to communicate change in target (minutes)	Minimum kickoff inclination (degrees)	Max RPM / WOB	Min flow rate (gpm)	Max flow rate (gpm)	LCM limits	Power source	Bit requirements	Integrated LWD?
	Steering system: No MWD system: Yes	Inc: 3.9 Others BHA dependent	Y	Flow rate change	While drilling ahead	0	300 RPM 100 klbf	300	1,600	Steering system: None MWD system: 40 lb/bbl fine nutplug (higher conc. on request)	Turbine generator	Application specific	No
	Steering system: No MWD system: Yes	Inc: 3.1 Others BHA dependent	Y	Flow rate change	While drilling ahead	0	400 RPM 55 klbf	200	900	Steering system: None MWD system: 40 lb/bbl fine nutplug (higher conc. on request)	Turbine generator	Application specific	No
	No	3.9 / NA / NA / NA	Y	Flow rate change	While drilling ahead	0	300 RPM 70 klbf	300	1,600	Steering system: None MWD system: 40 lb/bbl fine nutplug (higher conc. on request)	Turbine generator	Application specific	No
	No	3.1 / NA / NA / NA	Y	Flow rate change	While drilling ahead	0	400RPM 55 klbf	200	900	Steering system: None MWD system: 40 lb/bbl fine nutplug (higher conc. on request)	Turbine generator	Application specific	No
	Steering system: No MWD system: No	Inc: 5.9 Others BHA dependent	Y	Negative pulse from surface skid unit	While drilling ahead	0	400 RPM 56 klbf	300	750	Steering system: None MWD system: 40 lb/bbl fine nutplug (higher conc. on request)	Turbine generator	Application specific	Yes
	Steering system: No MWD system: No	Inc: 4.8 Others BHA dependent	Y	Negative pulse from surface skid unit	While drilling ahead	0	400 RPM 35 klbs	475	1,325	Steering system: None 40 ppb (114 kg/m³) medium nut plug, cedar fiber	Turbine generator	Application specific	Yes
	Steering system: No MWD system: No	5.9 / 5.8 / 11.5 / NA	Y	Negative pulse from surface skid unit & Automated Wellpath Trajecotory Control System	While drilling ahead & Automated Wellpath Trajecotory Control System	0	400RPM 56 klbf	300	750	50 lb/bbl medium nutplug, Cedar Fiber	Turbine generator	Application specific	No
	Steering system: No MWD system: No	Inc: 4.8 Azm : 4.8' Others BHA dependent	Y	Negative pulse from surface skid unit & Automated Wellpath Trajecotory Control System	While drilling ahead - Zero for Automated Wellpath Trajecotory Control System	0	400 RPM 35 klbs	475	1,325	Steering system: None 40 ppb (114 kg/m³) medium nut plug, cedar fiber	Turbine generator	Application specific	Yes
	Steering system: No MWD system: No	Inc: 5.9 Azm : 5.9' / GR4.1	Y	Negative pulse from surface skid unit & Automated Wellpath Trajecotory Control System	While drilling ahead Zero for Automated Wellpath Trajecotory Control System	0	400 RPM 35 klbs	120	350	50ppb fibrous LCM material, 80 ppb nut plug LCM material	Turbine generator	Integrated & Application specific	Not yet.
	Steering system: No MWD system: No	Inc: 5.9 Azm : 5.9' / GR4.1	Y	Negative pulse from surface skid unit & Automated Wellpath Trajecotory Control System	While drilling ahead & Zero for Automated Wellpath Trajecotory Control System	0	400 RPM 35 klbs	120	350	50ppb fibrous LCM material, 80 ppb nut plug LCM material	Turbine generator	Integrated & Application specific	Not yet

Product trade name	Point-the-bit or Push-the-bit	Length (ft)	O. D.& I. D. (in.)	Hole size (in.)	Max DLS capability (°/100')	Automated closed loop deviation control (yes/no) (+/-degrees)	Build rate increment	Is deviation force continuous?	Max temp (°C /°F)	Max internal pressure (psi)	Other special pressure limitations
Enteq Upstream											
SABER	Push-the-bit	6'	5 1/8" / 3 1/2"	6"-6 3/4"	8 °/100'	Yes. Inc +/- 0.25 degs. Azi - +/- 0.5 degs.	5% steps	No, duty cycle based	175 °C / 347 °F	20k	None
Nabors Drilling Services											
OrientXpress Rotary Steerable Tool 700 Series	Hybrid	12.5	7.1 OD 1.6 ID	7 7/8" to 8 3/4"	15	Yes Inclination (+/-0.1) Azimuth (+/- 1 deg)	Continuous	Yes	150°C	20,000	None
National Oilwell Varco											
VectorZIEL 800	Push the bit	30	OD: 8" ID: N/A	12 1/4" - 13 7/8"	5	Yes (0.1)	5%	Yes	150°C - 302°F	20,000	None
VectorZIEL 600	Push the bit	28	OD: 6.75" ID: N/A	8 1/2" - 9 7/8"	8	Yes (0.1)	5%	Yes	150°C - 302°F	20,000	None
VectorZIEL 400	Push the bit	26	OD: 4.75" ID: N/A	6" - 6 3/4"	8	Yes (0.1)	5%	Yes	150°C - 302°F	20,000	None
VectorEXAKT 900	Push the bit	26	OD: 9" ID: N/A	14 3/4" - 17 1/2"	Vertical Drilling	Yes (0.1)	Vertical Drilling	Yes	150°C - 302°F	20,000	None
VectorEXAKT 800	Push the bit	25	OD: 8" ID: N/A	12 1/4" - 13 7/8"	Vertical Drilling	Yes (0.1)	Vertical Drilling	Yes	150°C - 302°F	20,000	None
Sanvean Technologies • Scout Downhole											
9.625" Rotary Steerable Scout	Push	18.22	OD: 9.63 ID: 2.75	12.25 - 16.00	3	Yes +/- 0.1°	25%	Yes	150/302	20,000	None
7.125" Rotary Steerable Scout	Push	14.11	OD: 7.13 ID: 1.63	8.5 - 8.75	6	Yes +/- 0.1°	25%	Yes	150/302	20,000	None
Schlumberger • +1-281-285-8500											
PowerDrive Archer 675	Hybrid-Point-the-bit	16.15	OD: 6.75 ID: N/A	8.375 - 9.675	15	Yes, Azimuth and Inclination +/- 0.1°	1% and 1° TF resolution	Adjustable on Fully Rotating Tool	150/302	20,000	Optimized for Drilling conditions
PowerDrive Archer 475	Hybrid-Point-the-bit	14.98	OD: 4.75 ID: N/A	5.875 - 6.75	18	Yes, Azimuth and Inclination +/- 0.1°	1% and 1° TF resolution	Adjustable on Fully Rotating Tool	150/302	20,000	Optimized for Drilling conditions
PowerDrive Orbit G2 1100	Hybrid Push-the-bit	15.06	OD: 11 ID: N/A	20 - 28	2	Yes, Azimuth and Inclination +/- 0.1°	1% and 1° TF resolution	Adjustable on Fully Rotating Tool	150/302	20,000 (35,000 Optional)	Optimized for Drilling conditions
PowerDrive Orbit G2 900	Hybrid Push-the-bit	13.94	OD: 9 ID: N/A	12 - 18.5	5	Yes, Azimuth and Inclination +/- 0.1°	1% and 1° TF resolution	Adjustable on Fully Rotating Tool	150/302	20,000 (35,000 Optional)	Optimized for Drilling conditions

	Does tool require configuration based on anticipated flow rate?	Sensor distance (ft) Inc/Azm/GR/ Res	Control from surface (Downlink) (Y / N)	If yes, tool control method	Rig time req'd to communicate change in target (minutes)	Minimum kickoff inclination (degrees)	Max RPM / WOB	Min flow rate (gpm)	Max flow rate (gpm)	LCM limits	Power source	Bit requirements	Integrated LWD?
	Y	4'/4'/7'/7'	Y	Manual Pump Stroke Manipulation	3-5 mins	0 deg	400 RPM / 35 klbs	150	400	50lbs/bbl medium nutplug	Downhole Generator	Specific internal pin requirements.	Available Options - AZ GR, AZ Res, PWD.
	Yes (generator)	Inc/Azi 6.8ft Azi GR 22ft	Yes	Flow	3 mins (while drilling)	0	400 / 60K	400	700	None	Turbine alternator driven by mud flow	Nabors specifications preferred	Integrated with Nabors AccuMP or AccuSteer
	No	6/6/6/30	Y	Mud flow via surface skid	Avg 6 min	0	400 / 56,000	500	1100	Steering system none, MWD, 50ppb med nut plug	Turbine Gemerator	Application Specific	Yes
	No	4/4/4/29	Y	Mud flow via surface skid	Avg 6 min	0	400 / 45,000	290	650	Steering system none, MWD, 50ppb med nut plug	Turbine Gemerator	Application Specific	Yes
	No	4/4/4/27	Y	Mud flow via surface skid	Avg 6 min	0	400 / 16,000	210	300	Steering system none, MWD, 50ppb med nut plug	Turbine Gemerator	Application Specific	Yes
	No	6/NA/6/NA	Y	Mud flow via surface skid	Avg 6 min	Vertical Drilling	300 / 90,000	630	1500	Steering system none, MWD, 50ppb med nut plug	Turbine Gemerator	Application Specific	No
	No	6/NA/6/NA	Y	Mud flow via surface skid	Avg 6 min	Vertical Drilling	300 / 56,000	520	1100	Steering system none, MWD, 50ppb med nut plug	Turbine Gemerator	Application Specific	No
	No	8.42, 9.67, NA, NA	Y	Rotary	3 Minutes	0	400 RPM/85 klbf	500 psi pressure drop at bit	1800	60 lb/bbl med nut plug	Lithium Batteries	Application Specific	No
	No	5.17, 6.42, NA, NA	Y	Rotary	3 Minutes	0	400 RPM/55 klbf	500 psi pressure drop at bit	800	60 lb/bbl med nut plug	Lithium Batteries	Application Specific	No
	Optimized for Drilling conditions	Inc / Azm 9.9 / 12.01 GR 9.01	Y	Flow rate and/or RPM change	While drilling ahead	0	350 RPM As per Smith PDC bit guidelines	220	650	50 lb/bbl med. nut plug	Turbine generator	Application specific	Modular
	Optimized for Drilling conditions	Inc / Azm 8.41 / 10.51 GR 7.51	Y	Flow rate and/or RPM change	While drilling ahead	0	350 RPM As per Smith PDC bit guidelines	130	355	35 lb/bbl med. nut plug	Turbine generator	Application specific	Modular
	Optimized for Drilling conditions	Inc / Azm 8.86 / 11.06 GR 8.07	Y	Flow rate and/or RPM change	While drilling ahead	0	350 RPM 225 klbf	280	2000	50 lb/bbl med. nut plug	Turbine generator	Application specific	Modular
	Optimized for Drilling conditions	Inc / Azm 7.71 / 9.91 GR 6.92	Y	Flow rate and/or RPM change	While drilling ahead	0	350 RPM 370 klbf	280	2,000	50 lb/bbl med. nut plug	Turbine generator	Application specific	Modular

Product trade name	Point-the-bit or Push-the-bit	Length (ft)	O. D.& I. D. (in.)	Hole size (in.)	Max DLS capability (°/100')	Automated closed loop deviation control (yes/no) (+/-degrees)	Build rate increment	Is deviation force continuous?	Max temp (°C /°F)	Max internal pressure (psi)	Other special pressure limitations
PowerDrive Orbit G2 825	Hybrid Push-the-bit	13.72	OD: 8.25 ID: N/A	10.625 - 11.625	6	Yes, Azimuth and Inclination +/- 0.1°	1% and 1° TF resolution	Adjustable on Fully Rotating Tool	150/302	20,000 (35,000 Optional)	Optimized for Drilling conditions
PowerDrive Orbit G2 675	Hybrid Push-the-bit	13.43	OD: 6.75 ID: N/A	8.375 - 9.675	8	Yes, Azimuth and Inclination +/- 0.1°	1% and 1° TF resolution	Adjustable on Fully Rotating Tool	150/302 (175/350 optional)	20,000 (35,000 Optional)	Optimized for Drilling conditions
PowerDrive Orbit G2 475	Hybrid Push-the-bit	13.38	OD: 4.75 ID: N/A	5.875 - 6.75	10	Yes, Azimuth and Inclination +/- 0.1°	1% and 1° TF resolution	Adjustable on Fully Rotating Tool	150/302 (175/350 optional)	20,000	Optimized for Drilling conditions
PowerV 1100	Hybrid Push-the-bit	15.22	OD: 11 ID: N/A	20 - 28	Vertical Drilling	Yes, Azimuth and Inclination +/- 0.1°	1% and 1° TF resolution	Adjustable on Fully Rotating Tool	150/302	20,000 (35,000 Optional)	Optimized for Drilling conditions
PowerV 900	Hybrid Push-the-bit	14.05	OD: 9 ID: N/A	12 - 18.5	Vertical Drilling	Yes, Azimuth and Inclination +/- 0.1°	1% and 1° TF resolution	Adjustable on Fully Rotating Tool	150/302	20,000 (35,000 Optional)	Optimized for Drilling conditions
PowerV 825	Hybrid Push-the-bit	13.84	OD: 8.25 ID: N/A	10.625 - 11.625	Vertical Drilling	Yes, Azimuth and Inclination +/- 0.1°	1% and 1° TF resolution	Adjustable on Fully Rotating Tool	150/302	20,000 (35,000 Optional)	Optimized for Drilling conditions
PowerV 675	Hybrid Push-the-bit	13.53	OD: 6.75 ID: N/A	8.375 - 9.675	Vertical Drilling	Yes, Azimuth and Inclination +/- 0.1°	1% and 1° TF resolution	Adjustable on Fully Rotating Tool	150/302 (175/350 optional)	20,000 (35,000 Optional)	Optimized for Drilling conditions
PowerV 475	Hybrid Push-the-bit	13.5	OD: 4.75 ID: N/A	5.875 - 6.75	Vertical Drilling	Yes, Azimuth and Inclination +/- 0.1°	1% and 1° TF resolution	Adjustable on Fully Rotating Tool	150/302 (175/350 optional)	20,000	Optimized for Drilling conditions
PowerDrive Xcel 675	Point-the-bit	24.93	OD: 6.75 ID: N/A	8.375-10.625	8	Yes, Azimuth and Inclination +/- 0.1°	1% and 1° TF resolution	Adjustable on Fully Rotating Tool	150/302	20,000	None
PowerDrive Xcel 900	Point-the-bit	27.89	OD: 9.00 ID: N/A	12-17.5	6.5	Yes, Azimuth and Inclination +/- 0.1°	1% and 1° TF resolution	Adjustable on Fully Rotating Tool	150/302	20,000	None
PowerDrive ICE	Hybrid Push-the-bit	34.26	OD: 6.75 ID: N/A	8.5	8	Yes, Azimuth and Inclination +/- 0.1°	1% and 1° TF resolution	Adjustable on Fully Rotating Tool	200/392	30,000	Optimized for Drilling conditions
Scientific Drilling International											
HALO 650	Push-the-bit / proportional control.	35.5 ft	OD: 6.50" ID: N/A	7.875" - 9.875"	15	Yes, azimuth to 0.5 deg, inclination to 0.125 deg	Controllable in 12.5% Force or 0.125 deg increments	Yes, in Autopilot modes deviation force will auto adjust.	150 deg c / 302 deg F	20k psi	None
HALO 500	Push-the-bit / proportional control.	35.5 ft	OD: 5.00" ID: N/A	5.875"- 6.75"	13	Yes, azimuth to 0.5 deg, inclination to 0.125 deg	Controllable in 12.5% Force or 0.125 deg increments	Yes, in Autopilot modes deviation force will auto adjust.	150 deg c / 302 deg F	20k psi	None

	Does tool require configuration based on anticipated flow rate?	Sensor distance (ft) Inc/Azm/GR/ Res	Control from surface (Downlink) (Y / N)	If yes, tool control method	Rig time req'd to communicate change in target (minutes)	Minimum kickoff inclination (degrees)	Max RPM / WOB	Min flow rate (gpm)	Max flow rate (gpm)	LCM limits	Power source	Bit requirements	Integrated LWD?
	Optimized for Drilling conditions	Inc / Azm 7.85 / 10.05 GR 7.06	Y	Flow rate and/or RPM change	While drilling ahead	0	350 RPM 270 klbf	280	2000	50 lb/bbl med. nut plug	Turbine generator	Application specific	Modular
	Optimized for Drilling conditions	Inc / Azm 7.10 / 9.30 GR 6.31	Y	Flow rate and/or RPM change	While drilling ahead	0	350 RPM 180 klbf	210	970	50 lb/bbl med. nut plug	Turbine generator	Application specific	Modular
	Optimized for Drilling conditions	Inc / Azm 6.85/ 8.95 GR 5.96	Y	Flow rate and/or RPM change	While drilling ahead	0	350 RPM 31 klbf	120	355	35 lb/bbl med. nut plug	Turbine generator	Application specific	Modular
	Optimized for Drilling conditions	Inc / Azm 8.99 / 11.19 GR 8.19	Y	Flow rate and/or RPM change	While drilling ahead	0	350 RPM 225 klbf	280	2000	50 lb/bbl med. nut plug	Turbine generator	Application specific	Modular
	Optimized for Drilling conditions	Inc / Azm 7.71 / 9.91 GR 6.92	Y	Flow rate and/or RPM change	While drilling ahead	0	350 RPM 370 klbf	280	2,000	50 lb/bbl med. nut plug	Turbine generator	Application specific	Modular
	Optimized for Drilling conditions	Inc / Azm 7.94 / 10.14 GR 7.14	Y	Flow rate and/or RPM change	While drilling ahead	0	350 RPM 270 klbf	280	2000	50 lb/bbl med. nut plug	Turbine generator	Application specific	Modular
	Optimized for Drilling conditions	Inc / Azm 7.10 / 9.30 GR 6.31	Y	Flow rate and/or RPM change	While drilling ahead	0	350 RPM 180 klbf	210	970	50 lb/bbl med. nut plug	Turbine generator	Application specific	Modular
	Optimized for Drilling conditions	Inc / Azm 6.85/ 8.95 GR 5.96	Y	Flow rate and/or RPM change	While drilling ahead	0	350 RPM 31 klbf	120	355	35 lb/bbl med. nut plug	Turbine generator	Application specific	Modular
	Optimized for Drilling conditions	Inc / Azm 14.5 / 12.9 GR 15.83	Y	Flow rate and/or RPM change	While drilling ahead	0	350 RPM 55 klbf	260	805	50 lb/bbl med. nut plug	Turbine generator	Application specific - bi-center compatible	Modular
	Optimized for Drilling conditions	Inc / Azm 16.2 / 14.6 GR 10.89	Y	Flow rate and/or RPM change	While drilling ahead	0	350 RPM 75 klbf	260	1,800	50 lb/bbl med. nut plug	Turbine generator	Application specific - bi-center compatible	Modular
	Optimized for Drilling conditions	Inc / Azm 13.30/13.30	Y	Flow rate and/or RPM change	While drilling ahead	0	350 RPM 105.6 klbf	275	800	50 lb/bbl med. nut plug	Turbine generator	Application specific	Modular
	No	PWD - 2.3' NBI/NBA - 5.9' AZ GR - 15.4' Survey - 21.0'	Y	Rig pumps - variable flow rate.	3-6 mins with confirmation. Downlinks can be performed while drilling ahead. Full MWD decoding possible during downlink.	Vertical	350 RPM / 60 klbs WOB	300 gpm	650 gpm	50 ppb medium fibrous	System powered by downhole generator. Lithium battery used for flow off surveys.	Application Specific	Single collar loadout, with steering unit and integrated MWD system.
	No	PWD - 2.1' NBI/NBA - 5.5' AZ GR - 14.4' Survey - 21.0'	Y	Rig pumps - variable flow rate.	3-6 mins with confirmation. Downlinks can be performed while drilling ahead. Full MWD decoding possible during downlink.	Vertical	350 RPM / 30 klbs WOB	210 gpm	425 gpm	50 ppb medium fibrous	System powered by downhole generator. Lithium battery used for flow off surveys.	Application Specific	Single collar loadout, with steering unit and integrated MWD system.

Product trade name	Point-the-bit or Push-the-bit	Length (ft)	O. D.& I. D. (in.)	Hole size (in.)	Max DLS capability (°/100')	Automated closed loop deviation control (yes/no) (+/-degrees)	Build rate increment	Is deviation force continuous?	Max temp (°C /°F)	Max internal pressure (psi)	Other special pressure limitations
TerraVici Drilling Solutions • Rameen Bakhtiary rameen.bakhtiary@terravici.com											
TerraPoint 475 RSS	Point-the-bit	20	4.75	6.00 - 6.75	15	Yes ±1°	0-100% "Slide" Time, 1° TF Resolution	Yes	150 / 302	20,000	None
TerraPoint 650 RSS	Point-the-bit	22	6.5	7.875 - 9.875	12	Yes ±1°	0-100% "Slide" Time, 1° TF Resolution	Yes	150 / 302	20,000	None
TerraPoint 800 RSS	Point-the-bit	23	8	9.875 - 12.25	4	Yes ±1°	0-100% "Slide" Time, 1° TF Resolution	Yes	150 / 302	20,000	None
Weatherford • John Rice, Global Service Line Manager - RSS John.Rice@weatherford.com Brad Zukiwsky, Product Champion - Ma											
Revolution 825 rotary steerable system (Core, Heat)	Point	17.8	OD: 8.25 ID: 2.75	10.625 -18.25	7.5	Yes	Variable	Yes	149/300 Core 175/347 Heat	25,000 Core 30,000 Heat	None
Revolution 675 rotary steerable system (Core, Heat)	Point	14.8	OD: 6.75 ID: 2.0	7.875 - 9.875	10	Yes	Variable	Yes	149/300 Core 175/347 Heat	25,000 Core 30,000 Heat	None
Revolution 475 rotary steerable system (Core, Heat)	Point	12.9	OD: 4.75 ID: 1.75	5.875 - 6.75	10	Yes	Variable	Yes	149/300 Core 175/347 Heat	25,000 Core 30,000 Heat	None
Magnus 1100 Rotary Steerable System	Push	22.7	OD: 11.00 ID: 2.75	14.75 - 18.50	5	Yes	Variable	Yes	150/302	25,000	None
Magnus 950 Rotary Steerable System	Push	22.7	OD: 9.50 ID: 2.75	12.00 - 14.50 -	6	Yes	Variable	Yes	150/302	25,000	None
Magnus 675 Rotary Steerable System	Push	21.5	OD: 6.75 ID: 2.0	8.375 - 9.875	10	Yes	Variable	Yes	150/302	30,000	None

	Does tool require configuration based on anticipated flow rate?	Sensor distance (ft) Inc/Azm/GR/ Res	Control from surface (Downlink) (Y / N)	If yes, tool control method	Rig time req'd to communicate change in target (minutes)	Minimum kickoff inclination (degrees)	Max RPM / WOB	Min flow rate (gpm)	Max flow rate (gpm)	LCM limits	Power source	Bit requirements	Integrated LWD?
	Yes	Inc / Azm 10 / 10	Y	Flow Rate Change, MWD Direct-Connect/Hop, EM Downlink	Can Downlink While Drilling (Adjustable DL time from 3:20 to 20:00 based on conditions)	0	300 RPM / 25,000 lb (me-chanical)	200	350	40 lb/bbl med. nut plug	Turbine generator	Application Specific	No - Will function below any MWD/LWD
	Yes	Inc / Azm 10 / 10	Y	Flow Rate Change, MWD Direct-Connect/Hop, EM Downlink	Can Downlink While Drilling (Adjustable DL time from 3:20 to 20:00 based on conditions)	0	300 RPM / 50,000 lb (me-chanical)	410	750	40 lb/bbl med. nut plug	Turbine generator	Application Specific	No - Will function below any MWD/LWD
	Yes	Inc / Azm 10 / 10	Y	Flow Rate Change, MWD Direct-Connect/Hop, EM Downlink	Can Downlink While Drilling (Adjustable DL time from 3:20 to 20:00 based on conditions)	0	300 RPM / 55,000 lb (me-chanical)	410	750	40 lb/bbl med. nut plug	Turbine generator	Application Specific	No - Will function below any MWD/LWD
gnus RSS bradley.zukiwsky@weatherford.com www.weatherford.com													
	No	14/14/16/42	Y	Drillstring rotation or negative pulse from surface	Typically < 3	0	180 RPM 90 klb	No minimum requirement	1,500	Steering system: None MWD system: 80 lb/bbl fine/ med (higher conc. on request)	Lithium batteries	Long passive gauge PDC	Yes
	No	12/ 12/14/40	Y	Drillstring rotation or negative pulse from surface	Typically < 3	0	200 RPM 50 klb	No minimum requirement	750	Steering system: None MWD system: 80 lb/bbl fine/ med (higher conc. on request)	Lithium batteries	Long passive gauge PDC	Yes
	No	9/ 9/16/39	Y	Drillstring rotation or negative pulse from surface	Typically < 3	0	200 RPM 25 klb	No minimum requirement	350	Steering system: None MWD system: 80 lb/bbl fine/ med (higher conc. on request)	Lithium batteries	Long passive gauge PDC	Yes
	Yes	7/7/7/47	Y	Negative pulse from surface	Typically < 3	0	300 RPM / 90 klb	No minimum requirement	1,400	80 lb/bbl fine/ med (higher conc. on request)	Turbine Generator or Lithium batteries	None	Yes
	Yes	7/7/7/47	Y	Negative pulse from surface	Typically < 3	0	300 RPM / 90 klb	No minimum requirement	1,200	80 lb/bbl fine/ med (higher conc. on request)	Turbine Generator or Lithium batteries	None	Yes
	Yes	6/6/6/444	Y	Negative pulse from surface	Typically < 3	0	300 RPM / 50 klb	No minimum requirement	700	80 lb/bbl fine/ med (higher conc. on request)	Turbine Generator or Lithium batteries	None	Yes

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Port Fourchon champions offshore energy, the environment

GLPC's Chiasson voices support for 'balanced approach'

JESSICA STUMP, *ASSISTANT EDITOR*

FOR 61 YEARS, PORT FOURCHON HAS BEEN THE GULF of Mexico's premier service station for the offshore oil and gas industry. Today the port, which spans 1,700 acres, services all the energy production in the deepwater Gulf of Mexico.

In addition to the pandemic, market downturn, and new administration, the port faced Hurricane Zeta and five other hurricanes/tropical storms last year. Despite these challenges, Port Fourchon continues to evolve, expand, and enhance not only industrial capabilities but also the environment.

According to Greater Lafourche Port Commission (GLPC) Executive Director Chett Chiasson, resiliency is key. "We're very proud of the fact that we can balance ourselves in terms of playing a role in providing energy for our country," he said, "as well as being an example of how you can also utilize the assets, people, and the material you dredge to enhance habitat and the environment."

NEW LOGO

At the beginning of the year, the GLPC launched its Fourchon logo with assistance from White Car, a Thibodaux, Louisiana-based brand consultancy agency.

"It's a rebrand. It's something to take us into the future," Chiasson said. "We knew that the landscape in the country was changing, and we wanted to make sure that our brand was clean, sleek, and revived to have us open to whatever opportunities come our way."

The central theme of the gold logo highlights the grid-like development of Port Fourchon, where bulkheads intertwine with the adjacent waterways of Bayou Lafourche and the Gulf of Mexico. The blocks depict the solid nature of the port that has resulted through advanced mitigation techniques.

"Most people don't call it Port Fourchon. The people that work here every day call it Fourchon," he said. "So, we wanted to play on what everybody knows us as, and what everybody calls us."

The main Fourchon logo is only one of several subset logos that showcase the GLPC and its assets such as: Harbor Police, the South Lafourche "Leonard J. Miller, Jr." Airport, and the Coastal Wetlands Park. The subset logos feature a green line because the color was used in Fourchon's two previous logos.

COVID AND MARKET UPDATE

Between March 2020 and March 2021, the port lost $9.5 million in revenue due to COVID-19 and its impact on the economy and energy demand, according to Chiasson. However, Fourchon is in good shape.

"We were able to hold off having mass shutdowns. People did a good job of responding and keeping everybody safe," he said. "The entire port community did a really good job staving off any major issues. We're very proud of that."

Chiasson says that he is cautiously optimistic about the state of the market.

Port Fourchon spans 1,700 acres to service the offshore energy industry. *(Courtesy Greater Lafourche Port Commission)*

"What concerns us is the lack of exploratory drilling," he said. "That's really where the major business is. That's where the need for all the services is."

As the energy transition and US offshore wind market gain momentum, Chiasson said the country needs a realistic energy portfolio.

"We want a balanced approach, and we want to be a part of whatever is happening in terms of offshore energy," he said. "The Gulf of Mexico should always be seen as an offshore energy hub."

EXPANSION PROJECTS

Meanwhile, Fourchon continues to expand to serve the needs of the industry and the community.

After the GLPC funded the Section 203 Feasibility Study, Congress passed the Water Resources Development Act of 2020 last December. This gave the port authorization to begin dredging Belle Pass, Bayou Lafourche, and the Northern Expansion to 30 ft (9 m) in the coming years.

According to Chiasson, the ultimate goal is to dredge Belle Pass to 50 ft (15 m). This will allow for the development of the Fourchon Island project and the establishment of a deepwater rig repair and refurbishment facility. The project is in the conceptual phase, he said.

An LNG facility is on the horizon for development on West Belle Pass in the port. "We are keeping our fingers crossed that construction of the LNG plant will be nearing completion in about three years," Chiasson said.

Development also continues on Slip D. The 1,000-ft (305-m) wide slip will add about 200 acres of developed property to the port and more than 10,000 linear ft of waterfront.

As part of the mitigation of Slip D, the GLPC was mandated to create 60 acres of marsh but had enough material for about 100. As a result, the port commission decided to establish a

The Coastal Wetlands Park features a man-made tidal creek. *(Courtesy Greater Lafourche Port Commission)*

recreational and educational area known as the Coastal Wetlands Park. It will feature access to a man-made tidal creek for kayaking and non-motorized vessels, a two-story orientation hub with viewfinders, walking trails, boardwalks, and more. The park is expected to be open to kayakers this summer.

"We've been able to do all of this because of industry, not in spite of industry," Chiasson said.

IMPROVING LA 1

LA 1 is the only highway that services Fourchon. According to the LA 1 Coalition, more than 1,200 trucks and heavy vehicles travel the LA 1 southern corridor daily to support port activity and energy production.

On June 8, 2020, flooding from Tropical Storm Cristobal forced the highway to be closed for 20 hours. One week later, the US Department of Transportation awarded a $135-million Infrastructure for Rebuilding America (INFRA) grant to Phase 2 of the LA 1 Improvement Project. This allows the Louisiana Department of Transportation and Development (LA DOTD)

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to construct an 8.3-mi (13-km) elevated LA Highway 1 between Leeville and Golden Meadow in Lafourche Parish.

"The awarding of INFRA funds to the LA 1 project is the final piece of the puzzle that has been put together by the state, parish, port commission, and industry stakeholders," Chiasson said. "The future of our community and economy is bright with the reliable, safe access this project will provide."

Construction of the elevated highway is estimated to cost $445 million. The LA DOTD is expected to start taking construction bids in October 2021. Construction is expected to start next year, Chiasson said, and take an estimated six years to complete.

Henri Boulet, LA 1 Coalition Executive Director, said: "The completed elevated LA 1 will host millions of dollars of commercial activity moving in and out of Port Fourchon, Grand Isle, and our vibrant Gulf of Mexico. Whether for recreation, fishing, coastal restoration, or production of our abundant natural resources, drivers along LA 1 will have a much safer and dependable route to Louisiana's valuable working coast."

IN MEMORIAM

In April, the liftboat *Seacor Power* capsized 8 mi (13 km) south of Port Fourchon. Of the 19 passengers, six survived.

Among those that perished included: Capt. David Ledet, 63; Ernest Williams, 69; Anthony Hartford, 53; James Tracy Wallingsford, 55; Lawrence Warren, 36; and Quinon Pitre, 31. Chiasson paid tribute to these offshore workers.

Lady of the Gulf is the only dedicated Seaman's Memorial for Louisiana. *(Courtesy Greater Lafourche Port Commission)*

"Mother Nature has dealt a blow to our mariners and offshore workers that make their living by servicing our nation in the waters of the Gulf of Mexico. The truth is these brave men and women accept the risks and challenges of working in a marine environment to provide much-needed resources for all US citizens no matter their creed or ethnicity," he said. "The Lady of the Gulf statue, located in Port Fourchon, is a symbol that should give us all hope and strength at times like this as she gazes out on the horizon looking for the lost and calling them to her welcoming arms. I encourage everyone to continue praying for all those involved and to remember just how precious life is in moments like these."

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The deepwater facility offers simultaneous and fully automated capabilities.

(Courtesy Newpark Fluids Systems)

Expanded drilling, completion fluids plant facilitates deepwater E&P

New synthetic-based emulsion system enhances environmental safety

JESSICA STUMP, *ASSISTANT EDITOR*

FOR MORE THAN TWO DECADES NEWPARK FLUIDS Systems has been a tenant at Port Fourchon. Originally, the company's facility was designed for shallow water and inland barge activity. Today, Newpark provides both drilling and completion fluids to the deepwater Gulf of Mexico market from the port.

Tim Armand, president, North America, points out that the deepwater market is more logistically demanding than land operations: "The difference fundamentally in the operations themselves is probably the volumes that you deal with."

To help its customers handle these volumes, the company launched a deepwater initiative in 2015 to expand its infrastructure at the port, and thereby extend its reach out into the Gulf of Mexico.

Completed in 2017, the revamped facility increased both synthetic- and water-based drilling fluid mixing and storage capacities to more than 80,000 bbl. It also added a dedicated barite storage area.

The facility offers simultaneous and fully automated capabilities that allow quicker turnaround times and provide increased efficiencies. For instance, an automated system hauls bulk sack material to the mixing pits, which eliminates manual handling requirements.

According to Matt Kratzer, global accounts manager, the facility was designed for HSE, repeatability, and quality control. He also said the facility is one of the first in Fourchon to have a closed top mixing pit and Coriolis meters placed on the discharge lines to the vessels. "The Coriolis meter tells us the fluid is still in good shape as it's being delivered to the customer," Kratzer said.

As part of its initiative, the company introduced Kronos, a synthetic-based invert emulsion system designed primarily to comply with the environmental requirements for non-aqueous fluids used in deepwater.

More recently, Newpark expanded its completion fluids facility in Port Fourchon. An operator in the deepwater Gulf of Mexico recently chose the company for three completions from an ultra-deepwater, dual-activity drillship. In each case, the operator benefitted logistically from the company's facility in the port.

The company has a good relationship with the Greater Lafourche Port Commission, Armand said.

"They understand the industry and the ups and downs, especially with COVID tied in," he said. "It's very important, especially during the times we have right now." He also said the oil and gas industry should receive more recognition for how it has managed the coronavirus.

Kratzer pointed out the company's port facilities have been fully operational since the COVID-19 pandemic began. "There's been lots of barriers in place to mitigate any outbreaks. So, we've been very fortunate," Kratzer said. "It shows you the dedicated people and professionals that we have, because I think it's an individual thing that everybody has to commit to being safe. And part of being safe is getting all the precautions to prevent the spread of COVID."

Location, history enable Danos to meet the industry's need for skilled labor, integrated project services

JESSICA STUMP, *ASSISTANT EDITOR*

AS E&P ACTIVITY PICKS UP IN THE DEEPWATER GULF of Mexico, demand for skilled labor increases. Danos is helping deepwater operators and Port Fourchon tenants meet those skilled labor demands.

Since 1947, Danos has grown from a small crew boat company into a respected and well-known oilfield services provider. Based in Gray, Louisiana, its services include production workforce, fabrication, construction, project management, coatings, automation, instrumentation and electrical, scaffolding, shorebase and logistics, mechanical maintenance, regulatory compliance, rope access, and valve wellhead.

According to Reed Peré, vice president of sales and business development, the company has worked out of Port Fourchon

Located 30 mi (48 km) northwest of Port Fourchon, Danos' fabrication facility offers custom structural and process piping solutions. *(Courtesy Danos)*

in different capacities over the years. In the 1980s, the company operated a full-service dock. Today, the company provides skilled labor to its customers and tenants of the port.

"We're a people company," Peré said, "We've expanded our operations and our presence in the port as our customers have expanded. We've grown with the port."

Port Fourchon's proximity to Danos's headquarters and Larose fabrication facility enables the company to better serve its customers, according to Peré.

"Having the ability to access local talent, and have that talent support the work of our customers is one of our favorite ways of staying plugged in," he said.

Danos is both proud of and grateful for the port, Peré added. "The Greater Lafourche Port Commission does a world-class job," he said. And business is picking up, according to Peré. The company now has seven recruiters after recently hiring two more.

In February, a major Gulf of Mexico operating company awarded Danos a multi-year contract. Under the contract, Danos will provide production service operations and maintenance personnel, such as operators, shipping and receiving clerks, mechanics, and electricians.

Danos also has a new service offering for its customers at the port. In April, the company launched intelligent integrated materials solutions (i^2ms), a technology-based service offering that uses people, processes, and technology to provide warehousing logistics and inventory management.

Scott Theriot, general manager of supply chain services, said: "Customers are already seeing cost savings of 10-30%, depending on the scale of implementation. Our service is founded on the understanding that accurate, visible and up-to-date information is the key to greater efficiency, particularly as it relates to materials management."

Danos is also working to restore Louisiana's coast through participation in Partnership for Our Working Coast, an alliance of industry and environmental partners led by The Water Institute of the Gulf. Other members of the partnership include Chevron, Shell, and the Greater Lafourche Port Commission.

Most notable here is the planned deepening of Belle Pass, which will result in millions of cubic yards of dredged materials. The partnership is working to identify beneficial ways to use the dredged material to re-build Louisiana's coastal wetlands to support the environment, communities, and the industry.

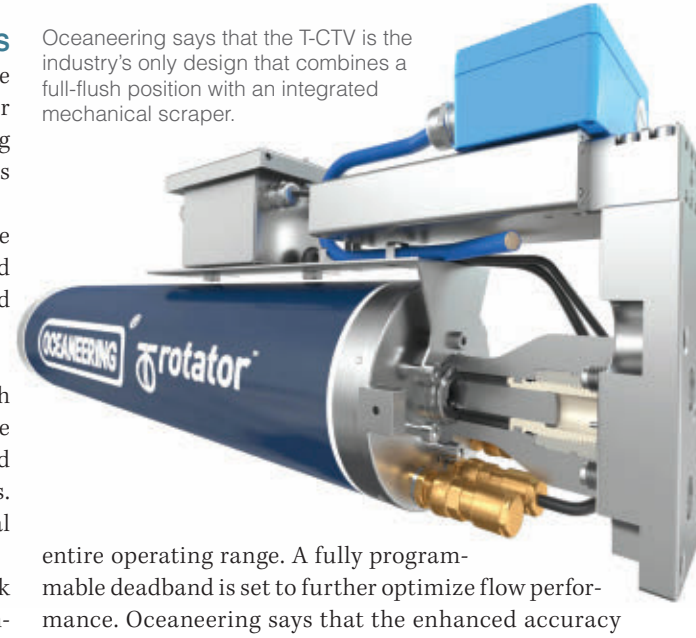
EQUIPMENT & ENGINEERING

Oceaneering unveils new topsides chemical throttle valve

OCEANEERING INTERNATIONAL'S ROTATOR BUSINESS has launched a new high-performance Topside Chemical Throttle Valve (T-CTV) for multiple industries for oil and gas and other industrial markets. The T-CTV is designed to leverage existing field-proven technology to address operational requirements for efficient topside chemical dosing.

The company says that the T-CTV provides a cost-effective and environmentally friendly solution for both greenfield and brownfield projects. The T-CTV is also ideal for unmanned and remotely operated applications across industries and can be configured with optional Wi-Fi capabilities. The valve is also reportedly the industry's only design that combines a full-flush position with an integrated mechanical scraper. This feature is designed to ensure superior contamination tolerance and deliver long-term performance without the need for filters. The increased accuracy of the valve results in less chemical waste, Oceaneering says.

The T-CTV control system uses continuous, live feedback from its Coriolis flow meter to automatically regulate and continuously display flow rates. The valve's helical flow path is designed to provide stable, controlled flow throughout the entire operating range. A fully programmable deadband is set to further optimize flow performance. Oceaneering says that the enhanced accuracy and reliability of the T-CTV will ultimately reduce opex via lowered chemical costs and improved uptime.



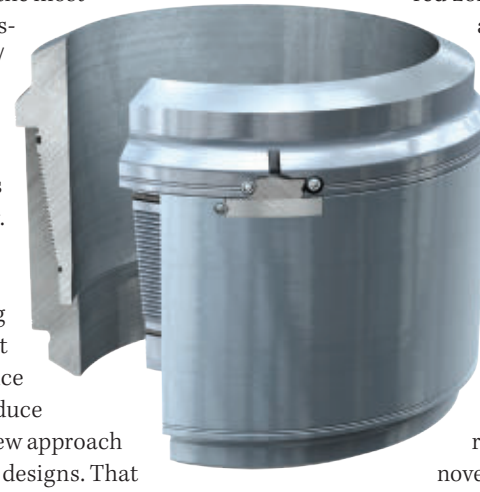
Oceaneering says that the T-CTV is the industry's only design that combines a full-flush position with an integrated mechanical scraper.

Hands-free, self-installing specialty connector saves time, improves safety

SCOTT ELLISOR, *DRIL-QUIP*

CONVENTIONAL CASING CONNECTORS AND TRADI-tional installation methods are employed offshore every day, but with the industry struggling to lower opex costs and reduce HSE risk exposure in increasingly complex environments, long-established approaches need to be reevaluated. The fact is that applying the same thinking and using the same types of components cannot deliver substantive improvements.

The need for reliability in more and more exacting operating environments has led to changes in industry connector standards and customer demands, but even the most stringent qualification requirements in existence today do not reflect the high-pressure/high-temperature conditions these components often experience when they are deployed. To provide connectors that can contend reliably in extreme conditions, it is necessary to set the performance bar higher.



Dril-Quip says that the BADGeR specialty casing connector has the longest fatigue life and lowest SAF in the industry.

DESIGNING FOR CRITICAL SERVICE

In designing the BADGeR specialty casing connector, Dril-Quip engineers realized that if they intended to deliver better performance that would reduce HSE risk exposure and reduce opex, they would have to take a completely new approach that eliminated the shortcomings of current designs. That meant taking a step back.

Instead of looking at ways to make current designs better, they started over with a blank sheet of paper, considering the limitations of existing connectors and thinking about how functionality and safety could be improved by eliminating components and simplifying installation. The goal was two-fold – to build the most robust connector possible and to make it easy to install to deliver permanent cost savings.

THINKING OUTSIDE THE BOX

One of the first areas targeted for improvement was the sealing mechanism. The team ruled out using O-rings as a primary seal to eliminate the common issues of degradation and gas decompression and focused instead on improving the sealing capacity of the connector's metal-to-metal seals.

Multiple designs were developed and tested before the team found a way to fabricate a seal that does not experience degraded integrity under high levels of tension and compression. The unique metal-to-metal sealing system improves under tension and is optimized for fatigue, delivering a gas-tight seal that can be used on large-diameter tubulars in a range of applications. The metal-to-metal primary seal is coupled with an elastomer secondary seal to provide dependable pressure containment for critical service.

The newly introduced connector also reduces risk with the integration of a unique hands-free anti-rotation device that allows the connector to make up automatically, eliminating the need for personnel in the red zone and preventing potential damages from dropped objects, missing components, damage to keys or injuries to personnel. Unlike conventional connectors, which must be installed by one to two crew members located in the red zone, the BADGeR connector's unique anti-rotation device is preinstalled offline allowing for reduced HSE risk exposure while also reducing opex and installation time.

The anti-rotation keys and the self-aligning profile not only eliminate cross-threading and simplify connector placement, but they also reduce installation time. Using this novel connector saves 2 to 10 minutes per connector installed. Calculating savings based on 100-150 joints on each 22-in. casing joint, using this connector can reduce costs by $80,000 to $100,000 per well.

TESTING TO EXTREMES

The connector underwent rigorous testing in house to API 5C5 CAL 1/ISO 13679 CAL 1-E criteria using high-pressure gas, with Lloyd's Register providing third-party verification. Technicians tested a 22.5 in. x 2.25 in. BADGeR connector for tensile strength, compression strength and bending capacity at an internal pressure of more than 16,000 psi with zero leakage.

Fatigue testing was performed following DNV RP C203 guidelines on six full-size samples. The tests exposed the connector to 40 million cycles at alternating stress from 15ksi to 22.5ksi. During three of the tests, the failures that halted testing occurred not in the connector but in the pipe body. Two other tests were discontinued after millions of cycles with no damage to the connector. In only one test were technicians able to cause the connector to fail. The test results for the six samples yielded a stress amplification factor (SAF) of 1.04, the lowest recorded for any connector in the industry.

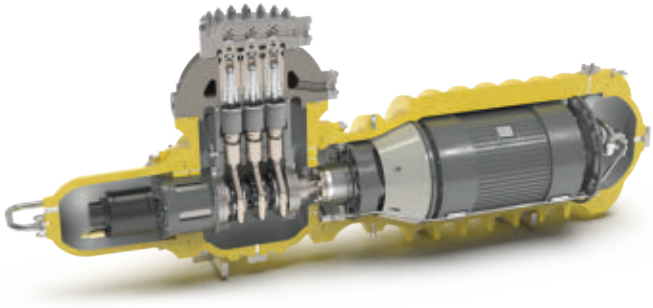
New subsea pump enables operators to move chemical equipment to the seabed

Pump can be used in HP/HT applications over 20k psi.

DANIEL KROHN, *OHI, LLC*

MOST RECENT ADVANCES IN OFFSHORE TECHNOL-ogy are designed to increase hydrocarbon recovery or reduce capex/opex by improve overall field design. One such new technology is the transfer of well treatment chemical storage and pumping equipment from the host production facility to the sea floor, adjacent to the wells. The significant advantage is that it allows for the reduction of complex production umbilicals and assists in supporting all-electric subsea trees by moving the chemical injection systems subsea.

Hammelmann Corp. has long since built chemical pumping systems for major operators' production facilities around the world. So, with the idea of moving this technology subsea, and with the support from major operators, the company developed their high capability and reliability pump into a subsea package. The challenge was to transfer this high capability and reliable system into a subsea package that could meet the stringent operational requirements needed for deepwater operation.



The Hammelmann Subsea Pump, including drive motor and variable displacement system.

With the operational profile assistance given to them by a major oil and gas concern, and with help from OHI, LLC in application, logistics, and configuration, Hammelmann embarked on the development of two pump configurations with multiple pressure and flowrate capabilities. The first challenge was picking the right size and configuration pumps to offer. Two of their highest priority goals were to meet high reliability and high-pressure multiple fluid flow rate and type compatibility.

The next challenge was packaging this system so that external subsea pressure could be managed, and internal components could use materials better selected for their operation and their compatibility with subsea. Hammelmann decided to place its pump, and supporting components inside an outer housing, that could ensure compensation to suction pressures while keeping the pump safe from external pressure transients while idle or pumping. This had the added benefit of isolating other components like the drive motor from sea water and sharing a common lubrication system with all components.

The operational challenges of placing these pumps long distances from the production facilities meant that the pump must be capable of operating with initial voltage losses and against full injection pressure head. To accomplish this, the drive motor is capable of handling large voltage drops, and the pump is internally configured and capable to de-stroke to zero flow output, start, then bring on flow gradually against pressure. In addition, the same pump with smaller plungers can be used in HP/HT applications over 20k psi (1380 bar), or with large plungers for high volume flow.

The initial pump is complete and has passed comprehensive tank testing. This same pump is now in the hands of the aforementioned oil and gas company and its offshore equipment supplier for additional long-term trials and environmental testing.

"We are confident in our subsea pump as we are in our very reliable surface pumps, as our track record for providing the best and most capable pumps is unparalleled," says Dr. Stephan Notzon, program manager for Hammelmann in Oelde, Germany. He adds: "Our use of a full enclosure allowed us to use the best and highest reliable materials and components on the market, so as our pump wears, as all pumps do, it wears slowly while providing exceptional service and very long life."

As Hammelmann initially intended the design be used for chemical injection, inquiries for other applications occurred, for example, as a lube oil pump for production booster pumps, or for other injection such as production enhancement chemicals. In most of these field design ideas, chemicals are stored in tanks subsea, but in high-flow constant injection applications, only a surge tank is needed, such that chemical supply can then be provided with a much lower cost low pressure field supply line.

PEOPLE

The Petrobras board of directors has elected **Joaquim Silva e Luna** as CEO; **Rodrigo Araujo Alves** as CFO and chief investor relations officer; **Cláudio Rogério Linassi Mastella** as chief trading and logistics officer; **Fernando Assumpção Borges** as chief exploration and production officer; **João Henrique Rittershaussen** as chief production development officer; and **Salvador Dahan** as chief governance and compliance officer.


Silva e Luna

Peter Coleman has retired as CEO of Woodside. The company has named **Meg O'Neill** as acting CEO.


Coleman

George Maxwell has succeeded **Cary Bounds** as CEO of VAALCO Energy.

ONGC has appointed **Subhash Kumar** as chairman and managing director.

Diamond Offshore Drilling Inc. has appointed **Bernie G. Wolford Jr.** as president and CEO, and **Neal P. Goldman** as chairman.


O'Neill

Kosmos Energy has promoted **Tim Nicholson** and **John Shinol** to senior vice president and head of Exploration, and senior vice president and chief geoscientist, respectively.

Tracey K. Henderson has joined APA Corp. as senior vice president, Exploration.


Henderson

The National Ocean Industries Association board of directors has elected **Tim Duncan**, president and CEO of Talos Energy, as chairman and **Paul Danos**, owner, president and CEO of Danos, as vice chairman for the 2021-22 term.

MODEC Inc. has named **Takeshi Kanamori** as president and CEO.


Kanamori

Golar LNG Ltd. has appointed **Karl Fredrik Staubo** as CEO, and **Eduardo Maranhao** as CFO.

Saipem has appointed **Francesco Caio** as CEO and general manager. In addition, the company has appointed **Silvia Merlo**, **Francesco Caio**, **Roberto Diacetti**, **Alessandra Ferone**, **Patrizia Michela Giangualano**, **Pier Francesco Ragni**, **Marco Reggiani**, **Paul Simon Schapira**, and **Paola Tagliavini** to the board of directors.


Caio

RWE AG has appointed **Dr. Markus Krebber** as CEO, **Dr. Michael Müller** as CFO, and **Zvezdana Seeger** as chief human resources officer and labour director.

Fraser Moonie has joined Decom North Sea as CEO.

Energi Coast has named **Tony Quinn** as chair.

Eidesvik Offshore Chairman **Kolbein Rege** has retired. The company has nominated **Arne Austreid** as his successor.

AFG Holdings Inc. has appointed **Michael Walter** as CEO.

Enteq Upstream has named **Andrew Law** as CEO. He succeeds **Martin Perry**, who has become non-executive chairman.

BW Ideol has named **Marco Beenen**, **Yngvil Asheim**, **Julian Brown**, **Yasuhira Matsui**, and **Jean Huby** to its board of directors.


Krebber


Walter


Law


Wayth


Sicker


Beumelburg

The Energy Institute has appointed **Dr. Nick Wayth** as CEO.

SBM Offshore has appointed **Ingelise Arntsen** as a member of the supervisory board.

Mitsubishi Heavy Industries America Inc. has appointed **Michael Sicker** as president of its Oil & Gas Division. He succeeds **Hiroaki Osaki**, who has retired from his role as president but continues to serve as chairman of Mitsubishi Heavy Industries Compressor Corp.

Ørsted has appointed **Richard Hunter** as COO.

Schlumberger has named **Dr. Katharina Beumelburg** as chief strategy and sustainability officer.

Paula R. Glover has joined the Talos Energy board of directors.

Ecopetrol S.A. has named **Elsa Jeanneth Jaimes** as vice president of Exploration.

Paul Aronzon has joined the Noble Corp. board of directors.

TMC Compressors has appointed **Christian Ness** as CEO.

Atkins has appointed **Campbell Gray** as CEO for the Middle East and Africa, effective August 2021.

Michiel Van Haersma Buma has joined Akselos as vice president of Customer Success.

Robin Macmillan has joined Data Gumbo as chief corporate development officer.

Maersk Supply Service has named **Jonas Munch Agerskov** as chief commercial officer.

Shawn D. Williams has joined the Tetra Technologies Inc. board of directors.

Maritime Developments has appointed **Chris Reid** as vice president – UK & Europe.

80:20 Procurement Services has appointed **Donald Macleod** as managing director of US operations.

The Outer Continental Shelf Governors Coalition has chosen **John Bel Edwards** (Louisiana) as chairman, and **Tate Reeves** (Mississippi) as vice chairman.

Phoenix has promoted **Troy Magness** to Louisiana diving operations manager.

US Wind Inc. has appointed **Albert Ploeg** as construction manager, **Benjamin Cooper** as director of Marine Affairs, and **Gener Gotiangco** as senior director for Transmission Development.

Jan Poulsen has joined Cenosco as CEO.

ROSEN (UK) has promoted **Marguerite Forde** to integrity

solutions specialist and sales manager.

FutureOn has appointed **Katherine Taylor-Jones** as CFO, and **David Bartley** as head of people.

Enelift has named **Jim Clark** as chairman, and **Adam Maitland** as non-executive director.

Seatex Corp. has hired **Jonathan O'Dwyer** as executive vice president of Operations and Technology.

Arnel Santos has joined mCloud as executive vice president and president, Americas.

Radix Engineering and Software has hired **Doug Sinclair** as business development director, and **Elliott Bell** as program director for Advanced Solutions.

Twin Brothers Marine has appointed **James Block** as account representative.

OPEX Group has hired **Alison Taylor** as emissions reduction lead, **Colin Deddis** as process engineering lead, and **Euan Bathgate** as chief product officer.


Macmillan


Agerskov


Reid

COMPANY NEWS

UK North Sea independent **Pharis Energy** has renamed itself **Orcadian Energy**.

GATE Energy has won the 2021 NOIA Safety in Seas Culture of Safety Award for its leadership and safety culture, including the development of an integrated management system that is compliant with occupational health and safety management requirements established in 45001:2018.

TechnipFMC has received the 2021 NOIA Safety in Seas Safety Practice Award for the Gemini ROV system.

ASTM International and the **American Petroleum Institute** have partnered to harmonize petroleum standards in West Africa, with impact in Côte d'Ivoire, Ghana, Nigeria, and Senegal. The three-year project is supported by the **USAID Standards Alliance** and managed by the **American National Standards Institute**.

Offshore Support and Logistics Services Co. has teamed up with **Mammoet** to deliver turnkey transport and installation solutions for projects in the GCC.

Express Engineering has opened a 48,000-sq ft (4,459-sq m) assembly and test center in Gateshead, England.

Danfoss Editron and the **Ship and Ocean Industries R&D Center** have partnered to launch the Green Energy Application Development Center in Taiwan.

Mammoet subsidiary **Conbit** has opened its Asia/Pacific hub in Johor Bahru, Malaysia.

Shell has awarded **Draeger** a three-year renewal of an enterprise framework agreement. This covers the supply of portable gas detection equipment and other safety technology for all of Shell's offshore and onshore facilities and installations worldwide.

Welltec has signed a long-form contract with **Saudi Aramco**. The company will deliver completion products and services across the Saudi Aramco portfolio.

3t EnerMech, an alliance between **3t Energy Group** and **EnerMech**, has launched a training and competency service in Angola. An unnamed international drilling contractor will be the first company to use the training facility in Luanda, developed in partnership with EnerMech's local entity **SoniMech**.

Ocean Infinity has acquired software engineering provider **Abyssal**. The company plans to integrate Abyssal's software capability with its robotic vessel fleet to provide safe and secure data acquisition operations through development of operational simulation, fleet management, and cloud data tools.

Aker BP has awarded **Bristow Group Inc.** a three-year contract extension to provide air transportation services for its operations on the Norwegian continental shelf.

Survitec has acquired **Hansen Protection**, a European provider of personal protective equipment.

TenneT has become the 100th member of **Amsterdam IJmuiden Offshore Ports**, an association for companies, regional government authorities and knowledge and research institutes active in offshore oil and gas and wind energy in the North Sea Canal region.

Ashtead Technology has signed a collaboration agreement with **Zetechtics** to offer customers a range of new ROV tooling technologies. The agreement will see an array of torque tools, control systems, and associated peripherals from the subsea control systems provider made available to customers through Ashtead Technology's nine customer service hubs.

Aleron Ltd. has partnered with **SEA.O.G Offshore** to bring its AUXROV system to the US market.

OMV has awarded **NorSea** a five-year contract to provide supply base services for its operations in the North Sea, Norwegian Sea, and Barents Sea. The NOK300-million ($35-million) contract includes two two-year extension options. It applies to storage and handling of pipes, terminal services, and warehousing services.

United States Steel Corp. has joined ResponsibleSteel, a global not-for-profit forum for the steel supply chain and civil society organizations to work together to promote steel's contribution to a sustainable future.

Bilfinger Salamis UK has formed a strategic partnership with **GEV Wind Power**.

Transmark Subsea has become the European distributor of ROV systems for **Boxfish Research**.

Vantage Drilling has awarded **ICM Group** a global preferred contract to provide onboard regulatory and crane training. This long-term contract covers the majority of ICM's training programs to support Vantage Drilling's onboard training requirements.

ClassNK has opened a Kyushu regional office in Hakata, Fukuoka, Japan.

Techouse has opened an office in Glasgow, Scotland.

Sulzer has acquired **Turbo Services Inc.**, an aeroderivative gas turbine provider.

James Fisher has launched **James Fisher Subtech**, which consolidates its subsea offering.

Offshore

SALES OFFICES

ENDEAVOR BUSINESS MEDIA PETROLEUM GROUP
10300 Town Park Drive, Suite S1000
Houston, TX 77072
PHONE +1 713 963 6206
FAX +1 713 963 6228
David Davis (Worldwide Sales Manager)
ddavis@endeavorb2b.com

United States • North America • Central America • South America
David Davis *ddavis@endeavorb2b.com*
PHONE +1 713 963 6206

UNITED KINGDOM • SCANDINAVIA •THE NETHERLANDS • MIDDLE EAST
10 Springfield Close, Cross,
Axbridge, Somerset,
United Kingdom BS26 2FE
PHONE +44 1934 733871

FRANCE • BELGIUM • PORTUGAL • SPAIN • SOUTH SWITZERLAND • MONACO • NORTH AFRICA
961 Camp Redon, 83830 Callas, France
PHONE +33 (0) 6 2123 6702 •
FAX +33 (0) 4 8981 9982
Stefania Piciotti Thompson
stefaniat@endeavorb2b.com

GERMANY • NORTH SWITZERLAND • AUSTRIA • EASTERN EUROPE • RUSSIA • FORMER SOVIET UNION • BALTIC
Sicking Industrial Marketing
Kurt-Schumacher-Str. 16,
59872 Freienohl, Germany
PHONE +49 (0) 2903 3385 70 •
FAX +49 (0) 2903 3385 82
Andreas Sicking *asicking@endeavorb2b.com*

ITALY • TURKEY • GREECE • CYPRUS • MALTA
Silvera Mediarep
Viale Monza, 24 - 20127 Milano, Italy
PHONE +39 (02) 28 46716 •
FAX +39 (02) 28 93849
Ferruccio Silvera *info@silvera.it*

CHINA • SOUTHEAST ASIA • AUSTRALASIA • JAPAN
19 Tanglin Road #05-20
Tanglin Shopping Center
Republic of Singapore 247909
PHONE +65 9616 8080 •
FAX +65 6734 0655
Michael Yee *yfyee@singnet.com.sg*

FOR ASSISTANCE WITH MARKETING STRATEGY OR AD CREATION, PLEASE CONTACT:
Endeavor Business Media
Marketing Solutions
David Davis
PHONE +1 713 963 6206
EMAIL *ddavis@endeavorb2b.com*

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Future offshore well construction to be defined by collaboration, remote solutions

THE OFFSHORE ENERGY INDUSTRY FACES CONSID-erable challenges, including smaller capital budgets and mounting pressure for improved operational sustainability.

To meet these challenges and remain competitive in a future marked by energy transition, we must adopt new well construction technologies and strategies that enable us to be more agile and efficient as well as good environmental stewards. Achieving these objectives, however, compels a shift away from traditional well construction processes that require ongoing involvement from various personnel performing a wide range of manual tasks at the rig site.

While many offshore well construction fundamentals remain largely unchanged since the 1960s, how we drill and complete a well today is very different. Some of the most significant progress in this space in recent years has been around advanced remote operations and autonomous drilling.

In the late 2000s, energy service companies began offering real-time field activity monitoring, representing a significant step change for the offshore energy industry. Since then, remote operations have steadily evolved into increasingly digitally connected solutions, transforming the operating model from real-time monitoring to live remote operations control.

Today, many aspects of the offshore well construction process are controlled remotely in real time due to digital advances that connect people with technology and key stakeholders. What this translates to for offshore operators is greater cost efficiencies and operational sustainability.

Leveraging a live remote operations control model, engineers perform their mission-critical tasks from offices in town and are no longer needed at the rig site. This reduces carbon emissions from personnel logistics, on-site housing, and equipment transportation. Furthermore, this model centralizes executional decisions to a smaller number of people while expanding access to domain experts from around the world. This increases collaborative opportunities that enable offshore operators to make faster, better decisions while improving their operational consistency. The results: improved drilling and completion efficiencies that save rig time and minimize environmental impact.

In the Gulf of Mexico, live remote operations control enabled an operator to optimize its well construction process and reduce wellsite footprint from five to one. The transition of personnel from the wellsite to an office directly improved the efficiency of operations by eliminating nearly 200 crew changes and nearly 1,500 staff days offshore per rig per year. This reduced average wellsite crew size by nearly 50%, with most services delivered with a single wellsite crew member. During this project, the operator achieved a 19% improvement on shoe-to-shoe drilling.

The next performance leap for offshore well construction efficiency and sustainability is autonomy. Unlike automated systems, technology, and processes, which replace some manual tasks performed during the well construction process, fully autonomous systems eliminate virtually all manual tasks, enabling more efficient, consistent, and sustainable operations.

Much like the auto industry's endeavor to build and deploy autonomous vehicles, our industry has been on a similar journey in the well construction domain. The future of well construction is a fully autonomous bottomhole assembly drilling every section of a well. This system will constantly analyze its position, formation characteristics, conditions, and trajectory to optimize steering and well placement.

While many of the building blocks of autonomy already exist today, including digitally connected technologies and hardware, edge intelligence, and live remote operations control capabilities, our industry is still several years away from delivering a fully autonomous solution for well construction—but we are making significant inroads.

The quest for system autonomy and self-direction is difficult to map out perfectly, and is more of an organic progression. Our industry's journey toward autonomy, and increased system cognition, can be aligned to six successive degrees. The baseline is defined by full human control and no automation, and the final step is fully autonomous systems. Today, the industry is deploying systems capable of performing single-workflow autonomy, where the system autonomously prioritizes and responds to simultaneous events. The next step in the journey is to reach orchestrated autonomy, where the system can prioritize multiple workflows. This is what our industry is advancing toward and where significant opportunities exist to increase drilling and completion performance.

In our dynamic industry, efficiency, consistency, collaboration, and sustainability are the major themes that link us all together. By adopting more collaborative remote working solutions and embracing the journey toward autonomous well construction, more efficient, sustainable operations are possible. This will help offshore operators increase their margins in today's environment and remain relevant and competitive as we move further into the energy transition.

JESUS LAMAS, *PRESIDENT—WELL CONSTRUCTION, SCHLUMBERGER*

This page reflects viewpoints on the political, economic, cultural, technological, and environmental issues that shape the future of the offshore energy industry. *Offshore Magazine* invites you to share your thoughts. Email your Beyond the Horizon manuscript to David Paganie at dpaganie@endeavorb2b.com.

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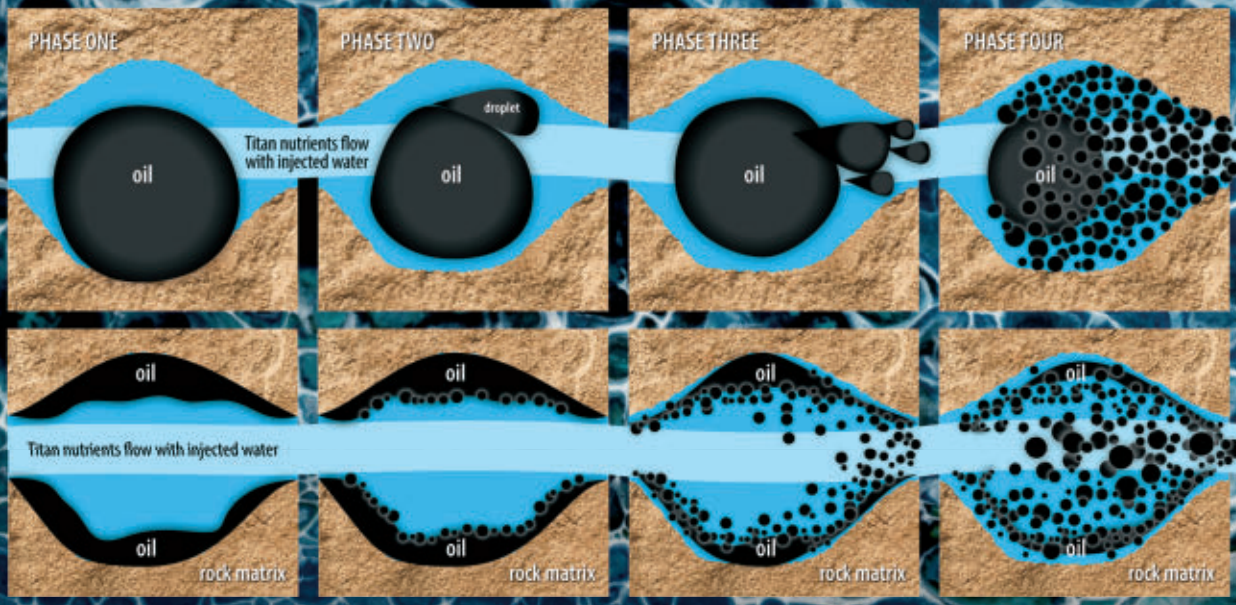

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For case studies contact Ken Gerbino at KGerbino@TitanOilRecovery.com

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Badentoy Avenue, Badentoy Industrial Park,
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Phone: +44 (0)1224 787000 Fax: +44 (0)1224 787100
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For Service in North & South America:
9595 Wilshire Boulevard, Suite 303, Beverly Hills, CA 90212 USA
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