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50 YEARS
1969–2019

OTC2018

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| THE OFFICIAL 2018 OFFSHORE TECHNOLOGY CONFERENCE NEWSPAPER | DAY 2

Innovate, Then Dive In

■ Speakers at the opening ceremony for OTC's 50th year address risk, technological achievement and the importance of the industry to the world.

BY JOSEPH MARKMAN

Their neckties were as wide as their fists and their slacks flared like associated gas at a drilling site. The first attendees at the inaugural Offshore Technology Conference on May 18-21, 1969, in downtown Houston paid a maximum of \$35 to attend. Those who belonged to sponsor societies could get in for \$20.

Times have changed as OTC marks its 50th year but the intrepid spirit needed to venture far from shore, punch holes in the seabed and safely bring hard-won hydrocarbons back to land has not. Nor has the need for such oil and gas subsided.

"Offshore oil and gas is absolutely essential to the world's economic prosperity, to human advancement and will remain so at least for the rest of our lives," Ryan Lance, chairman and CEO of ConocoPhillips Co., said matter-of-factly Monday morning at OTC's opening ceremony in NRG Stadium.



Ryan Lance

If contemporary operators believe that the sector has experienced tough times prior to today's improved outlook, the ceremony's speakers assured them that it always has.



Patrick Pouyanné

"This industry, in fact, got off to a slow start in the early '60s," said Patrick Pouyanné, chairman and CEO of Total. A number of factors held it back including the low price of oil at the time—about \$5/bbl—the cost of offshore extraction, limitations of technology and safety challenges.

Total's first big offshore discovery was made in 1958 at the Umm Shaif Field offshore the United Arab Emirates. A German vessel was hired to do the work because it could operate in depths of 50 m. The Middle East is most often associated with onshore oil production, but those facilities in the Persian Gulf from the 1960s are still producing, he said.

Pouyanné did not back away from the impact that catastrophic events have had in embedding safety into the sector's core culture:

The Ekofisk discovery in the Norwegian North Sea in 1969 was a turning point of offshore development, he said, but the Ekofisk Bravo accident in 1977 was a devastating reminder of the risk involved. Phillips Petroleum

See **INNOVATE** continued on page 27

BP Explores Tech's Impact on Future Energy Use

■ Monday morning breakfast highlights recent technology outlook report.

BY BRIAN WALZEL

David Eyton, group head of technology for BP, helped kick off OTC 2018 on Monday morning with a review of the company's "Technology Outlook," a report issued in March that examines the potential of technology to change the way the world produces and uses energy through 2050.

Eyton illustrated how emerging technologies and global trends in transportation, power and heat will evolve and impact the efforts at worldwide carbon emission reductions. He also provided an update on BP's estimates on the world's energy supply and its future demand. BP's "Technology Outlook" was a result of three years' worth of studies and involved support from eight other institutes, universities and consultants.



David Eyton

Eyton explained that the world's energy resources far exceed what will likely be global energy demand through 2050, and more resources are continuously being added to the world's supply.

"The world's actually got abundant energy resources," he said. "If you think of coal, oil and gas, uranium, solar, wind, biomass, geothermal—with all these things added together

there is probably more energy that's available to us than we need over the period of 2050."

See **IMPACT** continued on page 27

Innovative Processing and Design

■ New approaches deliver greater productivity and less risk.

BY JUDY MURRAY

When companies look to reduce costs offshore, one of the areas of interest is topsides processing, where improved efficiency often delivers greater safety along with better processes.

Certainly, this is the case for an improved process for removing mercury from condensate, which was the subject of a presentation by Imane Aguedach of Alfa Laval Lund AB in the "Topside Innovative Processing and Design" session on Monday morning.

Aguedach suggested mercury removal could best be achieved using a high-speed hot spin centrifuge that allows continuous operation without impacting production. She explained several advantages of this technology, including its small footprint, hermetic sealing that protects workers and the environment, and the ability to clean the equipment in place.

Another technology, which was developed by GE Power & Water for use by Petrobras offshore Brazil, focuses on reducing the amount of water used in offshore chemical cleaning in sulfate removal units (SRUs).

According to Gustavo Garios Lage, Petrobras, freshwater has become a scarce resource on some offshore assets. Instead of purchasing freshwater, which can be costly and logistically challenging, Petrobras is using the GE solution of using purified water. This permeate feed solution has low sulfate content and is used for injections and cleaning in place. In trials offshore, Lage said, Petrobras achieved the same results as were delivered with freshwater systems, using less water and fewer manhours while reducing downtime.

Another advancement was presented by Chien-Chiang Chen, ExxonMobil Upstream Research Co., who shared novel adsorption-based gas treating technology platform for use in upstream gas separation, a process similar to the conventional process but which happens more quickly. According to Chen, the new approach achieves in a 250-second cycle time what traditional systems can only deliver in a matter of multiple days.

See **PROCESSING** continued on page 23

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CELEBRATING
50 YEARS
1969–2019



OTC2018

SCHEDULE
OF EVENTS

All events in conjunction with OTC 2018 will be held at NRG Park in Houston, Texas, unless noted otherwise.

Tuesday, May 1

7:30 a.m. to 5 p.m. Registration
7:30 a.m. to 9 a.m. Topical/Industry Breakfasts
9 a.m. to 3:30 p.m. Poster Sessions
9 a.m. to 5 p.m. University R&D Showcase
9 a.m. to 5:30 p.m. Exhibition
9:30 a.m. to 12 p.m. Technical Sessions
12 p.m. to 2 p.m. Distinguished Achievement Awards Luncheon
12:15 p.m. to 1:45 p.m. Topical Luncheons
2 p.m. to 4:30 p.m. Technical Sessions
4 p.m. to 6 p.m. Networking Event
7:05 p.m. OTC Night at the Ballpark (at Minute Maid Park)

Wednesday, May 2

7:30 a.m. to 5 p.m. Registration
7:30 a.m. to 9 a.m. Topical/Industry/Ethics Breakfasts
8 a.m. to 11 a.m. OTC Energy Challenge High School Event
9 a.m. to 3:30 p.m. Poster Sessions
9 a.m. to 5 p.m. University R&D Showcase
9 a.m. to 5:30 p.m. Exhibition
9:30 a.m. to 12 p.m. Technical Sessions
12 p.m to 6 p.m. The Next Wave Program
12:15 p.m. to 1:45 p.m. Topical Luncheons
12:15 p.m. to 6 p.m. WISE Networking Event
2 p.m. to 4:30 p.m. Technical Sessions

Thursday, May 3

7:30 a.m. to 2 p.m. Registration
7:30 a.m. to 9 a.m. Topical/Industry Breakfasts
7:30 a.m. to 3 p.m. Energy Education Institute: Teacher Workshop
8:30 a.m. to 1:30 p.m. Energy Education Institute: Student STEM Event
9 a.m. to 2 p.m. Exhibition
9 a.m. to 2 p.m. University R&D Showcase
9:30 a.m. to 12 p.m. Technical Sessions
12:15 p.m. to 1:45 p.m. Topical Luncheons
2 p.m. to 4:30 p.m. Technical Sessions

Visit **EPMag.com** for additional OTC-related articles. Look for stories tagged “OTC Extra”!



Following the OTC 2018 Opening Ceremony in NRG Stadium on Monday morning, the St. Thomas Episcopal School Pipe Band led attendees to a ceremonial ribbon pulling by the OTC Board of Directors in NRG Center. (Photos by CorporateEventImages.com)

Chevron Touts Both Permian, Deep Water

■ The oil major sees deep water as a material part of its overall upstream portfolio.

BY EMILY PATSY

Massive opportunities in shale plays within the Permian Basin might have lured most companies faced with lower-for-longer oil prices to abandon offshore, but not Chevron Corp.

“For us, it’s not either offshore or the Permian—it’s both,” Jeff Shellebarger, president of North America E&P at Chevron, said during an OTC breakfast session on Monday, April 30.

Shellebarger, who called the Permian one of the biggest challenges facing the offshore business, said the nature of offshore—especially deep water—is it takes long-term commitment and the financial wherewithal to invest across the cycle.

Further, it takes considerable size and scale to manage the risk and to generate profit, which Shellebarger said Chevron has in both the Permian and deep water.

“At Chevron, we see deep water as a material part of our overall upstream portfolio, and as such we have put together the size, the scale and the organizational capability needed to be successful in the Gulf of Mexico [GoM],” he said.

This year alone, the company plans to invest \$8 billion in U.S. operations with a majority of that allocated to deepwater GoM and the Permian Basin.

Still, the last two years have been tough for the industry, with a lot of companies choosing to exit deep water.

“Deepwater offshore projects will have to generate competitive investment returns at the lower end of the price



Jeff Shellebarger

environment in order to be viable and to continue to attract that investment capital,” he said. “All this is possible. We are working on that as an industry to meet those investment challenges through efficiency, through technology and through standardization.”

Earlier this year, energy research and consultancy firm Wood Mackenzie forecast a comeback for deepwater GoM with expectations of record-breaking production in 2018.

“Although deepwater Gulf of Mexico has taken quite a beating over the last three years, the industry has clawed its way back to being competitive by significantly cutting costs, improving efficiencies and tightening up the supply chain,” William Turner, Wood Mackenzie’s senior research analyst, said in a January report.

The Wood Mackenzie analyst expects production of oil and gas in deepwater GoM to reach an all-time record high in 2018 with about 1.9 MMboe/d forecasted (80% oil), surpassing the previous record in 2009 by nearly 10% and representing 13% growth year over year.

Shellebarger said he shares that optimism. “For me personally I think that’s absolutely true and, as a company, Chevron remains committed to being a long-term player in multiple deepwater basins around the world,” he said.

So far this year in the GoM, Chevron has seen first production at its partner Hess’ operated Stampede project in January and successfully installed a Big Foot tension-leg platform in February.


Chevron plans to start drilling from the Big Foot platform in the next two to three months and expects to see first oil from that project by the end of the year.

Big Foot is located about 360 km south of New Orleans in water depths of 1,600 m. Production from the project was previously expected to start in late 2015 but was delayed due to failed installation in May 2015.

Shellebarger said Chevron also continues to invest in brownfield opportunities and is participating in the Mad Dog Phase 2 project with first oil expected in 2021. In the long term, the company announced two new “very promising” discoveries—Whale and Ballymore, he said.

“Between the resource potential, terrific discoveries, the size and the scale, the cost of efficiencies that we have and can achieve, and the fact that we’re effectively managing through the low-price cycle and achieving this step change of cost and efficiencies, you can see why I remain optimistic on the future of deep water whether it’s in the Gulf of Mexico or other basins around the world,” he said.

Chevron reported on April 27 first-quarter earnings of \$3.6 billion, up from \$2.7 billion a year ago. Its upstream earnings also improved, rising to about \$3.4 billion from \$1.5 billion. But, similar to Exxon Mobil, downstream earnings were down. ■



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Tuesday, May 1—Field Development & Offshore Wind

| | |
|----------|--|
| 10:00 am | Design and selection of pipeline systems to address the challenges of deepwater HPHT developments—Neil Simpson |
| 10:30 am | An innovative, cost-effective alternative to conventional semi (Paired-Column Semi)—Jun Zou |
| 11:00 am | Flat plate spar for deepwater marginal fields—Arun Antony |
| 11:30 am | Offshore wind farm optimization—Simon Evans |
| 12:00 pm | 'Game' changing VR demonstration |
| 2:00 pm | Design and selection of pipeline systems to address the challenges of deepwater HPHT developments—Neil Simpson |
| 2:30 am | An innovative, cost-effective alternative to conventional semi (Paired-Column Semi)—Jun Zou |
| 3:00 pm | Flat plate spar for deepwater marginal fields—Arun Antony |
| 4:00 pm | What the industry needs to advance offshore floating wind—Ike Udoh |
| 4:30 pm | 'Game' changing VR demonstration |

OPEN FOR BIDS: FIRST ABU DHABI EXPLORATION LICENSING ROUND

Six historic oil and gas licensing opportunities open for bidding in Abu Dhabi, comprising a total area of almost 30,000 km² in what is one of the world's largest hydrocarbon super basins.

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www.adnoc.ae/Block-Bid

*Subject to a strict prequalification process undertaken by ADNOC.

Offshore's \$50 Oil Obsession

■ Offshore companies see efficiency waiting to happen amid aging equipment, antiquated software and jumbled customer service.

BY DARREN BARBEE

With the price of Brent crude cruising to \$75 in recent days, offshore operators and service companies continue a downturn reenactment. For them, oil is perpetually fixed at \$50 and won't rise again.

At a Monday morning OTC panel, executives from BP, Maersk Drilling, National Oilwell Varco and IHS Inc. pushed to make structural cost changes permanent while continuing to push for greater innovation and efficiency, convinced that everything changed in the most recent downturn.



Susan Farrell

Leigh-Ann Russell, head of procurement and supply chain management for BP, said the company expects the recent surge in prices “could be short-lived and prices will moderate over the medium term.

Susan Farrell, a vice president at IHS, said much of the recent price improvements can be attributed to geopolitical instability.

Farrell expects global tensions to continue to create varying levels of instability.



Angela Durkin

U.S. foreign policy is expected to “harden” under U.S. Secretary of State Mike Pompeo and John Bolton, the president's national security adviser.

Both men have the experience and wherewithal to “make things happen” in a way that could influence many sectors but particularly the energy sector, she said.

IHS expects the U.S. to reimpose Iranian sanctions—either by May 12 or 90 days later. Because of willing buyers of Iranian crude in China, Iran's production is expected to fall by about 500,000 bbl/d, she said.

Since reaching a tipping point, Venezuela appears likely to see even more of a slump following the curtailment of about 400,000 bbl/d in production by the end of 2017. Farrell said another 500,000 bbl/d will likely fall off in 2018, leading to a two-year reduction of 900,000 bbl/d by the end of the year.

Venezuela can recover, but it will take years of investment in infrastructure and maintenance.

Angela Durkin, Maersk's COO, said that while geopolitical risk may have moved oil prices, it was not necessarily due to supply and demand.

“There's plenty of supply out there,” she said.

Maersk is also forging ahead with an emphasis on innovation and technology.

The company has installed its maintenance system on iPads so that crew can save time examining the systems instead of having to walk to another part of the rig. Maersk has reduced staffing on one of its best performing rigs by 11 people while keeping it as productive.

Customer behavior is changing, too, as offshore operators are “realizing that just regularly cutting out the cyclical costs is not good enough,” she said.

Durkin said a well can take 60 total contractors and 6,000 invoices.

“That's a huge amount of waste in our system,” she said. “There are still a lot of inefficiencies in the system,” she said.

Russell, who recently took on leadership of BP's procurement and supply chain, said the company and the industry is weighed down with acres of warehouse and supply bases filled with aging equipment. Worksites are dominated by manual processes. Software applications are more cumbersome than an iPhone's. Equipment redundancy levels are nonsensical: backups for backups for backups.

With customers, quality, audit and payment systems aren't uniform, but a tangle of different systems, checks and assurances.

“As I walk the line from our end-to-end supply chain, we have massive, massive waste,” she said.

Russell said that such practices aren't sustainable. She noted that the world's recoverable resources are sufficient to match global demand through 2050—twice over.

“With that context, we cannot afford to be complacent on cost in our industry,” she said, adding that it would be equally costly to return to a mentality of booms and busts. “We need to lower costs in a sustainable way.” ■

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Efforts for the Future

■ The University R&D Showcase highlights research projects that offer potential offshore solutions of the future.

BY ALEXA WEST

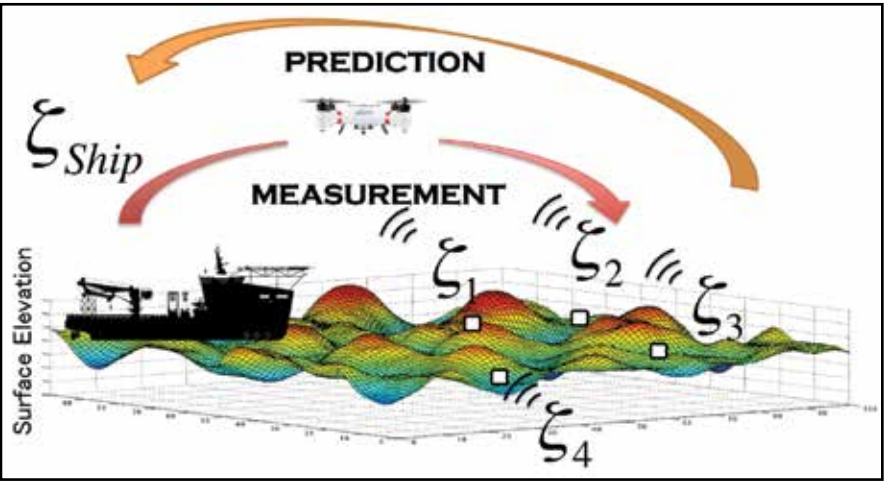
Thirty seconds doesn't seem like a lot of time. Maybe enough to send a text message, order a drive-thru meal or heat up a cup of morning coffee. But in the world of offshore oil and gas operations, 30 seconds can mean the difference between surviving a rogue wave or not.

One project out of The University of Tokyo looks to provide early notification of such waves. It and many more R&D projects from eight other universities are part of this year's University R&D Showcase.

For their Wave on Demand system, student researchers from The University of Tokyo will present on a system that, according to the team, can predict wave elevation 30 seconds before arrival and can be used as an alert

system for crews onboard or as input for feed forward control of heave compensation or dynamic positioning systems. In this case, 30 seconds could be the saving grace for an offshore crew, allowing a vessel to make the necessary adjustments and warn workers to brace for a threatening wave.

The system is a combination of two components, a marine drone for ad hoc *in-situ* wave measurement at the desired point and an algorithm for



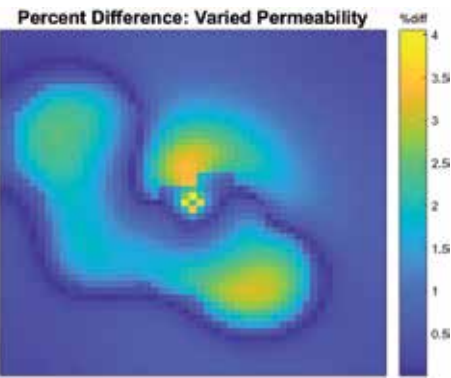
The Wave on Demand system will be presented by The University of Tokyo. (Image courtesy of The University of Tokyo)

wave prediction from multipoint wave measurement. The system was successfully deployed in the coastal region of Japan, and preparation is underway for testing using offshore facilities of Japan and Singapore, according to Ken Takagi, professor for The University of Tokyo and leader of RIO DE UT laboratory.

Student researchers at the University of California, Berkeley will present on their project that is investigating the feasibility of a thermal-hydrological-mechanical finite element simulation coupled with distributed fiber optics strain measurements of the well. Successful methane gas recovery from hydrate-bearing sediment depends on accurate prediction of gas and water production and on minimizing well integrity issues.

According to Kenichi Soga, research team leader and University of California, Berkeley professor, this project will impact the industry by contributing to commercializing methane gas production from hydrate-bearing sediments.

Rice University's student researchers will present their efforts on two flow modeling projects. The first project seeks to quantify the accuracy of agent-based models for single-phase flow in homogeneous and heterogeneous reservoirs.



The cell-by-cell percent error between an agent-based and differential equation model for a realistic oil reservoir permeability field is shown. (Image courtesy of Bryan Doyle, COMP-M at Rice University)

"It is well-known that agent-based models are computationally faster than models using differential equations," said Dr. Beatrice Riviere, Noah Harding Chair, professor at Rice University and team principal investigator of both university research projects. "Comparing the accuracy of these two types of models has never been done,

See **R&D** continued on page 27

A large image showing a worker in a blue uniform and yellow hard hat operating a red industrial machine. Sparks are flying from the base of the machine. The image is framed by a large blue circular graphic. At the bottom, the text 'Maintaining world-class operational performance' is displayed in a large, blue, sans-serif font. The Kuwait Oil Company logo is visible in the upper right corner of the image.

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Preparing the Next Generation

■ A new generation of industry leaders can hone its skills during 2018 OTC.

BY ALEXA WEST

Mock interviews, resume-building exercises and internships are just a few tools used to help prepare emerging professionals for the labor force. Working in an ever-changing industry with new technologies, innovative ideas and market shifts can be daunting for entrants hoping to forge a career in the oil and gas sector.

OTC aims to help prepare the next generation to meet the challenges through *The Next Wave* program, an annual event with the goal of mentoring young industry professionals.

In commemoration of OTC’s 50th anniversary, the program’s 2018 theme is “The Next 50: The Evolution of the Industry.”



Ernesto Cedeño

“We look to reflect on the evolution of the industry in the last 50 years—from new technologies, processes and pushing boundaries to bring energy to the world,” said consultant Ernesto Cedeño, *The Next Wave* session chairperson.

The Next Wave will include two keynote presentations. The opening keynote speaker is Emeka Emembolu, vice president, reservoir development, Gulf of Mexico and Canada, BP, whose presentation will focus on preparing for the future.

“*The Next Wave* participants are the future of our industry,” Emembolu said. “It’s critical for us to support



Emeka Emembolu

from across the industry.

“Our industry is one of change and has been from the start,” he said. “We will need to prepare ourselves technically and professionally to be ready to meet this head on, and if you do it right it can be a very rewarding experience and a force for positive change.”

The Next Wave’s closing keynote speaker is Åshild Hanne Larsen, CIO and senior vice president IT, Statoil, whose presentation will center on the technological shift and how it will transform the industry.



Åshild Hanne Larsen

“The game to transform the industry is on,” she said. “And while technology creates the opportunity set, our ability to realize this potential will depend on leadership, culture and capabilities.”

According to Larsen, this means there always will be a need for talent in the industry, and a competent and flexible workforce will continue to be a key differentiator. She added that *The Next Wave* program is great because it creates an arena where young professionals can share, learn and network with peers.

“I cannot stress enough how important that is,” she said. “Participants get the opportunity to obtain new insights, thoughts and ideas that they can discuss and implement when they return to their workplace.”

She also said that the program provides attendees with an opportunity to develop a network across the industry and exposure to information and tools that can help them succeed.

One practice in particular Larsen has found beneficial to her career is colleague and peer mentorships. In addition, she encourages industry newcomers to develop their careers by volunteering and contributing in industry organizations or programs such as OTC.

“There are many opportunities, but it starts with putting yourself out there and being willing to learn, contribute and share,” she said.

Larsen added that she never has shied away from challenges she didn’t necessarily feel qualified for and encourages young professionals to do the same.

“Sometimes others see things in you that you have not yet discovered yourself,” she said. “I have found that when people throw you in at the deep end, it is not because they want you to drown, it is because they think you can succeed.”

In addition to the two keynotes, *The 2018 Next Wave* agenda features a series of events including a group activity, a networking happy hour and a roundtable session with 24 industry professionals.

The Next Wave program is scheduled for noon to 6 p.m. Wednesday, May 2, in Room 300 on Level 2 in the NRG Center. ■



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Tuesday, May 1 Event Schedule



Merging the Physical with the Digital

Project Execution & Delivery at 1030 & 1430 daily
Development & Visualization at 1130 & 1530 daily



Amazon Virtual Reality Experience

Every morning at 0900, 1000 & 1100
Every afternoon at 1300, 1400, 1500 & 1600



CEO Panel featuring David Dickson

Integrated Offshore Activities, Mega Mergers & Alliances
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Reimagining the Subsea Market

■ New compact subsea tree is designed to reduce overall system costs across the total life of field.

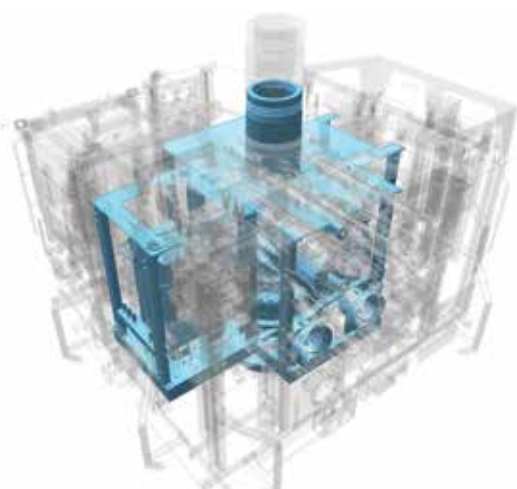
CONTRIBUTED BY BAKER HUGHES, A GE COMPANY

The past few years have undoubtedly been a challenge for operators and oil and gas service companies alike, with scaled-back operations, reduced upstream capex spend and the deferral of many major projects increasingly commonplace. As tough as this period has been, the longevity of this latest downcycle—with its relentless focus on cost-out, efficiency improvements and productivity gains—has forced the industry to create smarter solutions designed to drive a more sustainable future.

The subsea market is no different. Subsea projects must be more competitive in the wider energy supply market. To help customers prepare for the upcycle, Baker

Hughes, a GE company (BHGE) has introduced a new subsea system designed with full life-cycle costs at front of mind. This “TOTEX” mind-set is a shift from the traditional way of thinking that typically addressed one component, such as cost, and instead takes into account the total expenditure over the life of a field while prioritizing component reliability, production availability and the cost and impact of overall system maintenance. Starting with a lightweight compact subsea christmas tree, this technology will be vital in reviving the competitiveness of some basins.

A simpler, more integrated system
The tree is the result of a design study conducted with a major operator aimed at establishing a simpler



BHGE is introducing a new subsea tree concept that packages a lot of performance into a much smaller format while helping to reduce the total expenditure over the life of a field. (Image courtesy of Baker Hughes, a GE company)

and more integrated subsea system, one with the potential to make a significant contribution to lowering life-cycle costs with minimal product development at the component level. A vertical configuration, it incorporates proven products, interfaces, knowledge and innovation, which, when combined, present a differentiated solution that meets the functional requirements of API 17D and satisfies industry standards while offering a significant value proposition through both capex and opex reductions.

Reducing complexity
The system comprises two critical components. The main module, the tree functionality, incorporating reliable and testable well barriers, and the wellhead connector. The second element is the “life of field” tree cap that contains the active, “wear-sensitive” components of the system. It can be configured in multiple ways: a startup cap incorporating a HIPPS configurator, a production mode cap with the choke and sensors (pressure, temperature and sand), and the option for a multiphase flow meter and BHGE’s modular compact pump for later life use to enhance hydrocarbon recovery methods. Integration of these parts into a single assembly, which effectively takes the place of a traditional tree cap, means they can be more easily accessed and retrieved for simpler maintenance and reduced cost over the life of the field when enabling access to the well to optimize hydrocarbon recovery. Further, the tree has fewer valves and the associated hardware is less complex than that of a conventional system.

Reducing capex, opex
The tree does not compromise safety or functionality and, at the same time, offers improved reliability and maintainability. It offers life-cycle cost savings as high as 40% over a 15-year field life for the base case system. This lower system cost can be realized from both a capex and opex standpoint. Reduced capex results from a combination of less hardware and more straightforward interfaces. Opex reduction is principally due to improved

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See **SUBSEA** continued on page 26

Stepping Up Walk to Work Activity

■ Motion compensation technology has unlocked the full freedom of movement between vessels and assets.

CONTRIBUTED BY AMPELMANN

The team at Ampelmann (booth 1425) has plenty of reasons to chill at OTC as the company’s N-type “Icemann” gangway system is one of 17 to win a coveted OTC Spotlight on New Technology Award.

The first Icemann was deployed in August 2017 on the ice-breaking standby vessel *Stepan Makarov*, under a 20-year charter agreement between Sakhalin Energy Investment Co. Ltd. and vessel operator Sovcomflot. It is the first standby vessel in the world to deploy a gangway system of this kind for operations in severe ice conditions and temperatures as low as -28 C (-18 F). More than 23,000 personnel have safely “Walked to Work” on the Sakhalin-2 Field.

The pioneer in global access solutions has recently surpassed more than 4 million people transfers and transported more than 6 million kilograms of essential cargo to offshore oil, gas and wind assets, across 240 projects worldwide. Anniversary celebrations also will be a key feature at the company’s booth to mark a decade of global operations and innovations.

From aerospace to walking space

Using technology inspired by the flight simulator industry, The Netherlands-headquartered company has transformed the vision of “Walk to Work” (W2W) offshore into a reality. Its wide range of motion compensated gangway systems make the transfer of people and cargo offshore a safe and economical alternative to rope, basket and helicopter transportation.

The company has continued to lead the W2W movement with new innovations and enhancements to its existing systems, which bring further operational efficiencies.

For example, the flagship A-type gangway system was the first product to be commercially deployed in 2008. While it is still the most widely used system today, the A-type Enhanced Performance (A^{EP}) gangway system, launched in 2017, responds to demand from the oil and gas industry for a system that can safely operate in higher sea states in regions such as the North Sea and offshore South America and the Middle East.

The A^{EP} gangway system will transfer personnel from Wagenborg Offshore’s second W2W emergency response and rescue vessel (ERRV) *Kasteelborg* to support gas production in the Dutch and U.K. sectors of the southern North Sea.

The six-year contract is with Nederlandse Aardolie Maatschappij (NAM) and Shell UK Exploration & Production.

The system features an advanced motion compensation control system with precision controls to enable fast landing and comfortable people transfers. It is designed to transfer 20 personnel safely and efficiently in less than five minutes and move cargo loads of up to 100 kg with the KIB cargo basket from the vessel to offshore structures. It can operate in sea states up to 3.5 m (11 ft) significant wave height.

The *Kasteelborg* was converted from a standard offshore supply vessel to a specialized W2W vessel in 12 weeks at the Royal Niestern Sander shipyard in The Netherlands.

The dimensions of the A^{EP} are the same as Ampelmann’s original A-type gangway system. However, it boasts the ability to use smaller vessels to obtain similar or even better performance and operational stability. This ultimately saves cost by allowing flexible positioning on the vessel.

Joeri Poelmann, Ampelmann’s manager of sales and business development for Europe and Africa, said, “As NAM/Shell UK is pursuing their strategy to simplify operations

on unmanned offshore assets in the Southern North Sea, Wagenborg’s latest Walk to Work vessel combined with Ampelmann’s A^{EP} will enable workers safe and easy access to carry out essential offshore maintenance activities.”

A new era for offshore transfer

At a time when the oil and gas industry is being pushed to find new and innovative ways of working, particularly in extreme environments, motion compensation technology has unlocked the full freedom of movement between vessels and assets, and as such, has allowed for the most safe and efficient W2W and crew change solutions on the market.

As the industry continues to become more segmented, the ability to tailor gangway system solutions to these markets will be more important than ever. ■



Ampelmann’s A^{EP} gangway system will transfer personnel from Wagenborg Offshore’s second W2W ERRV *Kasteelborg* to support gas production in the Dutch and U.K. sectors of the southern North Sea. (Photo courtesy of Ampelmann)

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Digitalization in Oil and Gas: Adapt or Be Left Behind

■ There is an opportunity to capture value in the face of disruptive risks.

BY PRESTON CODY, WOOD MACKENZIE

To meet the goals of greater productivity and sustainability, companies across the energy and natural resource (E&NR) sectors are embracing digital technologies to help transform their businesses and improve margins in new ways.

The size of the prize is huge. Wood Mackenzie estimates up to \$150 billion per annum could be saved in operating costs across the E&NR sectors (i.e., upstream, refining and metals and mining). In the upstream sector, U.S. shale operators have typically saved up to 10% on drilling and completing wells through the use of digital technologies, primarily through Internet of Things/sensor data, enterprise data management, analytics and automation.

Clearly the benefits of digitalization are real, and companies are realizing significant savings in the near term through focused, incremental changes and optimization of assets. Long term, however, the biggest value will come from transformative and disruptive technology breakthroughs that dramatically increase the commercially recoverable resource base and shift the basis of competition.

Transforming business operations

This transformation will require companies to reimagine the way they operate and do business. Digital transformation is much more than an IT change or the adoption of a new software program or technology. True digital transformation takes time and commitment to organiza-

tional change and new talent. Oil and gas companies are at different stages of this digital transformation journey, and incumbent and dominant players face considerable obstacles due to legacy data challenges, cultural and organizational inertia.

One of the biggest hurdles facing oil and gas companies in their digital transformation journey is data governance and management. There are pockets of well-structured data, but as a whole across the sector those have largely been fragmented across business units, functions and companies (service companies versus operators).

This difficulty in managing the complexity and diversity of data sources and types has led to a proliferation of overlapping datasets within companies and siloed data within teams. Across the data life cycle, myriad tools and standards are being used, creating not only cost in operating separate unique structures but also making the ability to share data across teams and companies laboriously time-consuming.

Long term, for the oil and gas industry to really benefit from data as an asset, enterprise data management will need to be incorporated across the entire value chain. By cleaning, sorting and structuring data, digital technologies will be far easier to deploy and more importantly far easier to scale. From oil producer to oil refiner, data will be a common, consistent language that companies can share and converse into maximize returns.

Cultural challenges pose another big hurdle. As digitalization continues and companies change the way they go about producing oil and gas and refining crude, the face of the workforce also will change. Cultural acceptance is a major challenge to digitalization in the oil and gas industry, which has had a history of conservatism. Employers will have to be sensitive to workers' concerns and uncertainty over roles and new processes, while implementing and scaling digital technologies that the business environment demands and shareholders expect. Getting this change right will be key to delivering lasting benefits from digitalization.

As evidenced by other sectors, the oil and gas industry will be defined over the coming years by those who embrace the digital revolution to evolve and those who do not. To remain competitive, companies must not only look at where they can incorporate new technologies to improve operations but also fundamentally evolve their business models. The key will be capturing margin before disruption affects the price. Those that adopt quickly and at scale will be the ones that benefit the most. Those that do not are more likely to join the graveyard of other obsolete businesses from other industries, such as media and retail, that failed to capitalize on the value of Big Data.

Hear industry leaders discuss these issues during the "Big Data Next Chapter" presentation at 9:30 a.m. on Wednesday, May 2, in Room 306 of the NRG Center. Visit Wood Mackenzie at booth 4079. ■



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Composites Enable Safe, Durable Offshore Repairs

■ Successful installations prove viability of composites offshore.

BY BUDDY POWERS, CLOCK SPRING CO. INC.

When the offshore industry thinks about composites, the tendency is to envision complete structures made of composite materials. But around the world, interest is growing in using composite materials for offshore repairs.

Composite technologies are changing the way corrosion repairs are being executed offshore. Their efficacy has been proven over several decades onshore in pipeline and refinery repairs, and now, they are becoming more common offshore on risers and riser connectors, caissons and large components that have sustained damage in the extremely corrosive seawater/air environment.

Coatings designed for harsh offshore environments provide excellent corrosion protection, but over time, they erode, exposing surfaces to potential harm. When that happens, the most common approach to addressing the resulting damage has been to remove weakened sections of pipe and replace them by welding new sections in place. This approach, while it has been successful, introduces safety risks associated with heavy lifting and welding and is weather dependent. Another consideration to take into account is that when repairs are carried out in this way, production must be controlled or completely shut in, which makes what appears to be a simple and straightforward solution rather costly.



Trained installers using rope access apply filling material to the defect and use adhesive to secure the repair sleeves on an asset in the North Sea. (Photo courtesy of Clock Spring Co. Inc.)

Developing composite solutions

Composites were developed specifically to contend with corrosion, with products specially designed to provide structural reinforcement, leak repair and corrosion prevention. The composite repairs developed by Clock Spring have undergone third-party testing and are endorsed by peer review. These installations, carried out by certified, trained technicians, provide no risk to the environment and require no costly downtime. Because no cutting or welding is required for the installation of these composite products, operations can continue while reinforcements or repairs are carried out.

One of the important distinguishing characteristics of these composites is that they are manufactured under controlled

conditions, where the ratio of glass to resin can be verified. The unidirectional glass strands can be positioned, pre-tensioned and aligned, and the composite can be wound, crosslinked, heat-treated, fully cured and inspected before being shipped to the repair location.

Making repairs using these composite solutions also saves time because the repair kits are delivered to the site with the composite sleeves already assembled.

See **COMPOSITES** continued on page 26



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Impactful Technologies Earn OTC Honors

■ Spotlight on New Technology award winners recognized for innovation.

BY HART ENERGY STAFF

The following companies as well as the six award winners written about in Pt. 1 of this article, which appeared in the Monday, April 30, show daily garnered the 2018 Spotlight on New Technology awards. These technologies represent the latest and most significant advances developed for the offshore industry. (The Monday article included technologies from these winners: Advance Coating Systems; Ampelmann; Baker Hughes, a GE company; Delmar Systems; and Drill-Quip Inc.)



Halliburton provided an integrated drilling service, including the GeoBalance MPD service, to complete its first MPD job in the Gulf of Mexico for W&T Offshore. (Image courtesy of Halliburton)

Halliburton Energy Services Inc. has received an award for its GeoBalance Automated Managed Pressure Drilling (MPD) System, a comprehensive suite of software and hardware enabling automated managed pressure control from drilling to completion. The system combines automatic chokes, rig pump diverters, flow-metering and advanced control algorithms with proven hydraulics modeling to provide accurate pressure control at discrete points throughout well construction. The GeoBalance service can dramatically decrease nonproductive time and reduce drilling days to improve economics in applications where wellbore mechanics prevent use of conventional techniques. For more information about GeoBalance, visit Halliburton at booth 439.



The ALD LWD Service reduces geological uncertainty and refines the earth model by measuring structural dip in real time. (Image courtesy of Halliburton)

Halliburton also has been recognized for its 9½-in. Azimuthal Lithodensity (ALD) LWD Service. The service, from Halliburton Sperry Drilling, is the industry's first large-borehole LWD service capable of delivering azimuthal density, photoelectric and ultrasonic caliper measurements to enhance reservoir understanding and

reduce well time in borehole sizes ranging from 14½ in. to 17½ in. The ALD LWD Service reduces cost and time by eliminating wireline conveyance and optimizes wellbore placement through geosteering. For more information about the ALD LWD Service, visit Halliburton at booth 439.

LORD Corp. received an award for its 10K Completion Workover Riser Flexible Joint. The compact size of the 10,000-psi flexible joint allows smaller vessels to operate a top-tensioned riser without a stress joint or telescopic joint, enabling lower cost high-pressure interventions. When replacing a bottom stress joint, the significantly lower moment on the wellhead enables more workovers per well, extending field life. For more information, visit LORD Corp. at booth 2070.



LORD's flexible joints are rated to 10,000 psi and hydro-tested to 15,000 psi. (Image courtesy of LORD Corp.)

National Oilwell Varco (NOV) has been recognized for NOVOS, which is the industry's only reflexive drilling system, automating repetitive drilling activities, benefiting contractors by allowing drillers to focus on consistent process execution and safety, and benefiting operators by optimizing drilling programs. The NOVOS system provides the ultimate control and consistency for any operation. The NOVOS reflexive drilling system is easily scalable and can augment existing people and processes for greater control, consistency and enhanced performance, or expand all the way to full closed-loop automation. The system provides control and consistency for any operation. It allows drillers to automate repetitive drilling activities, such as making a connection (offshore), coming off and on bottom, with specific parameters for circulation, weight on bit and more. For more information about NOVOS, visit NOV at booth 2839.



Because the NOVOS reflexive system automates repetitive tasks, users achieve better average performance throughout the entire drilling life cycle, regardless of the experience level of the driller. (Photo courtesy of NOV)

The Seabox unit is NOV's base disinfection and sediment settlement unit. (Image courtesy of NOV)



NOV also has received an award for Seabox, a disruptive yet simple concept that makes it possible to treat seawater at the seabed, and thus provide high-quality water for reservoir pressure support to the industry. Driven by the suction pressure of a downstream pump, Seabox provides superior disinfection and sedimentation capabilities without adding chemicals. The current Seabox standard unit will treat 40,000 bbl/ of seawater and is operated and controlled by NOV's proprietary control system. For more information about Seabox, visit NOV at booth 2839.

Oceaneering International Inc. has been recognized for its E-ROV System. The E-ROV is a self-contained, battery-powered ROV system capable of operating for extended periods of time without being recovered to surface. Comprising an electric ROV, 4G connection buoy and subsea cage, the system reduces cost and risk without the need for a surface vessel. The E-ROV system also is capable of performing common ROV tasks including inspection, valve operation, torque tool operation and manipulator-related activities. For more information about the E-ROV System, visit Oceaneering at booth 2060.



The E-ROV System enables operators to intervene faster, keep production online more effectively and perform routine tasks with fewer deployments. (Image courtesy of Oceaneering)

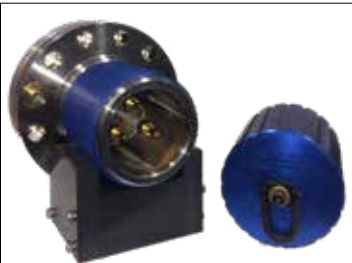
Oliden Technology has received an award for its GeoFusion Laterolog Resistivity and Imaging Tool, which is a drilling, formation evaluation and production optimization solution. It provides high-resolution and high measurement range array quadrant resistivities even while sliding. Augmented by bit resistivity and high-resolution wellbore resistivity images and azimuthal gamma images, GeoFusion offers solutions to drillers, petrophysicists and reservoir engineers. For more information about GeoFusion, visit Oliden Technology at booth 7451.



The GeoFusion 475 was co-developed with CNPC. (Image courtesy of Oliden Technology)

Teledyne Marine has been recognized for its FlameGuard P5-200. The offshore industry's first patented fire-resistant electrical penetrator reduces risk to personnel and assets. The penetrator, rated for 5 kV and 200 A at 5,000 psi, is designed for safe operation in potentially flammable atmospheres where ATEX and IEC Ex standards apply, such as those found on offshore platforms. The penetrator is a key technology element in a 5-kV electrical feedthrough system that provides three-phase power to downhole electric submersible pumps in offshore dry trees. For more information on FlameGuard P5-200, visit Teledyne Marine at booth 401. ■

The FlameGuard P5-200 is a flame-proof ceramic electrical penetrator for use as part of the fire resistant envelope of an offshore surface wellhead and Christmas tree system. (Image courtesy of Teledyne Marine)



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Generating Higher Offshore Profitability by Leveraging Big Data

■ Using actionable insights, operators can kill inefficiency in an engineer’s daily workflow while amplifying the engineer’s intelligence.

BY AMIT MEHTA, MOBLIZE

See **BIG DATA** continued on page 26

As optimism returns to the oil and gas sector and offshore drilling picks up, a concern senior executives have is how to plan and construct wells faster, cheaper and better to ensure optimal profitability. Traditionally, tremendous focus has been directed toward automation and control, which have undoubtedly helped in down-hole tools and machine optimization. Still, many wrong decisions, delayed decisions, opportunities overlooked and underestimating risks are common during offshore well construction. These add tremendously to overall nonproductive time. Consequently, the “elephant in the room” question is why?

Technology makes the difference

The simple answer lies in hidden inefficiencies in human workflows, which have never been measured despite the old saying that only “what gets measured gets done.” In actuality, (a) does it really matter if a field engineer spends two hours creating a daily morning report every day for the office team, (b) does it really matter if a geologist spends one hour preparing for his/her morning meetings, (c) does it really matter if a company man spends 30 min to one hour building the daily morning report? These and many more examples illustrate what is called “human inefficiency.”

The good news is that human inefficiency can be addressed today, not years from now, by applying data analytics to make humans—not machines—smarter. The concept of applying data analytics to make humans rather than machines smarter can be best explained by how the smart phone has collapsed the inefficiencies in consumers’ daily workflows, making most users much more productive.

Looking beyond the smartphone’s basic function of phone calls, this technological device has become a single source of truth. Users can do messaging, send and receive emails, take still photos and shoot video, listen to music and a host of other activities using apps. Users trust the data and insights on the phone display (it doesn’t require scrubbing). Overall, the smartphone has amplified human intelligence tremendously as users can get virtually unlimited answers to daily questions. In short, this makes it a decision platform, not a building platform.

‘Single source of truth’ huge offshore

As a result, to begin revolutionizing the human inefficiency issue, it’s not necessary to reinvent the wheel. The key is to



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Technology Redefines Well Construction Planning

■ A new digital solution maximizes the results from drilling teams in a single, common workspace.

CONTRIBUTED BY SCHLUMBERGER

Since the early days of E&P, industry experts have been innovating technology to handle the ever-increasing requirements of drilling such as higher pressure, higher temperatures and greater depths in a variety of complex geological environments. Pressure ratings easily reach 20,000 psi, and the depth of deepwater wells can exceed 9,144 m (30,000 ft) while horizontal drain lengths are double what they were a few years ago.

Although supplying discrete technologies for these incremental enhancements has produced significant technical advancements, the adoption of a holistic, consistent and collaborative approach to manage the entire well construction process—from well plan-



The DrillPlan solution in the DELFI environment enables seamless collaboration between experts, from the geologist to the drilling engineer and production specialist. (Image courtesy of Schlumberger)

ning and drilling to production and completion—has been missing.

Well construction planning solution

Schlumberger has launched the DrillPlan coherent well construction planning solution, which brings together the drilling technology portfolio with a suite of optimization workflows to create a step change in operational performance.

Deployed in the DELFI cognitive E&P environment—a secure, cloud-based technology environment that combines domain knowledge with advanced digital technologies—the new technology is part of a fully integrated well construction offering that improves the planning and execution performance, efficiency and quality of every well drilled.

Developed with a focus on improving collaboration among multidisciplinary drilling teams and service companies, DrillPlan provides users with access to all the data and science needed in a single, common system. This creates a circular workflow in which plans are improved as new data are added, enabling future drilling programs to benefit from prior experience. With the new solution, better-quality drilling programs are produced rapidly with automated tasks, including trajectory design, torque and drag, anticollision scanning and validation workflows.

The automation of repetitive tasks in the new solution frees up time for domain experts to focus on engineering and other core responsibilities. As changes to the drilling plan occur, the system automatically recalculates the well path and optimal trajectory in minutes rather than days, which ultimately increases planning efficiency. The trajectory is automatically integrated into the shared earth model so the geoscience team can work with the most updated version of the plan. Finally, continuous improvement through validation engines enables the software to monitor the drilling plan for deviations—bringing greater consistency to the well planning process.

The technology demonstrated both quality and efficiency gains while generating hundreds of plans through more than one year of field testing in various locations. Seven oil and gas companies in West Texas and Canada extensively evaluated the solution, customizing it to their well construction process. DrillPlan proved to be comprehensive in delivering well planning programs in days rather than weeks.

Strengthening integration

The DELFI environment leverages digital technologies such as analytics, automation and machine learning to improve operational efficiency and deliver optimized production at the lowest cost per barrel. The environment provides a new way of working for asset teams by strengthening integration between geophysics, geology, reservoir engineering, drilling and production domains. The openness and extensibility of the environment enables the users and software partners to add their own intellectual property and workflows.

Technical presentations about the DELFI environment and DrillPlan will be held at 11:30 a.m. on Tuesday, May 1, and at 11:30 a.m. on Wednesday, May 2, at booth 2415. ■

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Facing the Digital Deluge

■ A new digital operations model is driven by reservoir intelligence.

BY HASSANE KASSOUF, EMERSON AUTOMATION SOLUTIONS

The oil and gas industry is embracing the fourth industrial revolution. In this new landscape, where interconnectivity is enabled at every stage of asset operation, the informational and operational layers are merging. In one use case set to streamline operations, cognitive reservoir models aided by artificial intelligence (AI) and pervasive sensors installed in plants and pipelines send real-time data to the cloud to help implement predictive maintenance and optimize production. But as the industry grapples with digital transformation, a counterproductive trend has emerged. Digital sugarcoating—merely developing IT programs or adding a digital process to existing ventures—risks derailing this transformation. Conversely, genuine renewal requires combining a transformational mind-set for the digital age with industrial platforms that are robust enough to leverage digital applications.

Operational landscape

In post-downturn status quo, budgets favoring opex over capex continue driving the inefficiency elimination market. While there's value in reducing plant downtime, inefficiencies also exist in asset production and completion management.

In 2017, driven by activity in unconventional shale and offshore reservoirs, completion was the second largest expenditure, accounting for over a quarter of the total services market spend. Inefficiencies also exist in artificial lift (95% of wells in the U.S. use some system of lift). With more than a million wells in North America alone, the opportunity is massive. Digital transformation done right is key to unlocking this multibillion-dollar potential.

Which digital transformation?

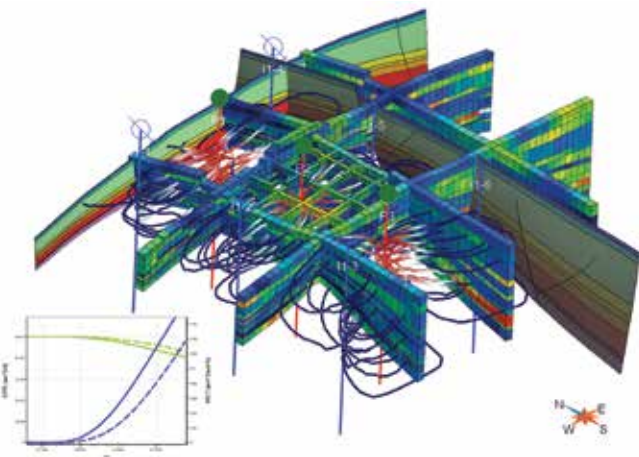
In contrast to digital sugarcoating, digital transformation is organization-wide, requiring a shift in mindset and building an ecosystem with new behaviors, values and decision drivers. Emerson's commitment to help industry partners achieve top quartile performance (in the top 25% of peers) is at the core of this mind-set. In addition to developing customer-centric business architecture, another building block of a genuine transformation, is a revamped digital foundation.

Emerson's investment in digital transformation technologies and services span upstream, midstream and downstream—from subsurface reservoir-driven intelligence, to surface network well control with remote automation, to plant process simulation and control, to the pipeline.

Moreover, the recent acquisition of Paradigm creates, with existing Roxar solutions, the first independent, end-to-end exploration and production software business. Combined with Plantweb, Emerson's Industrial Internet of Things (IIoT) technology and service platform, Emerson can monitor and manage flow from the reservoir to the refinery.

Reservoir-driven intelligence

Emerson's reservoir-driven Operational Certainty is a new digital operation model that joins well and equipment surveillance and predictive analytics with reservoir intelligence for production and completion optimization. It combines Paradigm k, a super-fast flow scenario analysis tool based on reservoir physics, with leading machine



This example of an Emerson Paradigm collaborative 3-D model with real-time updates from flow simulation, production data and geology represents how reservoir-driven intelligence optimizes production and streamlines operations. (Image courtesy of Emerson Automation Solutions)

learning methodologies that enable Big Data inclusive reservoir modeling. This cloud-based, collaborative workflow collects field data and updates the model to forecast performance in real time.

This solution applies advanced computational mathematics to deliver reservoir flow predictions

See **DIGITAL** continued on page 26



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Demystifying the Digital Twin

■ Models mirror the performance and operation of a physical asset or process.

CONTRIBUTED BY SIEMENS

Over the last two years, an increasing number of oil and gas companies have turned to digitalization as a means to reduce costs, improve efficiency and navigate the “new normal.” In the midst of this paradigm shift, one term that has garnered significant interest from operators and producers is “digital twin.” Despite the increased attention, however, there is still a great deal of confusion surrounding what a digital twin is and how it can be used to generate value for organizations.

This article will provide clarity by defining the digital twin, outlining the advanced capabilities it enables and offering insight into how Siemens is using this powerful tool to optimize the asset life cycle.

Defining the ‘digital twin’

Many companies in the oil and gas industry liken digital twins to advanced 3-D models that can be used to aid in the design phase of an asset, but they are far more than that.

Digital twins are dynamic, cross-domain digital models that mirror the performance and operation of a physical asset or process as it moves through the life cycle—from design, engineering, construction, commissioning, and finally, into operation. The digital twin evolves and continuously updates to reflect any change to its physical counterpart, creating a closed-loop of feedback in a virtual, single-source-of-truth environment.

The digital twin is the epitome of the plant digitalization—a virtual copy of an asset (or collection of assets) that is designed to help organizations better understand



Digital twins are dynamic, cross-domain digital models that mirror the performance and operation of a physical asset or process as it moves through the life cycle. (Image courtesy of Siemens)

the life cycle of their equipment and facilities. Harnessing the power of the digital twin affords companies a number of advantages that would otherwise not be possible, including the ability to run risk analyses, health assessments and what-if scenarios on equipment in real time. It also offers the ability to train personnel in a 3-D immersive environment and the capability to detect faults early before control limits are reached.

Digital twin for offshore

In Siemens’ integrated digital life-cycle approach to offshore oil and gas production (i.e., Topsides 4.0) an intelligent digital twin is constructed in parallel to the physical asset during the design and build phases of the project. It consists of two main components: a plant twin and a process twin.

The process twin is a digital simulation of the process and automation system that permits testing of the process and control infrastructure, safety logic and operating procedures before startup. This ultimately reduces time to first oil/gas by shortening the commissioning time for new topsides facilities.

The plant twin is a smart 3-D viewer for the entire topsides that provides access to equipment, maintenance and real-time operations data for construction, commissioning and planning. The plant twin enables operators to better understand the impact of different operating conditions on the process, equipment and maintenance. For example, personnel can view in a 3-D digital space where equipment is located or if it is accessible from the floor. Using the virtual environment, operators can directly access equipment characteristics, maintenance history and documentation by clicking through on the equipment in the 3-D view.

The impact these advanced capabilities have on overall project economics is significant—from three- to nine-month shorter cycle times, \$10 million to \$15 million capex savings, and \$100 million opex savings over a 10-year period.

Tried and tested

One common misconception among many oil and gas industry professionals is that the use of digital twins to reduce costs and drive efficiency is something that remains to be proven. However, Siemens has been capitalizing on digital twin capabilities long before their introduction to oil and gas. One specific example of this is in the design, configuration and operation of the company’s turbines and compressors. OTC attendees are welcome to visit the Siemens booth throughout the week, where virtual stations will be setup to illustrate how the digital twin concept is being used for lifecycle management of these assets. ■

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Taking Water Treatment from Surface to Seabed

■ System provides disinfection and sedimentation capabilities without additional chemicals.

CONTRIBUTED BY NATIONAL OILWELL VARCO

One of the recipients of the prestigious Spotlight on New Technology Award, National Oilwell Varco's Seabox subsea water treatment module, is set to disrupt conventional thinking by taking water treatment from topside to the seabed to the benefit of greenfield developments as well as brownfield production.

The result of 15 years of development in several joint industry programs, and with the support of the Research Council of Norway, the Seabox adds value in many dimensions. With an energy consumption of less than 10 kW, the Seabox has an approximately 50 times lower energy consumption than a surface water treatment plant of similar capacity. The module is located next to a subsea wellhead, which reduces pumping power for injection significantly, thus providing a total reduction in power requirement of typically 15% to 20% and a reduced environmental footprint right from the get-go. Furthermore, the Seabox helps operators increase recovery by enabling optimized sweep and better resource management.

Water injection is the oil industry's most common method for increasing production and recovery rates. Since the 1970s, water treatment systems and injection pumps have been installed on processing decks of offshore platforms, but topside water treatment systems pose several challenges. The treatment equipment and injection pumps on a platform are large and heavy, thus taking up valuable deck space. They are energy-consuming and use significant quantities of chemicals that come with their own HSE challenges. Another issue with topside treatment systems is that such equipment often must be designed, engineered, constructed and maintained long before anyone knows exactly how the reservoir behaves.

Operational flexibility

The inherent flexibility the operator will enjoy by using the Seabox technology is a game-changer in offshore secondary recovery as well as reservoir drainage strategy. The module allows the operator to defer the investment decision on water treatment. It frees up space and reduces environmental footprint. The pretreatment of the seawater provided by the module avoids injection problems such as reservoir pore blockage, souring and scaling and enables recovering of nonmovable oil. The Seabox treats the surrounded seawater at the seabed without additional chemical injection, and the seawater can either be injected into the reservoir as a dump flood solution or the treated water can be pumped to a topside facility, allowing the Seabox to act as a water intake. Adding the Seabox as a water intake to feed existing topside membranes will improve the membrane lifetime and the treatment plan uptime.

The membranes are fed with superior quality water, minimizing biofouling issues. The module also allows for decoupling from topside processes to fulfill operator needs for water injection in satellite fields. A tieback is often short-lived and very marginal. The process of supplying water for injection into such fields is often cumbersome and expensive, with a high-power consumption. The Seabox module can be placed next to the wellhead and only connected to the topside facility via an umbilical, providing the module power and communication.



The Seabox subsea water treatment module takes water treatment from topside to the seabed. (Photo courtesy of National Oilwell Varco)

Finally—and to many, most importantly—it is by its very nature a flexible solution that can be phased in as needed, thus delaying capex and optimizing reservoir management. Valuable acreage can be freed up on newly designed FPSOs and rigs by eliminating the need for a surface water treatment plant, which often stands idle for years but is included to cover any eventualities. With Seabox, these eventualities can be covered as needed.

The Seabox water treatment module is covered by several patents and consists of an 8-m by 8-m (26.2-ft by 26.2-ft by 26.2-ft) chamber with a specially designed electrochlorination

See **WATER TREATMENT** continued on page 26

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FOR A DEMO

Ice Structure Interactions Simulator for Frontier Exploration

■ Technology provides modeling solutions to facilitate responsible production in arctic regions.

CONTRIBUTED BY TechnipFMC

Mastering the risks of extreme ice conditions is crucial to oil and gas exploration in frontier areas. The design of offshore platform structures exposed to extreme ice conditions is a challenge for engineers since there exists few advanced numerical design tools able to cope with structure geometry and ice interaction and failure mechanisms such as drifting ice sheets or icebergs.

In 2012, TechnipFMC, Cervval and Bureau Veritas began working together to develop a new tool for the design of offshore structures interacting with ice, combining a variety of models and approaches such as

analytical, numerical and empirical. Called Ice-MAS (*ice-mas.com*), this numerical tool uses a multi-agent technology to combine in a common framework multiple phenomena from various natures and heterogeneous scales (i.e. drag, friction, ice sheet bending failure, local crushing and rubble buildup). The innovative tool can simulate the ice loadings on a fixed or floating structure by considering its mooring system, the drifting ice sheets, including ridges, and the impact of icebergs.

The software can model predefined structures such as conical, cylindrical, sloping and vertical walls, artificial islands or more complex geometry by user-input files following specific formats. One of the most outstanding

features is its ability to combine these elementary structures to create more complex ones like semisubmersible floaters with pontoon and columns, allowing the software to obtain detailed results on different parts of the overall structure.

The phenomenological approach used in Ice-MAS corresponds to a superposition of physical phenomena modeled in parallel like the contact detection between iceberg or ice sheet, all ice fragments and any part of the structure by the physical engine while the different phenomena solver embedded will detect failure events or calculate the external loads on each entity.

The main objective of this development program is to propose a solution at the early phase of project development allowing structure optimization. The modeling convenience provided by a multi-agent solver allows the user to choose the best-suited model and perform numerous simulations in a short period of time, minimizing ice loadings and ice rubble buildup prior to the final verification in an ice test basin campaign.

Ice-MAS provides modeling solutions that enable oil and gas production in arctic regions to be performed in an economic, safe and environmentally responsible manner. ■

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Industry News

DNV GL Releases New Findings on Industry Safety

New research from DNV GL, the technical advisor to the oil and gas industry, reveals that 46% of senior professionals in the sector believe there has been underinvestment in inspection and maintenance of infrastructure and equipment in recent years. Just a quarter (28%) said that they expect to increase spending on safety in 2018. 61% will maintain current budgets and 5% plan to cut investment.

The findings appear in “The State of Safety,” a special report from DNV GL’s research on the outlook for the oil and gas industry in 2018. Based on a survey of 813 senior sector players, the report also affirms expectations for digital technologies to bridge the gap between long-term cost efficiency and enhanced safety in projects and operations.

While cost efficiency has been the top, or a high priority, for more than 82% of senior industry professionals since 2015, 40% of respondents believe digital tools and technologies have already improved safety over the past three years.

Many new investments in safety will be aimed at digitalizing safety monitoring, processes and responses this year. For example, DNV GL’s MyQRA service draws on data from quantitative risk assessment (QRA) reports to create a single source of safety data that can help all stakeholders better understand important safety signals, make decisions and predict future outcomes.

DNV GL’s report also highlights the risks that implementing digital technolo-

See **NEWS** continued on page 23

Subsea Services



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gies can have on operations, particularly around cyber security. It concludes that existing guidelines and standards may not be sufficient to demonstrate the safety of new concepts.

The company is leading a joint industry project with a consortium of eight companies and two Norwegian universities to tackle the issue. Safety 4.0, due to begin this year, aims to develop a best practice framework to safely and securely introduce new technology solutions to the subsea sector.

Ampelmann Secures Two Contracts Offshore Nigeria

Ampelmann, a provider of safe offshore access to the global energy industries, has secured two contracts with vessel owner L.A.T.C Marine Ltd., on behalf of Exxon Mobil, for the supply of two L-type gangway systems offshore Nigeria.

Following successful sea trials of the L-type gangway system, the integrated solution was approved for operations. Vessel owner L.A.T.C Marine has installed the

personnel transfer system on its Damen FCS-5009 Fast Crew Supplier vessel *Dijama* for infield operations with Exxon Mobil. The L-type is particularly suited to small, crew change vessels and allows a continuous flow of up to 50 personnel every five minutes.

An updated version of the L-type is currently being fabricated and is planned to be installed onboard another Damen-built FCS-5009, the *Chilosco*, to support further maintenance operations offshore Nigeria for L.A.T.C Marine. It is expected to be delivered later this year. ■

PROCESSING (continued from page 1)

“What is exciting about this concept,” Chen said, is that it is a “platform technology,” which has much broader scope for application such as removing chemicals.

The current focus is deep dehydration and low-level CO₂ removal for cryogenic applications. Key enabling mechanical systems have been developed, and pilot studies have confirmed technical feasibility for deep dehydration.

Tom Latta, WorleyParsons Canada/ Advisian, talked about his company’s work on evaluating design considerations to minimize hydrocarbon entrainment. Latta explained the need to determine what valves are driving design, noting that the type of valve is important, but that estimating drop size distribution is critical for trying to get a “realistic” idea of what is going into the system. He presented his company’s work on developing a way to mathematically determine the distribution to improve understanding of what is happening in the system.

While some companies are looking at improvements on a systems level, others are improving components. David Leavitt, Emerson Automation Solutions, told attendees about a triple offset valve that can replace rising stem ball valves in natural gas molecular sieve applications that contends with the challenges of high-cycle frequency, thermal cycling, abrasive particles and corrosion where there is sour gas in the hydrocarbon stream.

According to Leavitt, this valve delivers quarter turn operation with metal-to-metal, torque seated, cone-in-cone seating, in a maintenance-free design that has proven to provide zero leakage.

Kenneth Rosén, ENI Norge AS, presented a new method for process isolation that was developed by Kjetil Aamodt at IK Norway AS. The special pipe clamp is used for sealing lines on pressurized lines.

The main benefits of the design, which Rosén said is the first in the world of this design, is that it enables shorter shutdowns and improved uptime and conforms

to recognized standards. It is field-proven and is available in two versions (one for process segregation and the other to isolate and disconnect). ■



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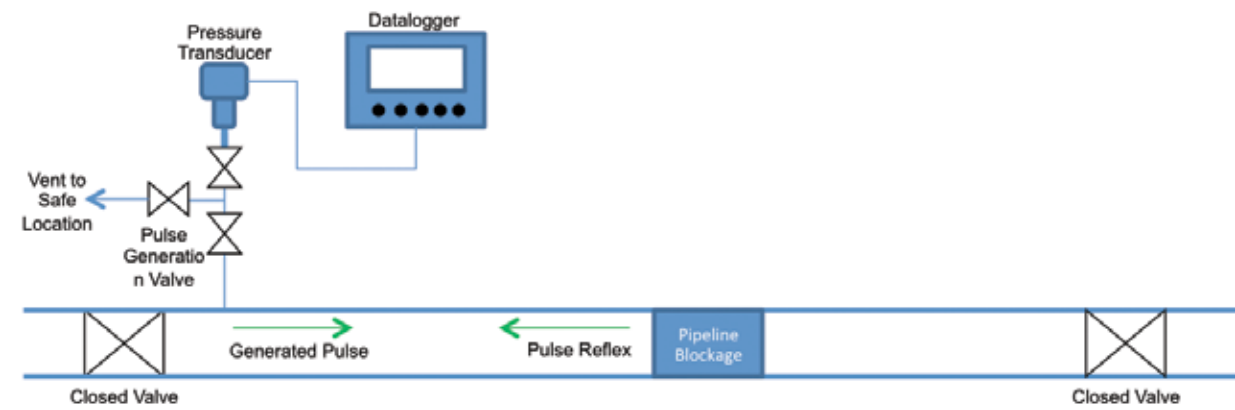
Pressure Wave Analysis Helps Locate Wellbore Deposits

■ Operators can maximize production uptime and throughput.

CONTRIBUTED BY HALLIBURTON

As E&P operators know, maintaining flow assurance through oil and gas pipeline systems is of high importance to optimize production and profitability of assets. However, it is also the source of frustrating challenges as pipeline restrictions commonly develop due to the buildup of wax (or debris) deposits/blockages that can significantly reduce, or even stop, production. The InnerVue PipeSuite diagnostics service—a member of Halliburton’s InnerVue nonintrusive diagnostics family of services—is designed to help mitigate such problems by identifying potential threats to pipeline operations before they require costly damage remediation and/or downtime.

Traditional methods, such as pigging, injection of chemicals and routine cleaning campaigns, go a long way toward managing and maintaining debris buildup inside of pipes. However, none of them are diagnostic in nature or capable of providing preventative/predictive knowledge. Traditional methods mentioned earlier are not always applicable to all situations and each has its limitations in terms of hazards and time to remediate the problem. There is now a proactive “diagnostic” approach to deposit assessment that provides insight and detailed understanding of a given pipeline’s inner flow path, efficiently and cost-effectively. Halliburton’s mix of pressure wave analysis and software technology offers a repeatable and verifiable method of profiling the entire



A typical blockage location data collection setup using pressure wave technology. (Image courtesy of Halliburton)

length of the pipeline, as opposed to excavating small sections to see what’s going on. The use of a “nonintrusive” method, like InnerVue pipeline diagnostics service, eliminates the risk of inserting tools into the pipeline for locating and removing blockages, and avoids other types of invasive onshore/offshore interventions—all of which could cause unnecessary downtime and expense.

This profiling technology uses pressure wave monitoring based on acoustic velocity in combination with pipeline characteristics of flow, pressure and temperature to depict the diameter throughout the length of a surveyable system. By connecting a datalogger to the pipeline near the pressure pulse generation point, changes in pipeline pressure

caused by the pressure wave reflecting from significant geometrical changes in the pipeline can be recorded and its signature displayed on the user’s computer screen.

Case study: Offshore Siberia

Recently, pressure wave technology was successfully applied by a major operator near Sakhalin Island to aid in the assessment and cleanout of a multiphase export pipeline in which a stuck pig severely restricted production. A buildup of hydrates and wax formed a blockage during a new platform’s very first operational pig run,

See **PRESSURE WAVE** continued on page 26

McDermott, CB&I Combine to Create EPCI Company

■ New venture creates a company that spans the entire value chain from concept to commissioning.

CONTRIBUTED BY MCDERMOTT

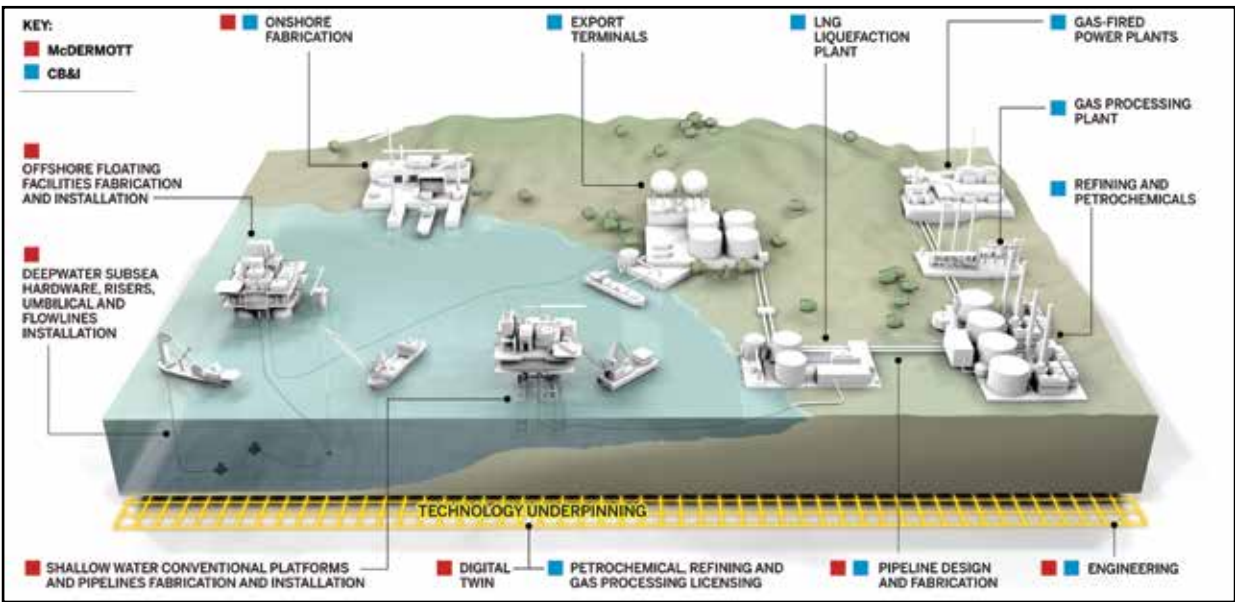
The continued low oil price environment is forcing international oil companies (IOCs) to rethink the way they contract for just about everything.

Traditionally, IOCs developed and contracted onshore, offshore and downstream facilities separately. But continued cost pressures are forcing many IOCs to consolidate procurement across their operations worldwide. The Exxon Mobil Development Co., for example, handles project development and contracting for everything from refineries and LNG plants to offshore and subsea facilities. Many other IOCs, including Shell and BP, are developing similar models.

The proposed combination of McDermott International and CB&I, announced in December 2017, is a direct response to this need for one provider that can offer a single solution across the project life cycle. The combination brings together a global upstream engineering, procurement, construction and installation (EPCI) facilities and subsea company with an established downstream provider of petrochemical, refining, gasification and gas processing technologies and solutions. The venture creates a company that spans the entire value chain from concept to commissioning—offshore and onshore, upstream and downstream.

The all-stock deal to create the combined business, which will keep the McDermott name, is expected to close in the second quarter of this year. The new McDermott will have approximately \$10 billion in revenues and an estimated backlog of approximately \$14.5 billion.

“Customers worldwide increasingly seek a single company that can offer end-to-end solutions, and the combination of McDermott and CB&I responds to these evolving customer needs by creating a leading vertically integrated company,” said David Dickson, president and chief executive officer of McDermott, who will lead the new company. “Together, we will have the integrated technology, engineering expertise, experience and global reach to design and build the energy infrastructure of the future.”



The combined business will offer an end-to-end integrated offering for customers in the energy industry. (Image courtesy of McDermott)

CB&I currently operates in four key onshore market segments including refining, petrochemical, LNG and natural gas-fired power plants and focuses on engineering and construction, fabrication services and technology. CB&I’s technology business, which will continue to operate as a distinct licensing, engineering and after-market services business, will be rebranded McDermott Technology but will continue to use the Lummus Technology brand name for its products.

The 94-year-old McDermott is an EPCI provider of fixed and floating production facilities, pipelines and subsea systems for complex offshore and subsea projects. This combination will unite McDermott’s established international presence, particularly in the Middle East and Asia, with CB&I’s robust operations in the U.S., creating a balanced geographic portfolio with a strong position in high growth developing regions.

The combined company will be headquartered in the Houston area and will be organized by geographic and technology areas.

Despite the planned organizational changes, most of the 11,800 McDermott employees and 26,400 CB&I employees will not be directly affected by this combination. They will continue to focus on their current projects, so customers and suppliers should not expect any disruptions.

Dickson will speak about the combination during OTC on a panel titled, “CEO Panel: Integrated Offshore Activities, Mega Mergers & Alliances,” on Tuesday, May 1, from 2 p.m. to 4:30 p.m. in Room 306 in the NRG Center. Five industry CEOs will join Dickson on the panel. In addition, executives from CB&I and McDermott will also be available at McDermott’s booth 2615 to help answer questions about the combined business. ■

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SUBSEA (continued from page 12)

mean time between failures, a direct consequence of the reduction in hardware and interfaces. Due to the weight reduction facilitated by the compactness of the upper module of up to 40% a lower-cost intervention vessel can be utilized for component change-out. The tree comes with a suite of SMART applications that help support reduced opex through diagnostic and prognostic capabilities, in addition to integrated virtual flow metering.

This technology solution is well-suited to both mature and emerging provinces. As the product family develops further, the portfolio will incorporate 5-in. and 7-in. applications at 15,000 psi, together with a 20-ksi HP/HT solution designed to offer a lighter, smaller and lower-cost solution for moderate to deep and ultra-deep waters. The first tree will be developed for deployment in 2019, in partnership with a major global operator. Visit BHGE at booth 2827. ■

COMPOSITES (continued from page 15)

The sleeves are ready to install, which means the time required for preparation is minimal. A typical installation takes about 30 minutes, followed by the adhesive curing, which takes approximately two hours. Once the composite is bonded to the pipe, it is as durable as the original structure.

Composites at work

Composite solutions have been used in a range of applications in the North Sea, where composite sleeves were used recently to repair a flare pipework bundle that was experiencing progressive degradation and wall thinning in multiple areas. The bundle was in an elevated area where close proximity to other pipework meant access would be tight, but physical constraints were not the only challenge. The operator required the work to be performed quickly to fit into a constrained budget, so the time to carry out the repairs was limited.

Based on defect data provided by the client, engineers delivered a full assessment per ISO 24187 and developed a solution that would meet the client's design life expectations. The resulting Clock Spring repair sleeves were delivered to the site and installed by trained technicians using rope access.

Using rollers to apply filling material in the defect and apply adhesive, the team placed and secured the first sleeve, repeating this process until all the composite sleeves were installed on the damaged section of the flare bundle. When all the layers were placed, installers secured ratchet straps around the shells to keep them in compression until they adhered. Because the sleeves were completely cured in the manufacturing facility, they only needed to dry fully onsite to deliver a reliable and durable repair.

In this and other applications, composites have proven themselves in the offshore environment, delivering successes that are a testimony to their viability for offshore repairs. ■

PRESSURE WAVE (continued from page 24)

just 40 days after it started pumping crude oil, gas and condensate. The resulting low pressure and reduced flow rate were of concern, as further wax buildup threatened to worsen over time. Halliburton worked with the operator to address the complex logistics of this urgent problem, complicated by extreme North Pacific Ocean weather conditions. An end-to-end solution was delivered to the client—from pre-engineering studies to deposit profile assessment to laboratory analysis of production fluids and deposit samples, and also the design, manufacture and testing of a specialized pigging loop for optimum reaming. The InnerVue PipeSuite diagnostics service was key to the positive outcome of this project as pressure waves and datalogging were used not only to accurately assess the thickness and location of the deposits at the front end, but also to monitor the progress of the pipeline clean-out, both during and after the remediation operations were performed. As a result of this advanced technology and thorough engineering approach, the pipeline was restored to its full production capabilities.

A detailed knowledge of the deposition content profile and volume is crucial for pipelines to allow production throughput as effectively and practicably as possible. Visit with Halliburton Pipeline and Process Services engineers at booth 439. ■

BIG DATA (continued from page 17)

replicate and apply the principles of the smart phone to offshore operations. This would entail using an enterprise software growth platform, which serves as a “single source of truth” for engineers. With this platform, users can do planning, daily operations, post well analysis and reporting, thus collapsing the current daily inefficiencies in those tasks.

The platform provides actionable insights to any participant:

- Users can trust the actionable insights, not question them;
- By responding to all the unanswered questions for users instantly, they can act upon and make big judgment decisions instantly, thus dramatically reducing the decision latency. This will result in killing the idle time, wait time and dead time that is hidden and virtually ignored in the human workflows; and
- Users can focus on high-value tasks, such as engineers devoting their workday to actual engineering and the company man focusing on monitoring rig operations not doing daily reports or similar non-productive activities.

Waste mitigation pays big dividends

The way to increase offshore profitability can be viewed from many perspectives, but human inefficiencies have either been overlooked or have not had technology applied to the problem. This is where Big Data accomplishes what has not been possible through humans try-

ing to outthink profitability issues.

By making humans smarter, companies now have a game changer. Using actionable insights derived from Big Data, operators can kill inefficiency in the engineers' daily workflows while amplifying the engineers' intelligence. This gives them power to make better, faster decisions, which ultimately will eliminate them overlooking opportunities, underestimating risks, delaying decisions and disputing decisions, resulting in mitigating risks and nonproductive time for greater profitability. ■

DIGITAL (continued from page 19)

with unprecedented speed. It aids in the design and predictive management of well systems, presenting performance metrics at the resolution of individual wells, enabling truly proactive production and completion management.

Future outlook

Remote asset management and surveillance will remain critical in subsea, deepsea, onshore and remote fields. With digital transformation ramping up, a new automation era will be instrumental in keeping assets up-to-date and reducing risk. The combination of AI-aided cognitive modeling and the power of IIoT, makes it possible to proactively provide the right technology for every asset. While this is set to revolutionize the operational landscape, tackling a fragmented and siloed industry system is a much greater feat, requiring facilitators to converge processes, people and technology. The adoption of a transformational mindset, together with partners who can comprehend and accelerate digital transformation while delivering a compelling business model for the digital era, is now more important than ever. ■


WATER TREATMENT

system, a large settlement tank and a hydroxyl radical generator cell, which combine to remove bacteria and inorganic solids down to 15 μm to 24 μm . Driven by the suction pressure of a downstream pump, the Seabox treatment stages provide superior disinfection and sedimentation capabilities without the need to add any chemicals. It has a capacity of 40,000 bbl/d, which is enough to cover the needs of typically one to two injection wells.

Visit booth 2839 to learn more about this game-changing technology. ■

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to our knowledge. It is our hope that an outcome of this project is to provide a viable alternative to traditional modeling techniques.”

The second project focuses on the development of a computational framework for modeling pore-scale flows on microcomputed tomography images of rock samples.

“Pore-scale flows are important to the oil and gas industry as they enable a correct and robust characterization of multiphase flow through reservoirs,” said Dr. Riviere. “This project is a great example of a successful collaboration between industry and academia. One of the most recent results is the development of new boundary conditions for wettability.”

Research that will be presented at the showcase by students from The New Mexico Institute of Mining and Technology’s focuses on controlled annular mud level (CAML) drilling. This drilling technique uses a submersible pump attached on the submarine riser to adjust the liquid level inside the riser, which controls the flowing bottomhole pressure.

Other universities participating in the R&D showcase include Covenant University, Texas A&M University at Galveston, University of Houston, The University of Oklahoma and The University of Texas at Tyler.

The 2018 OTC University R&D Showcase is scheduled for 9 a.m. to 5 p.m., Monday, April 30, through Wednesday, May 2, in the Level 2 lobby of the NRG Center. ■

IMPACT (continued from page 1)

Eyton said BP has over the last three years added 200 Bbbl to what the company views as the potentially economic resources in the world, which he said is largely due to the discovery of tight and shale plays. BP now estimates 4.9 trillion boe could be recovered using today’s technology.

He added that another 2.4 trillion boe could be added to potentially recoverable reserves by 2050 by emerging technologies. Despite the world’s energy demand far exceeding the availability of energy resources, Eyton explained the need for continued exploration and development for energy resources that are more economically efficient and offer a lower environmental footprint. He said it would take \$600 billion per year over the next two decades to meet the world’s energy demand.

Addressing how technology might affect the future of electricity generation, Eyton said that in North America “wind is increasingly the one to beat.” BP’s “Technology Outlook” estimates that the cost of onshore wind could be about \$25/MWh by 2050.

“When the wind is not blowing, natural gas is the natural candidate to back it up,” he said.

Regarding the future of transportation, Eyton said different drivetrains will likely continue to converge, with electric vehicles likely to compete with their oil-driven equivalents and “light-weighting” vehicles being the single largest source of improving energy efficiency in the world. He added that the application of digital technologies will impact the future of transportation by pushing more self-driving and shared vehicles into the global market.

Eyton said heavy-duty transportation and air transport face the most significant challenges in the move toward energy efficiency, calling aviation “the most difficult of all heavy-duty sectors to decarbonize.”

“If the objective is to move goods and people around at the lowest possible costs then mass transit is a good idea,” he said.

Although significant shifts in the use of energy and transportation through 2050 are evident in BP’s estimates, shifts which

Co’s Bravo production platform experienced an oil and gas blowout in April 1977 that resulted from the upside down installation of its “blowout preventer.” All aboard were safely evacuated but more than 200,000 bbl were released before the well could be capped seven days later.

With the Piper Alpha disaster, the industry was not as fortunate. The U.K.’s largest oil and gas producing platform had an output of 300,000 bbl/d when a gas leak ignited, causing a massive explosion that killed 167 of the 228 workers aboard. It remains the world’s deadliest oil rig accident.

Cement that was not allowed to dry was blamed for the BP Macondo incident in 2010 in the Gulf of Mexico that was the industry’s largest oil spill at 4.9 MMbbl.

Today, the industry relies on technological innovations to, like its onshore cousin, increase efficiencies

and lower break-even prices. Confidence in the future, the speakers said, is supported by the belief that those innovations will continue.

“Our industry thrives today on information,” Lance said. At ConocoPhillips, more than 4,000 members of the workforce are focused on downhole data analysis and putting that information to use. Machine learning by experience, or artificial intelligence, is pushing innovation forward, and blockchain methods connect the data dots and enable a coherent offshore strategy.

OTC, the speakers said, has provided an annual platform for the industry’s minds to gather and trade ideas on how to face the considerable challenges in offshore oil and gas.

“Our industry,” Lance said, “is the poster child for innovation.” ■

IMPACT (continued from left)

are driven by changing costs, Eyton said it’s “much more difficult” to decarbonize the heating sector of energy usage.

“It’s often something people don’t recognize how significant heating and high heat applications are

in the world’s energy systems,” he said. “It’s much easier to decarbonize brand new houses than it is to retrofit improvements for the carbon footprint of heating in homes.” ■

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