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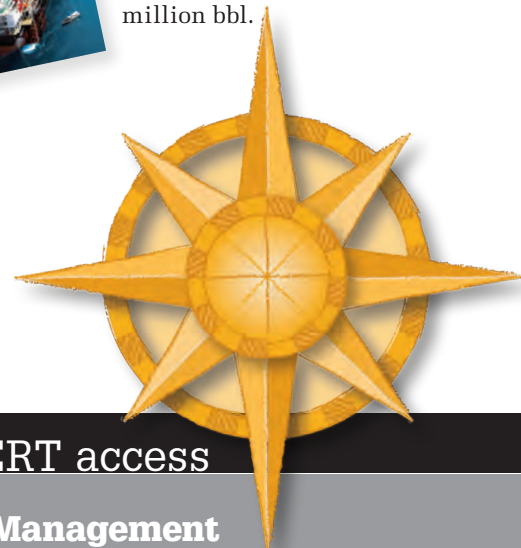
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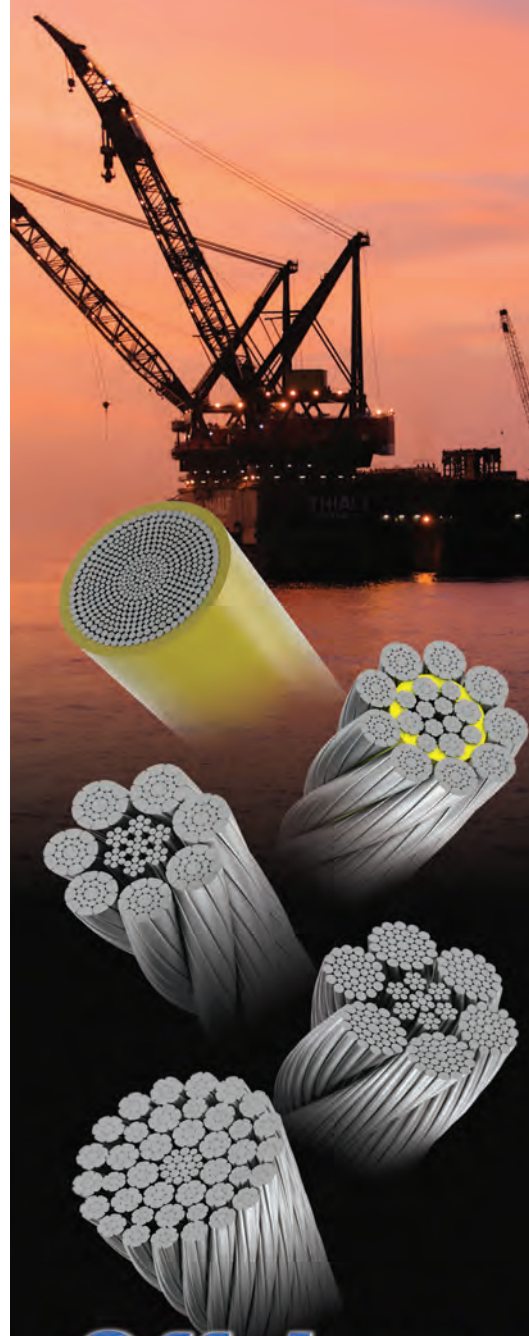
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Libya's evolving business climate
 OE's Elaine Maslin reports on the state of Libya's oil industry following the overthrow of Muammar Gaddafi in 2011.

What's trending

Energy's new era

Energy executives celebrated the oil and gas industry's trend upward at IHS CERAWEEK's 32nd annual conference in Houston.



Transforming PEMEX

Mexico's President Enrique Pena Nieto denied rumors that the state-owned oil company PEMEX will be privatized.



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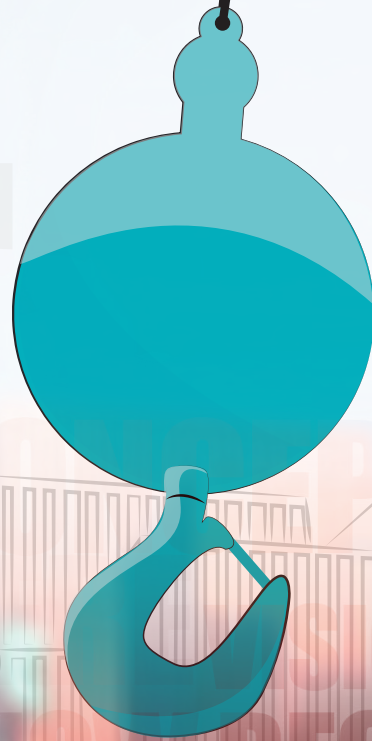


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INCEPTION

THE BEGINNING OF AN IDEA



LIMITLESS

► Renevic Amago

Behind me is our 50-ton crane and containers for offshore and onshore use. It was about three years ago when I started working with Transerve in Singapore with no background in oil and gas industry at all. But through time, patience, perseverance, teamwork, resourcefulness, and experience, gradually my knowledge and exposure improve as I continue to face the challenging world of this industry. As I grow, **OE** is one of the top magazines that is always there to update me on latest news, breakthrough innovations, network, and global interactions.

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Voices

Tech talk. With the 45th Offshore Technology Conference in Houston just on the horizon, OE sought answers to the question, "What emerging technology will have a direct impact on the offshore market?" Our think tank had this to say.



Subsea Asset Integrity, including Non-Destructive Testing (NDT) of assets will have a direct impact on the offshore market. Far surpassing

visual inspection in efficacy, ultrasonic measurements of deepwater installations and Alternating Current Field Measurement (ACFM) for NDT validation are newer subsea asset integrity technologies gaining wider global usage. Other promising subsea asset integrity technologies are in test phases. These technologies may solve currently problematic issues of accessibility and coatings. They could also aid in monitoring of hydrocarbon containment and testing the strength of structures to 4,000 meter water depths. The end goal is predictability and reliability of subsea assets.

Mike Hessel, Asset Integrity Americas Regional Manager, Oceaneering



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offshore E&P companies assess and forecast the performance of wells, facilities, and pipeline systems, improve the efficiency and safety of their operations, and reduce their environmental footprint. It can also provide exploration intelligence on new and potential oil and gas fields and enhance drilling accuracy and production output. **Steve Edwards, global leader, chemicals & petroleum, IBM**



Wireless instruments that protect the integrity of well casings; the annulus B – the space between the casing strings in subsea wells – is one of the few areas out of bounds to offshore operators today. Once the casing is sealed and cemented, operators are unable to access temperature and pressure measurements with no advance warning of a loss in casing integrity or that oil or gas might be migrating vertically towards the surface. That's why new wireless instruments that generate real-time pressure and temperature information from within the well casing represent such an important offshore development with significant implications for safety and well integrity.

Vincent Vieugue, vice president, Roxar Flow Measurement, Emerson Process Management



With mature assets in the UKCS there is focus on Integrity Management and we will see some very **clever technology playing a key part in inspection and maintenance programs ensuring longevity of the ageing infrastructure.** The other area that is growing is the development of subsea processing as more technology is moved from surface to seabed.

Neil Gordon, CEO, Subsea UK



Subsea processing is an emerging technology that will have an impact in 2013 and beyond. Currently, a number of subsea processing units are operational on a small number of milestone projects around the world. This proving ground for subsea gas/liquid separation, gas compression, water re-injection, and boosting is succeeding, and more units are planned. I expect the industry to **accelerate its adoption of this technology, which will help extend field life,** increase reservoir recoverability and exploit more deepwater developments around the world.

Patrick O'Brien, CEO, ITF (Industry Technology Facilitator)



Cold-based pipe connection solutions

– solutions that do not require access to heat, sparks, or other ignition sources, and are characterized by their flexibility, cost-effectiveness, and most important of all, safety. **It's time for the industry to start proactively evaluating new safely-related technologies** rather than opting for more deeply ingrained, disruptive approaches, such as hot-work welding, that come with considerable risk.

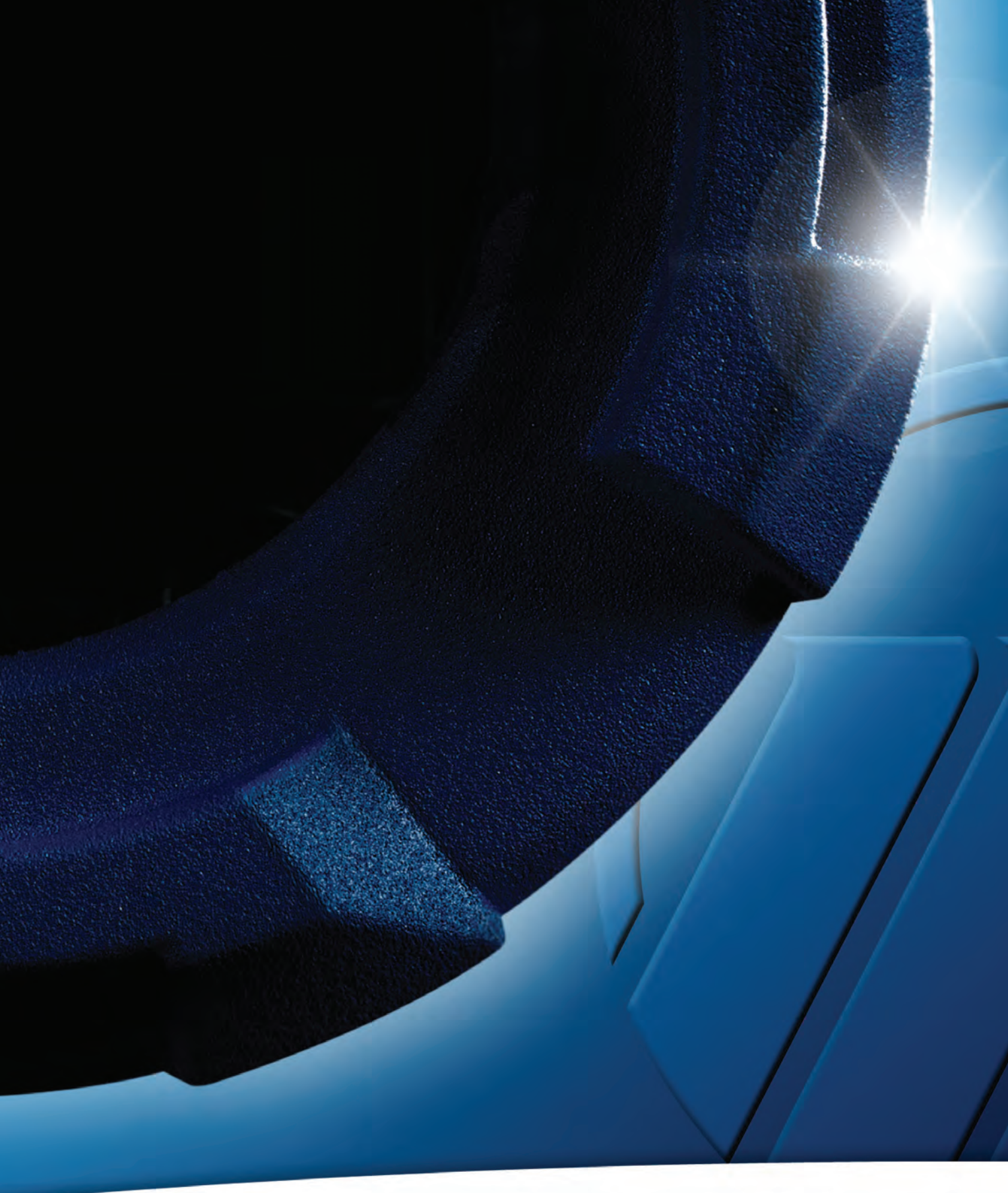
Rune Haddeland, CEO, Quickflange AS



In-well wireless communications has advanced significantly over the last few years, especially for monitoring subsea E&A wells for communication with other wells, once the rig has left a well and adjacent wells are being tested. This information is particularly useful in understanding reservoir connectivity and compartmentalization during any hydrocarbon prospect and field development evaluation.

Daniel More, group technology director, Expro Group

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PUBLISHING & MARKETING

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Shaun Wymes
shaunw@atcomedia.com

President/Publisher

Brion Palmer
bpalmer@atcomedia.com

Associate Publisher

Neil Levett
neil@aladltd.com

EDITORIAL

Editor

Nina Rach
nrach@atcomedia.com

Senior Editor

Victor Schmidt
vschmidt@atcomedia.com

European Editor

Elaine Maslin
emaslin@atcomedia.com

Associate Editor

Audrey Leon
aleon@atcomedia.com

Geosciences Editor

Andrew McBarnet
andrewmcbarnet@dc.rr.com

Asia-Pacific Editor

John Mueller
jrreports@hotmail.com

Contributing Editors

Meg Chesshyre
Bruce Nichols
Jennifer Leahy
Jeannie Stell

ART AND PRODUCTION

Production Director

James W. Self
jself@atcomedia.com

Design and Layout

Bonnie James
bjames@atcomedia.com

CONFERENCES & EVENTS

Events Manager

Sandy Basler
sbasler@ieimail.com

Exhibition/Sponsorship Sales

John F. Lauletta, Jr
jlauletta@atcomedia.com

PRINT

RR Donnelley & Sons, Pontiac, Illinois, USA

EDITORIAL ADVISORS

John Chianis, *Houston Offshore Engineering*
Susan Cunningham, *Noble Energy*
Marshall DeLuca, *Wilson Floating Systems*
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Nina Rach

Colloquy

Drivers of change

The IHS CERAWEEK conference took Houston by storm in March, with a solid program of topical breakfast discussions, illustrious keynote speakers, plenary sessions, and dialogues. The energy topics ran the gamut, from upstream to downstream, investment and finance to cyber threats.

IHS vice chairman Daniel Yergin opened the conference with Saudi Aramco president and CEO Khalid Al-Falih delivering the opening keynote. As conference chair, Yergin described the theme, “Drivers of Change,” as representing new technologies, sources of energy, and shifts in global demand. Innovation will be a constant; expected to drive down costs, improve output, and help shape the energy mix of the future.

Upstream growth

The boom mentality was riding high on sustained high oil prices and success with the new abundance of

unconventional oil production in the US. Natural gas was discussed with exuberance, particularly natural gas liquids (NGL) and global LNG, despite depressed prices in the US.

There were sobering discussions of industry challenges: tightened regulations, demographic shifts, building staff and the big crew change. J. Michael Yeager, CEO at BHP Billiton Petroleum said, “We’re in a tight and delicate market for talent,” during the Upstream Growth plenary.

Yeager was bullish on working in North America, saying that the US has a unique combination of favorable characteristics, including the “world’s largest gas market,” supportive regulators, attractive fiscal terms, and rig and service availability. “Fiscal terms change rapidly outside the US and Canada,” he warned. BHP is the fourth largest acreage holder in the US Gulf of Mexico, and has had four rigs

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operating there for 6-7 years. He said the average Gulf well costs \$180 million to drill and produces about 20,000 bo/d.

Tim Dodson, EVP of global exploration at Statoil, agreed that the upstream sector was growing and acknowledged that we're in a period of increased optimism. He attributes the rejuvenation of exploration opportunities to high oil prices and technology developments. The three pillars of opportunity for Statoil are in mature provinces (Norwegian shelf), complex offshore, and unconventional. "Innovation and tolerance of risk are the drivers for success," he said.

The complex offshore includes the pre-salt in the Santos and Campos basins off Brazil, gas fields off East Africa, and ultra-deepwater fields. He pointed to Statoil's two giant discoveries in the Barents Sea and the giants found off Tanzania as recent successes with new 3D acquisition geometries and processing algorithms.

"Technology can be a black swan," said Dodson, "turning things upside down and presenting a very different picture. The US may become a net exporter—the opposite of a few years ago."

Peter Jackson, VP of upstream research at IHS, mentioned the likelihood of increased automation, including robotics in offshore exploration and production.

New approaches are critical. In 2010, more than two-thirds of all oil brought onstream was discovered before 1980, Dodson noted. In 2012, just 29% of oil produced was replaced with new resources. Gas is obviously different, and will need to be a bigger part of the future energy mix, he said, channeling Churchill: "For myself, I'm an optimist. There doesn't seem to be much point in being anything else."

Dodson stressed collaboration, saying there will be more, not less, particularly in Arctic exploration and development. "Industry needs to explore and develop new business models and must share common costs."

Africa

Among the pre-conference summits was the Africa Energy Summit, at which the BG Group mentioned they had created a new model for Tanzanian gas potential. The following day, Natznet Tesfay, head of Africa forecasting for IHS, was asked about Tanzania's ability to develop a gas plan. Tesfay said the country's delay in discussion has also delayed its fourth licensing round, and the issues revolve around education, labor force, government stability, and the young population. It will take years to work out the master plan, he said, because of the need to electrify and improve other infrastructure and human capacity.

"For myself,
I'm an optimist.
There doesn't
seem to be much
point in being
anything else."

- Winston Churchill

Tesfay was among five IHS specialists who anchored an Expert Briefing session on Africa. Another was Catherine Hunter, senior principal analyst for the Levant and North Africa, who stressed the importance of localism and popular support for projects to succeed. West Nile Delta developments could supply 20% of Egypt's domestic demand, but projects are delayed because of popular dissatisfaction with onshore processing facilities, leading to more than two years of delays. The opposite problem occurs in Tunisia, where locals want onshore facilities in their areas. In a bid for greater local content in northern Africa, she said there are great opportunities for service companies in joint projects. Governments are keen to harness benefits of oil and gas development

through taxation and ambitious infrastructure plans. Changes in capital gains taxes began in Uganda, spreading to Mozambique, Tanzania, and further afield.

Laurent Ruseckas summarized the session: much acreage is available in Africa on relatively favorable terms; there are above-ground risks, with the potential of the Arab Spring spreading; localism can make or break projects and operators need to develop popular support for their endeavors to succeed; there is still a need to build local regulations, as currently seen in Tanzania.

See more of our staff coverage of IHS CERAWEEK online at OEdigital.com.

Venezuela, Caribbean

The week was also marked by the death of Hugo Chavez on March 5, the immediate impact of which included a larger than expected crowd at the IHS expert briefing session on "Latin America: A New Beginning." We have yet to see the impact on Venezuela's petroleum production, but the future of the PetroCaribe program is at stake, raising tensions in the 17 Caribbean nations that benefit from the below-market pricing on Venezuelan crude. The bulk of the subsidized oil goes to Cuba, elections are scheduled for April 14.

The threat to supply and continuing high oil prices are refocusing attention on Caribbean drilling opportunities—beyond Trinidad. We may see more deepwater drilling off Guyana and Suriname, a third well off French Guiana, and potential drilling off the coasts of Barbados and Jamaica, in addition to a resurgence in drilling off the Bahamas.

Team OE

I'm pleased to announce that Elaine Maslin debuts in this issue as our new European Editor, based in Aberdeen. She has been covering the industry as an energy reporter at Aberdeen's *Press and Journal*, and previously honed her skills as business editor at the *Eastern Daily Press*. Welcome to the team, Elaine! **OE**



Bob Dudley, BP CEO

ThoughtStream

Risk comes in many forms, but it has to be challenged,

For many years it's been clear demand is rising – and that trend has stayed consistent – but there has been a lot of change in where the supply is coming from.

BP estimates that global energy demand is likely to grow by more than a third between now and 2030. According to the projections we make in our *Energy Outlook 2030* publication, emerging economies such as China and India are likely to account for almost all that growth – over 90% of it.

Non-fossil energy – nuclear, hydro, biofuels and other renewables – will grow faster as a group than any fossil fuel. But they start from a very low base and will only provide, on a combined basis, about a fifth of all energy in 2030.

Gas will be the fastest growing fossil fuel at around 2% annually. It's clean, cheap and increasingly available. Oil will grow more slowly, at less than 1%/yr. But that still means the world will need around 16 mm b/d more in 2030 than today. That increase alone is nearly the combined daily 2011 production of Russia, Canada, and the United Arab Emirates.

Thanks to new frontiers such as shale and the deepwater, our industry is now producing an enormous amount of previously unreachable oil and gas. At current consumption rates, the data suggests the world has 54 years'

worth of proved oil reserves and 64 years' worth of proved gas reserves in place – and more will be found.

So we are working in a world with ever more diverse sources of supply – and diversity of course increases energy security by avoiding over dependence on any one source.

Thanks to new frontiers, our industry is now producing an enormous amount of previously unreachable oil and gas.

However, this diversity comes at a price. Many of the new supplies are in places that are hard-to-get at: shale oil and gas, tight oil and gas, heavy oil, the deepwater – and, in due course, the Arctic Circle.

And the physical and technological risks are not the only ones. Other factors range from fiscal regimes and other policy-related issues, to geo-political tensions and even the risk of terrorism.

We at BP were brutally reminded of that fact a few weeks ago, when four of our employees and

colleagues from other companies were murdered in the terrorist attack on the In Amenas gas plant in Algeria.

Our thoughts are very much with the loved ones of those who died, from BP, Statoil, JGC, and other organizations. And our sincere gratitude goes to all who have offered support and sympathy. In particular, I would like to thank the Algerian Energy Minister, Youcef Yousfi. His personal involvement during the crisis was outstanding and greatly valued.

BP and Statoil staff, and the contracting companies, are incredibly resilient and committed people and we will go on. We will never forget, but we will go on with our mission of providing energy to the world. We have spent over 100 years producing energy in tough surroundings and we will not be deterred.

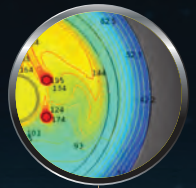
But the new opportunities bring new challenges, and we need constantly to develop our technology, capability and risk management. **OE**

Bob Dudley has been BP's group chief executive since 2010. He previously served as CEO of TNK-BP from 2003-2008 and was named a BP executive director in 2009. He has earned degrees in chemical engineering from the University of Illinois, and an MBA from Southern Methodist University.



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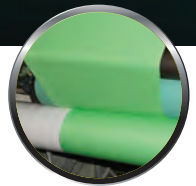
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Global Briefs

A Pangea LNG to export from Texas

The US Department of Energy granted Pangea LNG (North America) Holdings, long-term, multi-contract authorization to export up to 8 million tonnes per annum (mtpa) of LNG to free trade agreement nations from its south Texas LNG Project. Pangea LNG is authorized to export LNG produced from domestic gas fields for a 25-year term.

B Light oil discovery

Karoon Gas Australia encountered light oil at the Kangaroo-1 explora-

tion well on block S-M-1101 in the Santos Basin off Brazil. Karoon drilled the Kangaroo prospect to 3049mRT. Mudlog, wireline petrophysical and MDT pressure data confirmed the presence of a 25m oil column in the Eocene. Karoon estimates that the trap holds a potential gross hydrocarbon column of about 350m.

C Falkland seismic

PGS vessel *Ramform Challenger* began gathering London-based Borders & Southern Petroleum's 3D seismic program off the Falkland Islands in the South Atlantic. Located

about 140km south of the Falkland Islands and covering more than 1000 sq km, the survey is in Quad 61, next to the company's 2007/08 3D survey. Acquisition will take about six weeks to complete. The program will evaluate fault/dip

closed structures, tracking Darwin reservoir sands.

D Cairn explores off Malta

The government of Malta



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ern North Sea York gas field. The field 40km east of Humberside in 45m of water and is expected to produce about 120mmcf/d of gas at its peak. Gas will be exported via pipeline to CSL's terminal in Easington, East Yorkshire, UK. Drilling is underway on a second well.

F Expansion pact

ExxonMobil and Rosneft signed an addendum to their 2011 strategic cooperation agreement extending ExxonMobil's access to seven new exploration blocks in the Chukchi, Laptev, and Kara Seas, an area of about 600,000 sq km. Rosneft gained the option to pick up 25% of the Point Thomson Unit on Alaska's North Slope. ExxonMobil and Rosneft

awarded blocks 1, 2, and 3 of Area 3 to Capricorn Malta, a subsidiary of Edinburgh-based Cairn Energy. The blocks are north of Malta and total

6400 sq km. Capricorn Malta will reprocess existing 2D seismic data, acquire and process 1500km of new, 2D seismic data, conduct a study,

and assess the exploration potential of the acreage.

E York field flows

Centrica Energy has started production on its south-

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Contract Briefs

Palfinger Dreggen has been awarded a contract for the delivery of 28 cranes to Sembcorp Marine's subsidiary Jurong Shipyard. The contract includes the supply of cranes for seven drillships to Sete Brasil, scheduled for delivery 2014-17.

Keppel Offshore & Marine's subsidiaries won two contracts worth S\$200 million (US\$161.5 million) from repeat customers. Keppel Fels Brasil's contract is with MODEC and Toyo Offshore Production Systems, to integrate the topside modules of an FPSO unit. In Singapore, Keppel Shipyard has been engaged by SBM Offshore to fabricate an internal turret for a newbuild FPSO, to be installed in the Ichthys field, offshore Australia.

Aker Solutions has signed a contract with Statoil for the supply of a subsea production system for the Aasta Hansteen field development project on the Norwegian Continental Shelf. The contract value is about Nkr2 billion. The work includes three template-manifold structures, seven subsea trees, wellheads, controls, workover, and tie-in systems.

Heerema Fabrication Group's Vlissingen yard (Netherlands) signed an EPC Letter of Award with Statoil for a 16,000 ton launch jacket and 155 ton pre-drilling module for the Dagny field development in the central North Sea.



Baúna starts producing

Petrobras began producing at Baúna field, in the southern Santos Basin, off Brazil. The FPSO *Cidade de Itajaí*, which arrived at the field in December, was connected to well 9-SPS-88. That well is estimated to produce up to 12,000b/d. Over the next few months, Petrobras expects to connect ten more wells – five production, four water injection, and one gas injection to the FPSO, and reach peak production in August. The FPSO can process 80,000 bbl of light oil (34°API) and 2mmcm/d of gas. It is anchored in 275m of water, 210km off the coast.

plan to conduct a joint study on LNG development in the Russian Far East.

PSVM production starts

BP began production from the PSVM development in block 31, off Angola. Three wells at the Plutao field are expected to increase production at PSVM to about 70,000b/d of oil. Output will increase to 150,000b/d once Saturno, Venus, and Marte fields come online later this year and next. Forty production, gas, and water injection wells will be connected to the FPSO through 15 subsea manifolds and associated subsea equipment.

Sidetrack confirms discovery

Panoro Energy found 20m of oil pay in a sidetrack to its earlier Tortue pros-

pect discovery in Dussafu Marin PSC, offshore Gabon. The discovery well, Dussafu Tortue Marin-1 (3430m TD, 118m water depth), found oil in the pre-salt Gamba and Dentale reservoirs. The confirming sidetrack, DTM-1ST1, found pay in the Dentale reservoir southwest of the original well, but with better reservoir character. It is currently being appraised.

Mountain lair to enter service

Norwegian Ministry of Defense approved the sale of Olavsvern naval base, 20km outside of Tromsø, to investor group Triko, which includes Odfjell Drilling, PSW Rig Service, private investors. In cooperation with Petro Support Group, Triko will convert the base to an offshore service center. The property has a subma-

rine dock, a 25,000 sq m facility carved out of a mountain with tunnels for direct access to the sea, and a helipad.

KG D6 investment

Reliance Industries and BP plan to invest US\$5 billion in deepwater gas development of the KG D6 block over the next three to five years. The plan proposed will develop about 4tcf of discovered natural gas reserves. The partners plan to optimize KG D6 through compression and water handling. BP expects to begin a drilling program to test a deeper reservoir.

South Kecapi find

Salamander Energy found oil and gas pay at its South Kecapi-1 DIR/ST exploration well in the Botang PSC in the North Kutei basin off Indonesia. The well found a combined 40m of net oil and gas pay in high-quality, stacked, Pliocene channel sandstones. A drill stem test flowed light oil at a rate of 6000b/d (constrained) and 8mmcf/d of gas.

Diamond Offshore's *Ocean General* semisubmersible drilled the well to 2102m TVDSS.

Tender rig sale

Norway's Seadrill completed the sale of its tender rig business to Malaysia's SapuraKencana Petroleum for \$2.9 billion. SapuraKencana will acquire all the tender rigs in Seadrill's fleet except for the West Vencedor, T15, and T16.

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Analysis

Working with quiet efficiency

With increased focus on the negative impact of subsea noise on the marine environment, regulators are considering action. Until then, different stakeholders are working together to develop a range of technical solutions to manage the issue. Mark Fuhrmann reports.

Over the past decade, regulators have sought to manage the impact the shipping industry has on the environment by introducing legislation covering ballast water treatment, restrictions on substances used in marine coatings and carbon emissions, among other issues. However, while subsea noise has long been recognized as a threat to marine life, there has been little action to manage the issue.

That may be changing. Last year, the IMO's subcommittee on ship design & equipment established a correspondence group on reducing commercial shipping noise through non-mandatory technical guidelines. The committee identified four focus areas for noise reduction: propulsion, hull design, onboard machinery, and operational modifications. In Europe, the EU Marine

Strategy Framework Directive is working with university researchers to assess noise pollution and define baseline levels of underwater noise. Once complete, the EU hopes to introduce legislation setting standards to reduce noise levels by 2020. At the same time, the US-based National Oceanic & Atmospheric Administration (NOAA) is working on a global project to document human-generated subsea noise to create the world's first sound maps.

Specialist field

In the meantime, most of the work to develop quieter ships so far has been driven by owners with commercial or scientific incentives to reduce subsea noise. According to DNV's Kai Abrahamsen, principle engineer (noise and vibration), interest in this

specialist field is growing. "Our work in this area has been confined to vessels active in seismic surveys, scientific research, commercial fishing, and government-related naval projects. But we have also been engaged by energy companies, who seek to shield sensitive acoustic instrumentation related to subsea construction and communications from underwater noise," he says.

"We are encouraged by NOAA's focus on subsea noise and statements made by the IMO and the EU suggesting that action may be taken to apply new standards for merchant vessels, which produce the most noise."

Abrahamsen explains that low frequency sound waves can travel for hundreds of kilometers underwater before they dissipate, upsetting the highly evolved hearing

abilities that fish and sea mammals (especially dolphins, whales, and seals) rely on to hunt and communicate. “Reducing noise and vibration can be a complex engineering challenge, but we are seeing specialists in different areas working together to develop some highly innovative technical solutions,” he says. “A lot of subsea noise generated by ships can be traced to propellers, but some industry players are turning their attention to another significant contributor – engine vibration.”

Water is an efficient conductor of sound, and engine and propulsion noise is amplified by a vessel’s hull. Underwater noise results from airborne noise, which is generated from the machinery to the structure of the vessel, and structure-borne noise, which is generated from the vibrations of the machinery to the hull of the ship. To minimize this noise, engineers must consider a broad range of issues, including engine and generator mounting systems, base frames, materials and the position of isolators.

Propulsion systems

One company working with noise and vibration is Pon Power Scandinavia, a leading distributor of Cat and MaK marine propulsion systems. In 2008, Pon Power began work on a mounting system designed to isolate engine vibration of high-speed gensets. According to Pon Power’s area



Vessel noise can interfere with the hearing of fish and sea mammals, upsetting their hunting and communication. Research is being conducted in order to define baseline levels of underwater noise.

service manager, Øystein Skår, the development of the Genflex system was driven by the increasing power density of generator sets. “Over the last decade, engine output has been increasing. As a result, generators can no longer survive the mechanical noise and vibration produced by many of the new, more powerful diesel engines,” he says. “We identified a market for a mounting system that could reduce noise and vibration and be flexible enough to work with generators manufactured by different suppliers.”

Pon Power developed a system where the generator is rigidly mounted on easily adjustable chocks, and flexible mounts are fixed between the engine and base frame. Introduced in 2009, the Genflex concept has attracted significant industry interest. “The development process brought us into contact with a number of noise and vibration specialists around the world and has enabled us to carve out a strong reputation in a growing market,” he

says. “This has led to our participation in some interesting projects within noise and vibration.”

In 2008, Pon Power was asked by Siemens to provide generators for a diesel-electric powered research vessel under construction at the Jong Shyn Shipyard in Taiwan. Ocean Research Vessel (ORV) *Aerial* was ordered by Taiwan Ocean Research Institute to monitor sea life and perform acoustic surveys and high-resolution imaging of the seabed, among other tasks. To meet standards set by International Council for the Exploration of the Sea (ICES), the yard contacted DNV and the US-based company, Noise Control Engineering, to work with Siemens to ensure the vessel fulfilled the underwater noise requirements by reducing the vibrations and mobility levels of the gensets.

Jeanette Jonasson, project manager for Pon Power Scandinavia, says the company assembled an international team to get the job done. “Our first

challenge was to perform a lot of calculations to determine the optimal position and calibration of the mounts, isolators, and base frame,” she says. “To get it right, we relied on other specialists to arrive at a good solution.”

Oriantek, a US-based company specializing in power train vibration and acoustic engineering, provided critical high-end dynamic analysis and layout schematics, including connections between engine and alternator and related pipe work. Jerry Vietinghoff, a 20-year veteran in the world of noise and vibration, says that the two companies have a long working relationship. “Oriantek supported Pon Power’s development of Genflex and has worked with Caterpillar on a number of noise and vibration projects over the years,” he says. “It is a real advantage to work with familiar faces who know what they are doing.”

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Isolators

Jonasson says Oriantek's work led to a unique solution. "We selected highly flexible and resilient engine mounts and seismic masses in a three-stage isolation scheme and added a flexible coupling between the engine and the generator," she says. "By placing isolators between the base frame and the blocks, and the blocks and the foundation, our calculations indicated that we could reduce vibration levels significantly, especially between the rotor and stator." The design also included the addition of an extra mass of 15 tons below the flexible skid to further reduce vibration to the hull.

Pon Power turned to Christie & Grey, a leading manufacturer of precision anti-vibration and isolation mounts. Patrick Bergin, lead engineer on the project,



Recently launched ORV *Aerial*, was designed to ensure it fulfilled underwater noise requirements.

says the company applied its proprietary design software to calculate the natural frequencies and response to seaway motion of five different masses (the diesel engine, the alternator/base frame, and three cast iron blocks) to properly design the resilient mounting system. "We had worked on three-stage systems in the past, but never one that accounted for so many masses and frequencies," he says. "I've worked in this field for many years and believe this system

is not only unique, but represents a big step forward in structural noise control." The calculations were then completed and verified by the shipyard.

After more than a year, the team assembled at Pon Power Scandinavia's facility in Esbjerg, Denmark for the Factory Acceptance Test (FAT). Other participants included a large delegation from Taiwan, including government officials and shipyard personnel, and representatives from

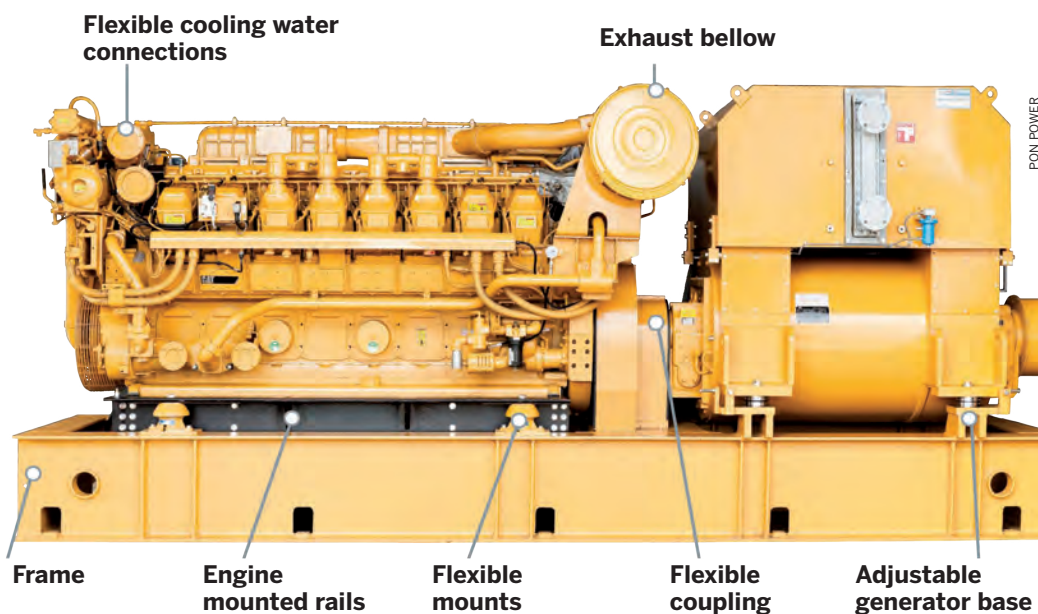
Siemens, Oriantek, Christie & Grey, and Noise Control Engineering. DNV was also present to verify that the solution complied with ICES. "The test won approval and, save for a few minor adjustments, the project was a complete success," says Jonasson. "Members of our team were on hand during installation and were very impressed by the care the yard had taken on the foundation," she says. "This was one critical part of the project we did not control, but they did a fantastic job."

Working together

Launched in 2012, the ORV *Aerial* completed sea trials and is now in active service. DNV's Abrahamsen, who followed the development process from beginning to end, says that demand for innovative technical solutions to manage noise and vibration will continue to rise. "Increasingly, noise and vibration have been included in environmental impact studies for coastal projects. Also energy companies with operations at sea have started to apply stricter requirements on underwater sound for offshore support vessels," he says.

"This project is a good example of how different industry stakeholders can work together to develop innovative solutions that, pending more action from regulators, will have a positive, long-term impact on fragile marine eco-systems all over the world." **OE**

For the ORV *Aerial*, Pon Power engineered three CAT 3512C gensets to reduce excitation from the diesel engine into the genset using resilient mounts and seismic masses in a three-stage isolation scheme. Noise isolation and damping was done at the points indicated.



Quick stats

OE's at-a-glance guide to offshore hydrocarbon reserves and key offshore infrastructure globally is updated monthly using data from leading energy analysts Infield Systems (www.infield.com).

New discoveries announced

Depth range	2010	2011	2012	2013
Shallow (<500m)	93	104	70	6
Deep (500-1500m)	29	23	22	0
Ultradeep (>1500m)	30	20	34	5
Total	152	147	126	11

Note: Operators do not announce discovery dates at the time of discovery, so totals for previous years continue to change.

Reserves in the Golden Triangle

by water depth 2013-17

Water depth	Field numbers	Liquid reserves (mmbbl)	Gas reserves (bcf)
Brazil			
Shallow	31	3,880.75	2,180.00
Deep	18	3,810.00	2,505.00
Ultradeep	44	14,232.45	21,290.00

United States

Shallow	20	94.95	1,223.50
Deep	28	2,031.87	2,180.78
Ultradeep	27	3,576.75	4,040.00

West Africa

Shallow	152	3,444.60	18,742.81
Deep	46	5,735.00	6,440.00
Ultradeep	18	2,750.00	3,060.00
(last month)	353	35,675.62	59,482.09
	(390)	(43,238.32)	(65,502.09)

Greenfield reserves 2013-17

Water depth	Field numbers	Liquid reserves (mmbbl)	Gas reserves (bcf)
Shallow (last month)	1370 (1367)	80,529.39 (79,451.73)	839,326.52 (832,101.61)
Deep (last month)	178 (182)	15,540.74 (18,261.24)	98,551.48 (111,621.48)
Ultradeep (last month)	110 (109)	21,248.20 (21,949.95)	74,957.00 (67,237.00)
Total	1658	117,318.33	1,012,835.00

Global offshore reserves (mmboe) onstream by water depth

	2011	2012	2013	2014	2015	2016	2017
Shallow (last month)	10,462.16 (10,462.16)	6259.20 (9415.75)	69,222.24 (68,701.61)	31,671.16 (31,344.31)	41,312.10 (40,285.68)	32,349.61 (31,984.21)	54,316.60 (54,205.43)
Deep (last month)	1316.73 (1316.73)	2533.96 (2618.75)	3682.02 (3930.65)	5933.60 (6362.53)	4,755.45 (5901.90)	5395.51 (5520.23)	13,139.90 (14,389.76)
Ultradeep (last month)	199.94 (119.94)	797.15 (952.73)	3180.44 (3039.86)	3123.81 (3137.31)	3,103.77 (3177.35)	6356.75 (6820.52)	18,707.44 (17,641.38)
Total	11,978.84	9590.31	76,084.70	40,728.58	49,171.32	44,101.87	86,163.95

16 March 2013

Pipelines

(operational and 2012 onwards)

	(km)	(last month)
<8in		
Operational/installed	42,494	(41,208)
Planned/possible	21,926	(22,894)
Total	64,420	(64,102)

8-16in

Operational/installed	77,854	(79,966)
Planned/possible	46,567	(47,095)
Total	124,421	(124,061)

>16in

Operational/installed	88,086	(87,538)
Planned/possible	47,271	(48,139)
Total	135,357	(135,677)

Production systems worldwide

(operational and 2013 onwards)

Floaters	(last month)
Operational	272 (269)
Under development	46 (46)
Planned/possible	326 (325)
Total	641 (641)

Fixed platforms

Operational	9873 (9828)
Under development	129 (151)
Planned/possible	1430 (1453)
Total	11,432 (11,432)

Subsea wells

Operational	4401 (4357)
Under development	396 (415)
Planned/possible	5886 (5917)
Total	10,683 (10,689)



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Rig Market Review

By **Nina Rach**

The global rig market is strong, with high utilization, high day rates, and nearly 200 offshore drilling rigs under construction. Drilling contractors are changing their fleet makeup, modernizing, streamlining, and concentrating on market sectors. National oil companies are assembling their own fleets of non-competitive rigs.

The global recession, followed by the drilling moratorium after Macondo, created extreme conditions in the US offshore market in 2009-2011, and many drillers took a hit, reflected in stock prices that have not yet fully recovered.

As oil prices diverged from natural gas prices, E&P companies have shifted drilling programs to target oil, driving demand for drilling rigs, increasing fleet utilization, day rates, and building a backlog for the worldwide drilling fleet.

Rig utilization rates have improved over the past 12 months. According to Rigzone, as of 28 March 2013, there were 600 rigs working out of a total offshore fleet of 708 (575 of 677 competitive rigs), representing a utilization of 84.7%. This is an increase from 81.4% six months ago and 78.1% 1 year ago.

National oil companies have been aggressively building their offshore rig fleets since early 2011, particularly Petrobras. In addition to dozens of rigs currently under construction, the NOCs already run significant rig fleets: ONGC (10), PDVSA (26), Pemex (19), Petrobras (16), and Azerbaijan's Socar (17).

Deepwater

Seadrill CFO Rune Magnus Lundetrae told investors at the

Howard Weil 41st Energy Conference in March that despite a "massive influx" of new rigs since 2005, he sees a limited supply of ultra-deepwater rigs. Since 2005, 107 additional UDW rigs and 138 jackup rigs have been delivered and absorbed by the market, and yet offshore oil production has decreased by 4%, according to Seadrill. Magnus believes significant new capacity is needed to maintain offshore oil production, as aging fields have a higher decline rate.

In late February, Macquarie Capital analyst Nigel Browne noted that drilling stocks underperformed last year, and that "valuations right now are still relatively low on a historical basis, especially names levered to North America." But he says that "investors have really embraced the whole deepwater drilling story, which in turn reflects confidence in sustained crude oil demand. The most prolific, new sources of oil are in the deepwater frontier regions and we are starting to see the huge uptick in demand for services that target those reserves..."

Browne noted that stock prices in the deepwater/subsea segments increased over the past two years. But, "the large-cap diversified names have lagged and current stock prices do not fully reflect their exposure to the inflection in growth - especially deepwater rig count, which is forecast to grow ~12% /year over the next two years."

In the "Deep & Ultra-deepwater Market Report to 2016, analysts at Infield Systems Ltd. see four development trends: deep water, harsh environment, remote areas, and smaller developments. The key basins are the Lower Tertiary in the

Stock prices of Offshore Drillers 2008-2013

Atwood Oceanics Inc.

(NYSE: ATW) 16 rigs



Diamond Offshore Drilling Inc.

(NYSE: DO) 44 rigs



ENSCO plc

(NYSE:ESV) 73 rigs



Hercules Offshore Inc.

(NASDAQ: HERO) 54 rigs



Nabors Industries Ltd.

(NYSE: NBR) 71 rigs



Noble Corp.

(NYSE:NE) 82 rigs



Parker Drilling Co.

(NYSE: PKD) 15 rigs



Rowan Companies plc

(NYSE: RDC) 35 rigs

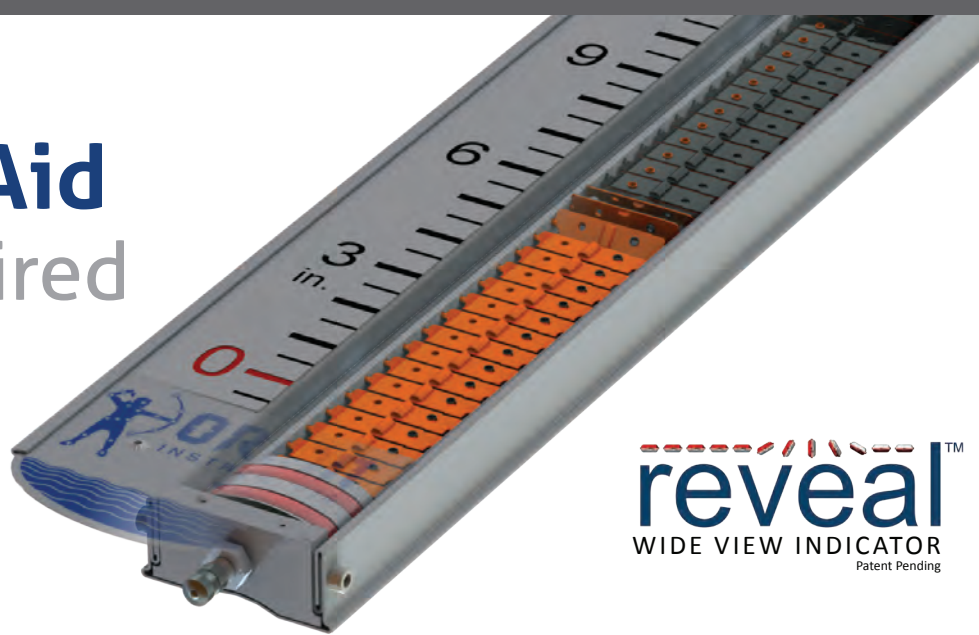


Transocean Ltd.

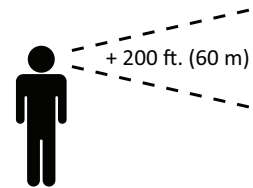
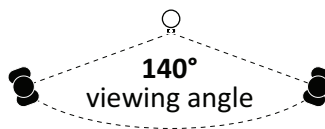
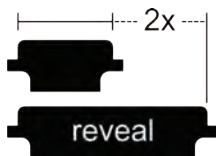
(NYSE: RIG) 99 rigs



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MLI suitable for a variety
of applications.



Aurora[®]

Redundant MLI with
integrated Guided Wave
Radar level transmitter.



Gulf of Mexico, the Arctic, Brazilian deepwater, and East African offshore gas provinces. Infield notes Petrobras, ExxonMobil, Total, BP, Chevron, and Shell among the more significant deepwater operators.

Shallow water

When drilling resumed in the Gulf of Mexico, following the post-Macondo shutdown, demand surged for shallow-water rigs and companies such as Hercules Offshore, with 54 rigs, began to shake off years of losses.

At the Howard Weil Energy Conference, Hercules said their domestic offshore utilization rate improved by about 10% in 2012, and that leading edge day rates are up ~60% year-over-year for 200ft mat-cantilever (MC) rigs in the US Gulf of Mexico and they are reactivating stacked capacity. Recent contracts in the Gulf of Mexico are averaging 6-12 months or longer, compared with prior contracts of 3 months or less. Hercules runs the third-largest fleet of jackups worldwide and the world's largest liftboat fleet (64), with a core in the West Africa market.

The jackup fleet has been near full utilization since Q4 2011. In the Gulf of Mexico, three operators account for approximately 42% of jackup demand: Apache Corp. (19%), Chevron Corp. (11%), and Energy XXI (Bermuda) Ltd. (11%). Others using jackups include EPL Oil & Gas Inc. (8%), Arena (6%), W&T Offshore (6%), and then 16 other operators leasing only one or two rigs.

According to ODS-Petrodata, the current international demand for jackup rigs is 375, a historical peak. Demand in most major international jackup markets (Mexico, West Africa, Middle East, North Sea, SE Asia) has surpassed the prior peak in October 2008 of 334. Current excess marketed capacity of jackups is only

28, with only 20 rigs stacked.

In 2015, more than 289 jackups will be more than 30 years old. According to Pareto Securities, scrapping and conversion of older jackups increased in 2011 and 2012, and is expected to continue.

The North Sea fleet is aging, with high-spec jackups averaging 18 years old. But nearly 90 jackups are under construction worldwide and most will enter the market this year. New jackups need to be able to drill deeper wells, and require updated equipment.

Rig rates, utilization

Utilization is high for competitive offshore drilling rigs, ranging from 80% for drilling barges, 83.1% for jackups, 87.5% for drillships, and 88% for semisubmersibles (Rigzone, 28 March 2013). Drillships have shown the greatest increase from a year ago, up 30.4%, with 80 competitive rigs in the market now. Semisubs show the next highest improvement, up 10.4% from a year ago, with 191 competitive rigs in the market. There are 30 drilling tenders in the market, and utilization is 83.3%, essentially

flat from last year (82.8%).

IHS Petrodata day rate indices track competitive mobile offshore drilling fleet day rates and utilization for four rig categories: US Gulf of Mexico jackup rigs, northwest Europe jackups, mid-water depth (2001ft-5000ft) semisubmersibles, and deepwater (5001+ft) floating rigs.

As of March 15, the IHS Petrodata US Gulf jackup day rate index hit a four-year high of 487, reflecting the greatest variation of all four rig categories. The fleet utilization averaged 68% for both February and March 2013, up 10% from a year ago. Demand for 250 to 300ft jackups is raising day rates and increasing utilization.

Utilization of jackups off northwest Europe remained at 90% in March, the same average over the last 13 months. The IHS Petrodata day-rate index for European jackups dropped 13 points to 599, but remains 112 points higher than a year ago.

Utilization of mid-water-depth semisubmersibles has remained steady at 79% for the past three months, slightly higher than the average for the past 15 months, but below the short-term spike seen in November-December 2012.

The day rates for deepwater floating rigs are improving and utilization has approached 100% for the last three years, spurring construction of new units. The IHS Petrodata day-rate index increased slightly in March, a slight improvement over a year ago, still about 33% higher than two years ago.

Rig construction

Yard prices for newbuild ultra-deepwater vessels reached a high of about \$775 million in 2008, but have dropped to about \$530 million, although day rates have now reached the same high as in late 2008.

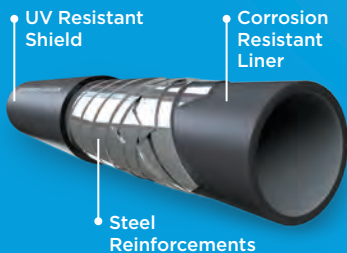
Average Offshore Rig Day Rates, Worldwide

Rig Type, WD	Rigs Working	Total Fleet	US \$1000/d
Drillship, <4000ft	5	8	236
Drillship, 4000+ft	67	76	468
Semisub, <1500ft	8	15	264
Semisub, 1500+ft	73	91	302
Semisub, 4000+ft	100	113	422
Jackup, IC <250ft	40	53	87
Jackup, IC 250ft	46	61	90
Jackup, IC 300ft	103	138	92
Jackup, IC 300+ft	143	168	157
Jackup, MC 200+ft	14	23	85
Jackup, MS 200+ft	7	12	63
Drill Barge	25	48	-
Inland Barge	14	74	48
Platform Rig	140	249	45
Tender	24	34	135

IC: Independent leg cantilever; MC: Mat-supported cantilever; MS: Mat-supported slot

Source: RigZone, 28 March 2013

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There are 74 drillships under construction at yards in South Korea, China, and Brazil. The South Korean yards have 51 drillship contracts, at Daewoo Shipbuilding & Marine Engineering Co. Ltd. (DSME), Hyundai Heavy Industries (HHI), Samsung Heavy Industries, and STX Shipyard, Jinhae. The ships are on order from 14 drilling contractors: Atwood Oceanics (3), Diamond Offshore Drilling (4), Dolphin Drilling (1), ENSCO (3), Maersk (4), Noble Corp. (4), North Pole Drilling (1), Ocean Rig ASA (4), Pacific Drilling Ltd. (4), Queiroz Galvao Oleo e Gas SA (1), Rowan (4), Seadrill Ltd. (6), Transocean (6), and Vantage Drilling (2)

China began taking turnkey drillship contracts away from the South Korean shipbuilding giants a few years ago. Three drillers currently have ships under construction in China, including Noble (1) at the STX yard in Dalian; Reignwood Group's subsidiary Opus Offshore (2) by China State Shipbuilding Corp. (CSSC) at the Shanghai Shipyard; and Vantage Drilling (1) at the Cosco Dalian Shipyard.

Two Brazilian shipyards are building 23 drillships are under construction in Brazilian yards. The Estaleiro Atlântico Sul (EAS) yard in Pernambuco state and the Estaleiro Jurong Aracruz (EJA) yard in Espirito Santo state.

There are 20 semisubmersibles under construction in South Korea (7), China (6), Brazil (6), and Singapore (1). Frigstad Offshore has two, and China Offshore Services Ltd. (COSL) and North Sea Rigs AS each have one at the CIMC Raffles Shipyard, China. Sevan has two cylindrical drilling units being built at the Cosco Shipyard, China.

There are 13 drilling tenders under construction in China (10), Lumut, Perak, Malaysia (2), and Keppel FELS Singapore (1). The Chinese yards building tenders include: Cosco Guangzhou (3), Cosco Nantong (3), Dalian (2), and Rongsheng Shipyard (1).

And there are 84 jackups under

construction at yards in South, Southeast, and Far East Asia, as well the Persian Gulf, Caspian Sea, and the Keppel AmFELS yard in Brownsville, Texas.

Construction market

In January, the Energy Research Group at GBI Research released a report on the offshore rig construction market to 2016 and current rig deployment scenario for jackups, semisubmersibles, and drillships. Not surprisingly, the analysts say that the rig construction market is "linked to the demand-supply scenario of offshore rigs worldwide, which both directly and indirectly affects offshore rig day rates, and the availability and deployment of rigs globally."

The study says that rig designs promoting better safety conformation and increased operational capabilities are key to newbuild orders. It also stresses that rig contractors currently prefer to acquire rival companies as part of their business strategy, an option that has become commonplace over the past years.

Among the trends, cited by GBI:

- Demand for semisubmersibles and drillships expected to rise as E&P companies venture into deepwater and ultra-deepwater basins.
- High offshore day rates are pushing demand for rig upgrades in the form of new changes in blow-out preventers (BOPs).
- New rig orders are being driven by stringent safety regulations, aging of old rigs, harsh-environment rigs, and sustained high oil prices.
- Long-term contracts are expected to be strongly favored by E&P operators for leasing deepwater and ultra-deepwater rigs.
- South Korea is expected to continue as the market leader in the number of newbuild orders for deepwater rigs.
- The rig equipment business is expected to benefit from the imposition of stringent regulatory norms leading to newer, safer equipment designs.
- New business strategy by ship-

yards to diversify into deepwater rig construction and subsea equipment manufacturing to increase profit margins.

- Orders for jack-up rigs capable of operating in water depths of 300 ft or more are on the rise.
- Improved risk assessment is expected to reduce costs and time delays for rig construction projects.

Acquisitions

The cost of rig manufacturing and tightening of credit in world markets has affected newbuild rig orders and has led to acquisitions of smaller drilling contractors.

At the end of November 2012, Transocean announced that it had completed its sale of 38 shallow-water drilling rigs to Shelf Drilling Holdings, Ltd., for \$1.05 billion. Shelf Drilling is a newly-formed company sponsored equally by Castle Harlan, CHAMP Private Equity and Lime Rock Partners. Transocean president and CEO Steven Newman said the transaction "improves Transocean's long-term competitiveness by effectively repositioning the company as a more focused operator of high-specification drilling equipment."

Seadrill was established in May 2005, is domiciled in Bermuda, and run from Stavanger by John Fredriksen, Chairman, and Frederk Halvorsen, CEO. Seadrill acquired Odfjell Drilling (July 2005), followed by Eastern Drilling., then Stavanger-based Smedvig ASA (January 2006), Scorpion Offshore (2011), and Asia Offshore Drilling (2011).

Seadrill is selling its 18 rigs in its tender rig division to SapuraKencana for \$2.9 billion, to close this quarter – but will they receive enough to finance a takeover of Pacific Drilling?

Houston-based Pacific Drilling Services Inc. (PACD) has four deepwater drillships in service and four additional drillships under construction at Samsung Heavy Industries: two for delivery in 2013, their seventh rig for delivery in May 2014, and an eighth rig for delivery in March 2015. **OE**



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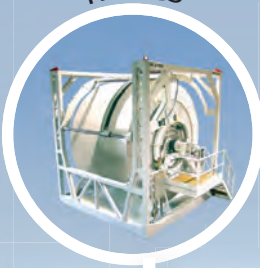
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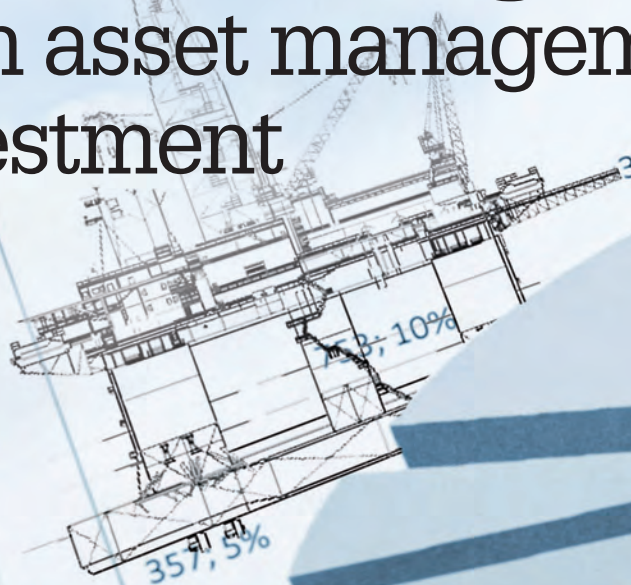
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The offshore industry is perhaps the single most demanding environment for assets. Exposure to the elements, the remote nature of drilling equipment, limited space, a volatile project-oriented environment, and risk management concerns, all need to be addressed by enterprise asset management software. The right application can, however, says IFS North America's **Patrick Zirnhet**, meet the needs of companies, reducing cost, increasing productivity, and mitigating risk.

Increasing returns from asset management investment

200

199



365, 5%

423, 5%

357, 5%

365, 5%

321, 4%

299, 4%

423, 5%

An increased focus on asset integrity management (AIM) and risk management means that more rig owners and operators are reassessing their investments in enterprise asset management (EAM) software to ensure they have applications in place that are properly implemented and functional, help them ensure compliance with regulations, and adopt AIM best practices.

EAM software features can play a role in software project return on investment (ROI) for drilling contractors as can specific, discrete steps taken during implementation. The following concerns ought to be addressed by EAM software in the offshore oil & gas industry:

- Serialization
- Inventory management
- Cash and contract management
- AIM and risk management
- Support for industry standards
- Document management for the asset lifecycle
- Usability, ease of implementation
- Offshore/onshore replication.

Serious about serialization

The offshore industry needs to track individual pieces of equipment over their lifespans at a very granular level. As each piece of equipment is deployed, a comprehensive record of service, repair, overhaul and other work performed upon it, is necessary. This requires the equipment be issued a serial number that the various work orders and project documents can be attached to.

Consider the level of documentation that is required for a key component like a blowout preventer. Imagine that BOP being deployed on a rig for eight months before being moved to shore-based storage. A year later, if it is redeployed on another rig, managers must be able to see the traceability/serialization record of that BOP. It is crucial that before the BOP goes into operation, there be a full history of inspections, work history, transport orders, preventive maintenance

orders and even parts replaced over its lifecycle. Only then can management make intelligent decisions on the actual level of asset integrity of assets in the field. And that, all by itself, can contribute to ROI from the standpoint of risk management.

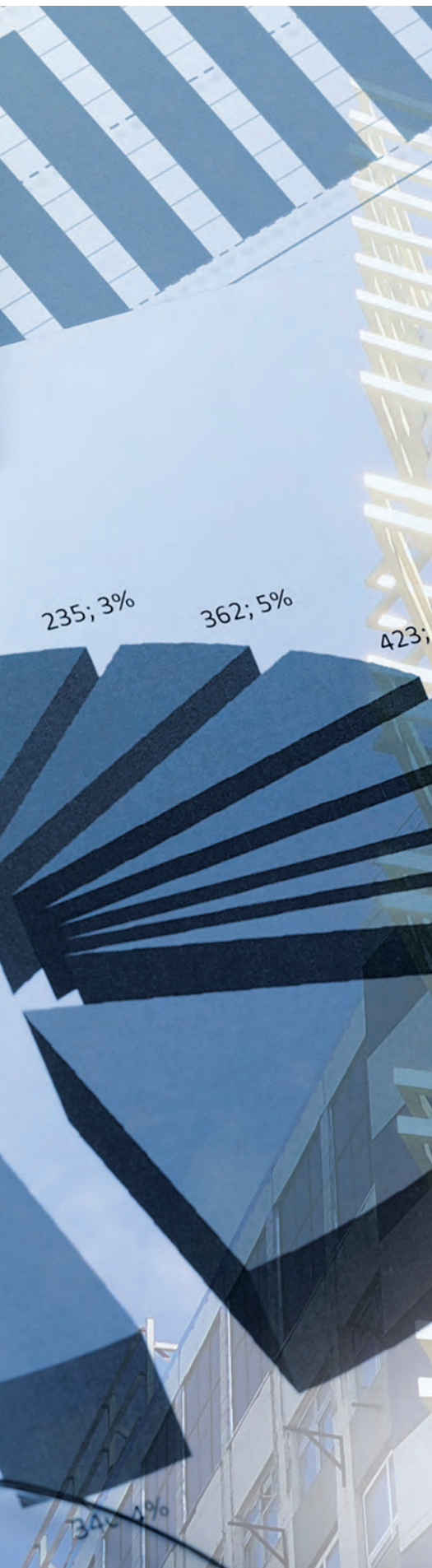
Inventory management

Selecting EAM that offers strong functionality beyond maintenance – specifically in the area of advanced inventory management – will drive more rapid returns.

EAM with strong purchasing functionality can help an offshore drilling platform owner improve procurement processes and strike a balance between having excess safety stock on the rig and experiencing downtime when a part is needed but not available. Establishing this balance is critical when considering the isolated nature of drilling rigs and vessels, which would tend to indicate that more stock is better than less. Conversely, the physical real estate to keep spare parts is limited, and as is the case with inventory in any business environment, too much inventory ties up operating capital that could be used to address other priorities in the organization.

One factor of inventory management that is important for the offshore industry is the ability to share inventory across multiple locations in a given region. Whether it is the Gulf of Mexico or the North Sea, platform operators and owners are often involved with multiple drilling projects in a region. This really amounts to a multi-site arrangement, which some EAM applications can handle more easily than others. It also requires a unique master ID for part identification. If each location is using a different language to refer to parts, true visibility and effectiveness is compromised. EAM for this industry must include standardized part ID so management can reduce the ongoing investment required to manage the asset.

If you look at a fleet of ships or



jackup drilling rigs, there might be 100,000 different parts or objects in that asset environment. You might have 50,000 different spare parts in your inventory and all of these are named in a very localized way. That is because the part-naming convention was likely developed on each shorebase or rig over a period of years, and the problem may be a lot worse if the company has grown by acquisition – a common thing in the drilling industry. Therefore, it is impossible to know that a motor in company A, called Alpha, is the same motor as company B is storing under the name Beta. And the expected level that you need to have on the shelf is maybe 0.2 of this motor, which means you need to store at least one. But if you can treat five sites as one common unit with different inventory locations, you would be able to store just one motor to service all five sites.

Once inventory is received on a rig, EAM software for the offshore industry must also be configured to deal with the logistics including all manifests necessary to transfer the containers and other load carriers with equipment and spare parts on- and offshore. This will result in reduced cost for shipping and reduced downtime, increasing ROI from an EAM project.

Cash and contract management

A significant portion of the variable cost of offshore operations consists of the cost of contracts for

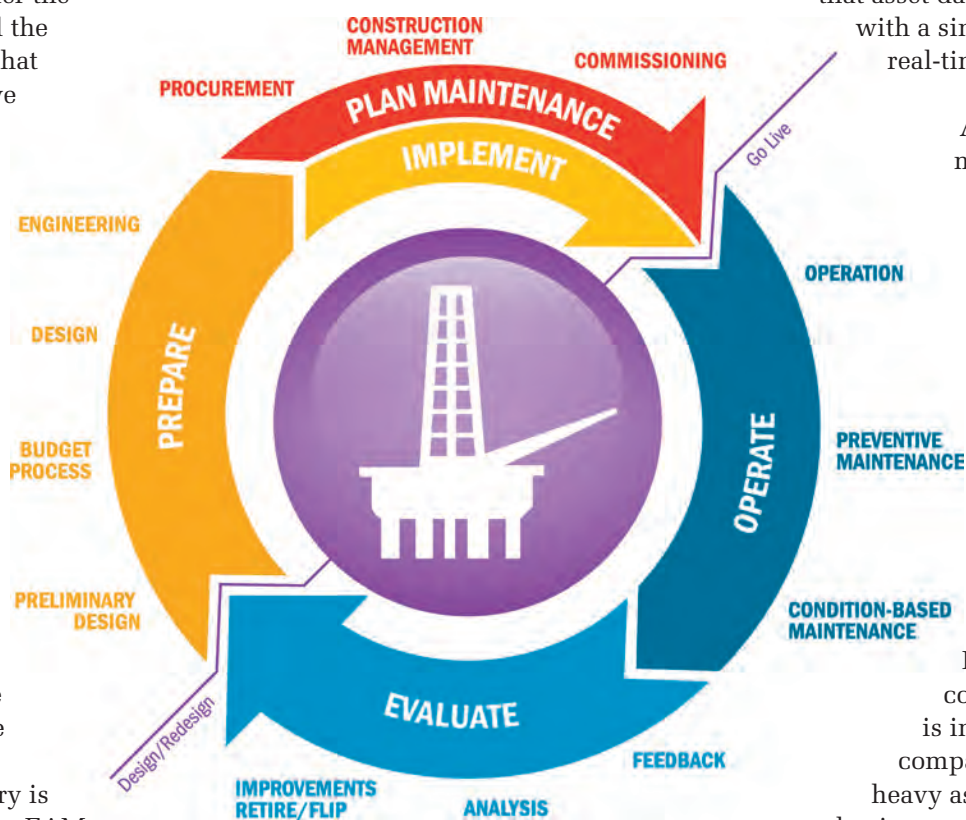
supporting services and materials. EAM that is truly optimized for the offshore industry will take this into consideration and offer integrated contract management. Cash outlays necessary under each contract will be planned as the contract is finalized so cash flow decisions can be made accordingly.

The lifecycle of a contract with a supplier should be encompassed entirely within the EAM application, starting with call for bids on

try a consistent view of all asset information – one version of the truth – insuring policies, plans, and actions, are based on an accurate understanding of the history and current status of asset infrastructure. In order to accomplish this, an EAM software product must actually address all phases of the asset lifecycle.

Not many do.

It must also provide portals or other methods for outside parties like engineering firms and maintenance contractors to use the system so that everyone touching that asset data is interacting with a single database in real-time.



Asset lifecycle management supports decisions on asset integrity.

the project, acceptance of the bid and then the projected cash outlays and associated work performed by the contractor. This has benefits far beyond cash and contract management.

Truly effective contract management is one way EAM can deliver to a company in the offshore indus-

try a consistent view of all asset information – one version of the truth – insuring policies, plans, and actions, are based on an accurate understanding of the history and current status of asset infrastructure. In order to accomplish this, an EAM software product must actually address all phases of the asset lifecycle. Not many do. It must also provide portals or other methods for outside parties like engineering firms and maintenance contractors to use the system so that everyone touching that asset data is interacting with a single database in real-time. AIM, risk management, permitting That one version of the truth – particularly related to data centralization about the asset – is another way that EAM software can deliver ROI to drilling contractors. AIM is important to any company that relies on heavy assets to achieve business results, but for the offshore drilling industry, where asset failure has an impact far beyond business productivity, it is positively critical.

Drilling contractors and rig owners can experience asset failures when they make decisions without complete visibility of the condition, status or current configuration of their assets. An EAM software application for the offshore industry should ideally be used to support asset design and construction, enabling the asset data to flow directly into

the systems that will be used to sustain, maintain and operate the asset. This approach, known as 'Design, Operate, Maintain,' really involves a single asset management system that supports the asset over its entire lifecycle, cradle to grave.

The contract management tools have a role in true cradle to grave support because they ensure that the same enterprise system and data set is used regardless of who is making alterations to the asset.

EAM software for the offshore industry must also include configured workbenches for the offshore drilling industry with integrated permit and incident tracking built into the work order system. Increasing AIM visibility is one way to avoid injuries or deaths, and that is certainly one more way EAM software can deliver ROI. Indeed, more companies in the industry are realizing that in today's environment, drilling

without a truly effective EAM application that can document their maintenance activities and give them full visibility of the asset is just not responsible.

Industry standards

In an industry where asset failures can have safety and environmental implications, the amount of pressure to document compliance to safety standards is expected to increase. The most rigorous of these standards is NORSOK, which was developed by the Norwegian petroleum industry, based on the ISO 13628 standard.

From a compliance standpoint, support for NORSOK ought to be seen as a gold standard that is to be sought after in EAM software for the offshore drilling industry. The extent to which an EAM application offers a NORSOK compliance function ought to be key selection criteria.

Across all asset-intensive industries, another standard that is being taken seriously by more and more stakeholders is PAS-55 and the associated ISO 55000. This standard is specifically intended to cover the lifecycle of assets and in particular assets that are mission critical to the organization.

Usability, ease of implementation

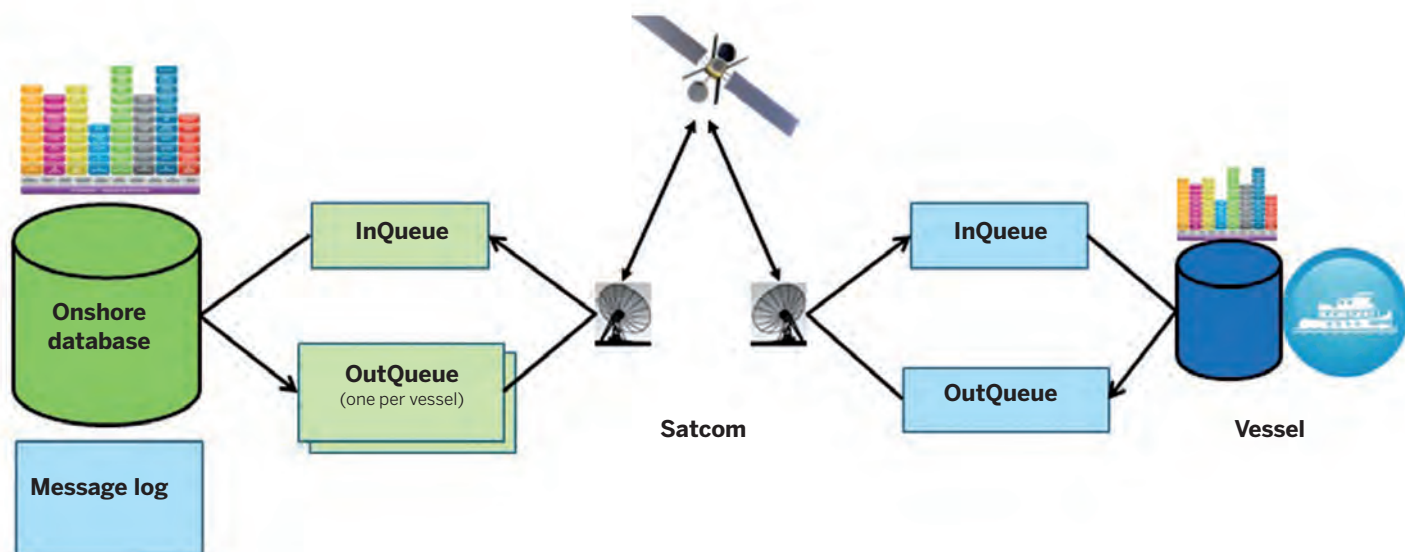
In the offshore oil & gas industry as well as other industries, technicians and other front-line employees will not use a system that is confusing or presents functional barriers to their individual jobs. And there is no way that anyone can use a system until it has been implemented, so EAM software products that have a history of years-long or failed implementations are to be avoided.

For the drilling industry, an EAM application that allows a phased approach to implementation may be ideal. Mission critical



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Replication keeps data onshore and offshore more or less identical.

elements like work orders, and document management to track the specifications of the asset as it is maintained, and inventory can be implemented immediately, allowing safe asset operation. Additional functionality including permitting, health & safety, and even full-blown reliability centered maintenance (RCM) functionality, can be implemented later.

Subpar implementability and usability are both potential barriers to a drilling contractor to realize ROI on an EAM software investment.

Documentation, asset lifecycle

For any number of reasons, including standards compliance and risk management, it is critical to have all of your asset data in a single repository. EAM software for the offshore industry needs to have integrated document management so as assets are set up in the system, all relevant CAD drawings, contracts, maintenance schedules, testing reports, and other documents, are stored in a central repository. These individual documents must also be linked to the asset object in the EAM system, which frankly not every EAM application will be capable of.

In a perfect EAM world, as new drillships or other assets

are commissioned, a drilling company would be able to take the CAD serialized assets from the builder and pull them directly into their own EAM and document management system. Some EAM packages may be able to import the asset data, but lack the hooks into CAD and 3D CAD systems necessary to fully build those assets out into the system.

Integrated document management delivers an ROI by reducing the time it takes to find, manage and update documents relating to the asset.

On/offshore data replication

EAM vendors with a focus on the offshore industry offer a built-in data replication solution. While many offshore operators may run software that relies on a third party replication solution, EAM software with its own offshore replication functionality offers ROI benefits originating from both reduced cost and increased utility.

Replication involves one or more application databases onshore and one application database located on each offshore vessel or oil rig. Replication will keep business critical and transactional data at these sites more or less identical.

When the EAM vendor themselves offers the replication

functionality, it is much easier for that data to be replicated at the application level instead of directly within the database. This means that data exchanged between systems goes through the data integrity controls built into the software.

Most data replication functionality focuses on transactional data rather than data objects because CAD drawings and other documents can be quite large. But the transactional data itself must in fact be replicated, and EAM software with built-in replication functionality will offer greater data integrity and cost less to license and implement than a third party solution that must be configured, integrated and then tested, hence, increasing ROI. **OE**



Patrick Zirnhelt is director of sales for asset-intensive industries for IFS North America. He has almost 20 years of experience working with enterprise systems, and is a professional engineer registered in Ontario. He holds an MBA from the York University, Toronto, and a BS degree in mechanical engineering from Queens University, Kingston, Ontario.

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Andrew McBarnet

G & G Notebook

What kind of summer will it be?

2012 was a big year for marine seismic in NW Europe.

Andrew McBarnet asks whether we can expect a repeat in 2013.

The summer season offshore NW Europe is often seen as the bellwether of the marine seismic industry's state of health. This was definitely the case in 2012, which saw exceptionally high survey activity reflecting a strengthening market. Not all the same conditions apply this year, which has left a bit of a question hanging over what can be expected. Not that anyone is suggesting that the seismic business as a whole is facing a reverse in its current fortunes far from it rates are said to be firm, even rising, and vessel capacity worldwide is as close to equilibrium with demand as it is ever likely to be.

One of the more innocent expla-

nations for talk of a less frenetic NW Europe this year may simply be a matter of vessel logistics in a global market place. Last year the region experienced the equivalent of swarming, with plenty of time-sharing agreements for company survey campaigns. In other words, it may be that there just aren't enough boats to go around, or they are in the wrong place.

Plays now compete for the world's seismic fleet, in West, South and East Africa, India, the Atlantic Rift and Caribbean, Brazil, Australia, and Asia Pacific, not to mention a revitalized, post-Macondo Gulf of Mexico. Contractors are always going to think carefully about the

cost of transiting vessels from one region to another unless the prospect of good backlog is in the offing. WesternGeco and Polarcus, for example, have vessels committed to the SE Asian and Australasian markets, and are unlikely to be relocated to the Northern Hemisphere.

That said, some companies have jumped in early, possibly too early, given the prolonged winter conditions off NW Europe. CGG really pushed the seasonal limits by starting work in February on UK Quad 30 Phase 7 of its Cornerstone CNS dataset covering over 5500sq km in the Q29, 30, and 38 areas. The company is operating its Oceanic Phoenix with a 10 x 100 x 6000m long-offset streamer configuration deploying its BroadSeis and BroadSource technology.

The focus on broadband seismic is a key reason why oil companies can continue to commission new seismic over areas that have already been shot many times over. As a point of historical reference, in June 2014, it will be 40 years since then-Secretary of State for Energy Tony Benn in Harold Wilson's second Labour government inaugurated the first UK oil from the Argyle Field, operated by Hamilton Bros.

In subsequent decades, the UK has maintained a "pedal to the metal" speed in its drive to produce its offshore oil and gas. As a result, the remaining pickings in the mature



Oceanic Phoenix: CGG's first vessel on the scene.

areas are assumed to be slim, but not so slim that the latest seismic might not highlight some previously unseen reserve possibilities.

Based on previous surveys in the region, CGG says that use of broadband in its Cornerstone project enables the imaging of thinner and more complex reservoirs from the deep Carboniferous-Permian section through the Jurassic and up to the shallower Paleogene targets, which could be an important solution for unlocking bypassed hydrocarbons in the Southern Central Graben.

Another early starter is TGS, which has started on two 3D multi-client surveys in the Norwegian Barents Sea. The Finnmark Platform 2013 (FP13) survey, covering 3500sq km, was started last month by the Geo Barents ship towing eight streamers. In the meantime, the Hoop to Fingerdjupet 2013 (HF13) survey, scheduled for early Q2, will cover 8600sq km deploying the Oceanic Challenger towing 12 streamers. Both 3D seismic surveys are said to cover areas of complex geology and are designed to address specific customer imaging requirements. TGS has no broadband acquisition capability of its own, but is using its Clari-Fi processing technology to meet customer appetite for broadband insight.

Dolphin Geophysical 3D seismic vessel Polar Duke is embarking on acquisition of its remaining 3D multi-client survey in UK Quads 29 and 30, expected to take five months with sister vessel Polar Duchess taking over some of the project when Polar Duke leaves for other pre-booked contract work. Dolphin is also playing up the broadband advantage, although it



Malcolm Webb,
chief executive,
UK Oil & Gas.

does not have the proprietary acquisition technology like the Big Three (Petroleum Geo-Services, WesternGeco, and CGG). Instead, Dolphin depends on a processing solution called SHarp BroadBand High Resolution. There is an acquisition aspect to this: the company says that 75m streamer separation is necessary to image steeply dipping salt flanks and faulting.

In a way, it's strange that NW Europe should continue to be such a key focus. The UK and Norway have both slipped standings in the oil production league and no longer feature in the top 10. Any expectation of big finds that would potentially attract significant investment by the supermajors (preoccupied with finding "elephants") is now mainly confined to some emerging areas off Norway, notably the Barents Sea. Some still believe that West of Shetlands could be a sleeper; west of Ireland remains to be properly investigated, and who knows what will eventually emerge from Greenland exploration.

Of course, there is always the capacity to surprise. The most dramatic examples in recent years were the Avaldsnes and Aldous Major South finds in 2010 and 2011 by Lundin Petroleum and Statoil respectively, on the Norwegian

Continental Shelf. Now renamed Johan Sverdrup, after a 19th Century Norwegian prime minister, the combined discovery is currently estimated to contain gross contingent resources of between 1.7 and 3.3 billion bbl of recoverable oil, making it one of the five largest known accumulations on the Norwegian Continental Shelf. Icing on the cake is that the field is in 115m of water the reservoir has excellent characteristics and oil quality, at a depth of less than 2,000m, and is close to existing infrastructure with spare capacity.

What seismic contractors are primarily looking for is sustained oil company E&P investment, that requires seismic survey support. The omens are still favorable in Norway and the UK, where, like the US Gulf of Mexico, there is a huge pool of operators and licensees, from supermajor to small independent, many of them playing in their own backyard. The human dimension of this proximity is not to be underestimated, in terms of closeness to home and family, and working in a familiar environment.

There are obvious business advantages of working offshore Europe, starting with stable, industry-friendly governments and orderly fiscal and regulatory regimes. That means access to everything from technology, equipment, and finance to people. The infrastructure accumulated during four decades of production enables otherwise marginal finds to be worth developing.

The Norwegian Petroleum Directorate (NPD) is predicting high activity in the next 5-years, with total production expected to remain about the same as in 2012. Thirteen

new discoveries were made last year: five in the North Sea, five in the Norwegian Sea, and three in the Barents Sea. Forty-one exploration wells were completed.

NPD director general Bente Nyland summed it up recently: “The increase in the resource estimate and major new discoveries show that the Norwegian shelf still has some surprises left, and that there is good reason for continued optimism on behalf of the oil and gas activities in Norway.”

Oil and Gas UK, the representative body of the UK offshore oil and service companies, is singing from the same hymn sheet. Thanks to recent improvements in the tax regime, it says that more oil and gas reserves have become commercially viable for development. The number of projects submitted to the Department of Energy and Climate Change (DECC) and given development approval almost doubled between 2011 and 2012. The 33 projects that DECC has approved since January 2012 involve invest-

ment of £13.4 billion.

ment of £13.4 billion. UK Oil & Gas warns that reserves moved through into production have not been fully replaced with new discoveries. While sanctioned reserves rose at the start of 2013 to 7.4 billion boe, the highest level for 6 years, the total reserves on companies’ plans fell by 500MMboe. Production fell to 1.55MMboe per day in 2012, down 14% from 2011 and down 30% from 2010. According to UK Oil & Gas, much of this fall can be attributed to damaged investor confidence by the numerous adverse tax changes in the

mid-2000s, with new developments reaching a low point in 2008-2009.

Commenting on a new survey of its members, Malcolm Webb, chief executive, UK Oil & Gas, said: “Only 21 exploration wells per year on average were drilled over the last three years. As a result, in 2012 not enough barrels were discovered to replace all those produced. However, again, there is real cause for encouragement as the survey results lead us to forecast 130 exploration wells over the next three years, which, alongside the use of new and improved sub surface technology, should result in many more barrels being discovered.”

While production may fall again slightly this year to 1.45–1.5MMboe/d, thanks to the recent surge in investment, a significant upturn can now be predicted over the next three to four years, rising to approximately two million boe per day by 2017 with significant benefits for the UK economy.

Investment confidence and encouraging activity levels are just

from mature areas. The UK categorizes its licences into “traditional,” “promote,” and “frontier,” with “promote” designed to encourage innovative approaches to already well-explored areas. Norway has its Awards in Predefined Area (APA) program to serve a similar purpose, well supported by oil companies. Relinquishment strategies assure that there is extra acreage to consider.

New licensing translates into business for the marine seismic contractors with a trend toward multi-client, as opposed to exclusive, programs. In 2012, there was actually more multi-client than proprietary seismic shot in NW Europe, heavily influenced by surveys in the Barents Sea that were stimulated by Norwegian government licensing. Block sizes are also shrinking in mature areas, so it makes sense for oil companies to share survey costs.

This is a win-win situation from a contractor perspective, because economies of scale apply once a survey is up and running, especially if it is more vessel-intensive broadband acquisition. Prefunding for multi-client work is an important consideration that has to be weighed against other available options for the vessel and the likelihood of post-survey data sales. In higher risk areas such as the Barents Sea where data is still relatively scarce, multi-client surveys look more like fully-funded group shoots.

With continued aggressive government licensing, program commitments will lead to a steady flow of seismic work. In producing fields, companies may opt for reservoir monitoring using 4D seismic. This will be a continuing source of work, although technical, geological, and economic factors all come into play. The use of 4D is more likely at better-resourced companies with the expertise to make best use of imaging from repeated surveys.

Overall, the fundamentals will keep oil companies ordering seismic offshore NW Europe. It’s just not clear yet how busy it will be in 2013. **OE**



Five good years in prospect:

Bente Nyland,
director general,
Norwegian Petroleum
Directorate.

the preconditions that keep bringing seismic companies back to the NW Europe. More tangibly, the expectation of regular licensing rounds in both the UK and Norway has provided a continuing stimulus, even in difficult years. The most recent 27th UK licensing round was one of the biggest ever and the 22nd Norwegian licensing rounds saw a significant opening up of new sectors including the Barents Sea. Both countries have policies encouraging exploration of new or frontier areas, as well as focusing on incremental additions to oil and gas reserves

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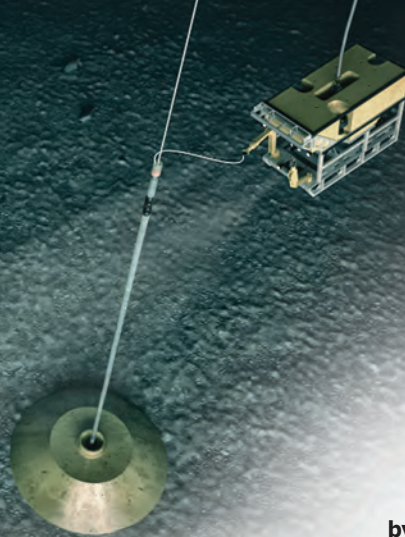
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Rigless drilling enters the pilot stage

Exploration could be radically altered by a simple idea, **Victor Schmidt** explains, saving industry months and millions.



The Badger tool is guided into position by an ROV, which then connects it by cable to a subsea power source.

How does the offshore industry evaluate a new deepwater play? Conduct geologic research, examine studies, collect samples, acquire seismic, process, interpret, budget, and ultimately contract a rig to drill a hole. It's a time-consuming and expensive process, especially the sample/seismic/drilling segments.

What if there were a way to quickly and inexpensively (relatively speaking) gather the needed information to test a play idea, or quickly evaluate a traditionally discovered deepwater reservoir ahead of full field development. Think of the money it could save and the increased number of play ideas that could be tested. The industry has done this before by drilling small diameter expendable holes, but this approach is only practical for shallow-depth targets.

That idea, quick evaluation, is the driver behind the Badger Explorer tool concept now under development by Stavanger-based Badger Explorer ASA. The concept is deceptively simple: lower an expendable tool to the seabed to drill through rock formations, and evaluate the rocks as the tool moves downward through the earth's layers. When the target depth is reached, abandon the tool. Just clip the cord and walk away; the tool is permanently sealed in the rock. If the tool is used for field evaluation, it can remain active as a sensor set for

the life of the tool, once the field is developed.

According to Badger, it will work like this:

The tool will be lowered to the seabed from a vessel of opportunity and be connected to a power source, using an ROV if in a developing field. The electrically-powered drilling system will then start burrowing into the subsurface. As the tool moves into the earth, formation fluid will circulate from the outer annulus down to the bit, carrying cuttings to the top of the tool, where they will be compacted above the tool filling the hole as the tool advances.

While drilling, the tool's sensors will record data continuously and send it uphole by a power and communication cable that will pay out behind the advancing tool. The MWD logs produced from the data stream will allow formation evaluation in real-time and yield data to fine-tune both geologic models and seismic datasets. In field surveillance mode, the sensors will produce continuous, long-term data for production monitoring.

Goals for the tool include drilling a 6in. hole to 3000m TVD in two months (average rate of penetration of 2m/h). Traditional logging parameters (gamma ray, acoustic response, pressure, temperature, resistivity, neutron porosity, fluids testing, etc.) will be recorded. Power required is gauged at 10 kW.

Research program

Badger Explorer was created in 2003 to carry this idea forward. The Research Council of Norway (RCN) and three sponsors: ExxonMobil, Shell and Statoil supported basic research behind the idea.

During 2012 significant progress was made. A structured evaluation of the tool design was conducted, to identify and evaluate elements that could limit longer-term capabilities. Challenges considered included subsea operations, deeper drilling, rock formation types, and drilling through gas zones.

A beta version of the tool was produced and work continued on the cable storage system. An improved drilling unit was designed and the test jig modified. Tests included: drill bit, stone crusher, and the transport system.

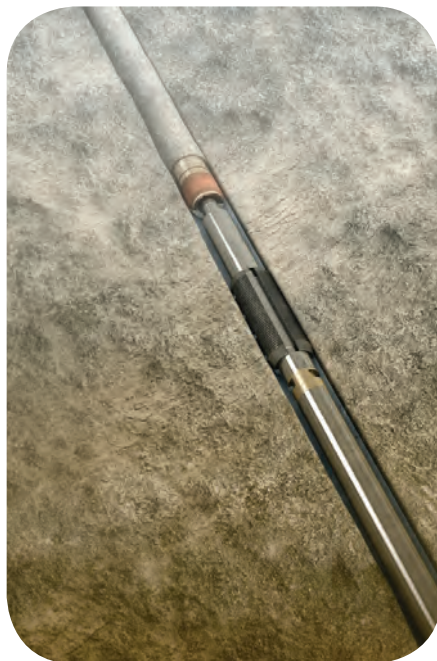
The compaction system was improved and the need for clean circulation water while crossing gas zones was eliminated. A way to quantify apparent compaction was devised and is being tested. Flow capabilities of drilled cuttings with low fluid content were also tested.

The number of tool segments was increased and a low-friction coating was chosen for the tool body. In addition, a commercial frameless motor was selected to drive the bit.

New Resources

After the basic research phase, Badger moved into Phase 2 – Pre-

Fluid transfers drill cuttings up the tool's center to a compacting element at the top. This fills the void space, as a spooled power/communications cable pays out from inside the tool.



commercial and its Demonstrator Program (DP). Exxon and Statoil carried over into this phase and Chevron replaced Shell as a supporter. The company received a boost recently when it added a fourth sponsor, Wintershall, to the DP.

The DP establishes a design basis for the next generation Badger tool, where lessons from the prototype will be used to develop and configure the tool for commercial applications. This involves choosing sensors and instrumentation for use during the drilling process, as well as sensors for long-term reservoir monitoring and management.

According to the company's 4Q 2012 Quarterly Report, the addi-

tion of new sponsors fulfills conditions for additional funding from Innovation Norway. The first part of a grant of NOK20 million will be given to Badger to support the DP, with remaining payments based on

other milestones during 2013 and 2014.

This phase is slated for three years. The company plans to deliver the tool for its first field pilot tests after completing the DP later this year. These pilots will be undertaken as a separate program, to which the Research Council of Norway has already awarded NOK8 million of support.

The first field pilot is slated for the Canadian oil sands, even though some qualification and permits are required. Other sites, some in Norway, were investigated to avoid any delay in the technical program.

The first pilot tool will face the challenge of glacial tills, mudstones and relatively unconsolidated formations, conditions similar to many locations across the globe. A second pilot will test geology representative of the Barents Sea.

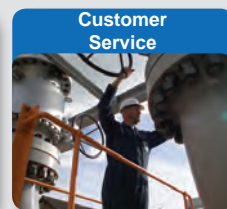
Badger Explorer expects to introduce the tool to the commercial market sometime in 2015. **OE**

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M-I Swaco gets SMART on

displacements

M-I Swaco, a Schlumberger Company, took OE on a tour of its new SMART 3D package of integrated displacement services. **Audrey Leon** reports from Houston.

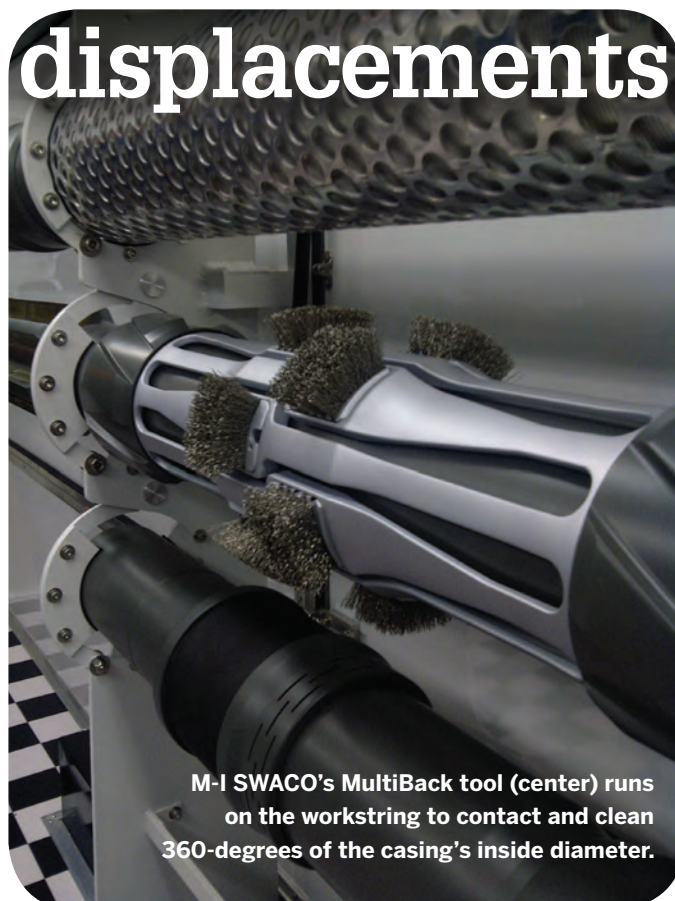
M-I SWACO unveiled its SMART 3D displacement package on February 28 at the Houston Museum of Natural Science, offering an integrated, customizable package of mechanical, chemical, and hydraulic displacement services provided by a single company.

“Displacement operations are often marginalized because no single group owns the operation,” the company says. With SMART 3D, M-I SWACO will service all aspects of displacement so that the wellbore is properly prepared for completion or production.

M-I SWACO developed its drilling fluid-to-brine displacement operations at its Houston Technology Center. SMART 3D aims to reduce non-productive time (NPT), risk of formation damage, and cross-contamination of drilling fluids and brines, both on- and offshore.

M-I SWACO says all displacements have three core dimensions: fluid hydraulics, mechanical debris removal, and chemical debris removal. The company argues that 30% of failed completions result from poor debris management, where fluid or drilling residue remains in the hole after displacement.

At the heart of SMART 3D is a



M-I SWACO's MultiBack tool (center) runs on the workstring to contact and clean 360-degrees of the casing's inside diameter.

series of tools that facilitate cleanup operations. M-I SWACO's BRISTLE BACK and RAZORBACK tools scrape and brush debris from casing walls while the pipe runs in the hole. The WELL SCAVENGER, introduced in 2011, cleans above FIVs and other critical areas during pre-production debris removal.

M-I SWACO's range of solvent and surfactant chemical spacers prevent incompatible synthetic- or oil-base drilling fluids and completion brines from creating viscous emulsions, which could jeopardize displacement. The DEEPCLEAN additive is a non-aqueous fluid cleaning agent that satisfies all the requirements of a multiple-stage displacement train with a single product.

Additionally, M-I SWACO's Virtual Completion Solutions (VCS) modeling software is designed to

simulate displacements utilizing actual information on well geometry, casing, drill string dimensions, and active mud properties. With this data, engineers can design a displacement to optimize elements such as contact time, flow regime and pump pressures.

A deepwater operator in Nigeria sought an alternative to the displacement recommendations and chemicals of the local provider that would reduce both rig time and on-site inventory requirements. Previous displacements required five or more circulations before the Nephelometric Turbidity Unit (NTU) was below

100, which was the operator's criteria for a clean well.

M-I SWACO recommended a DEEPCLEAN spacer train in conjunction with the BRISTLEBACK and RAZORBACK mechanical wellbore cleanup tools. A multi-function circulating tool was utilized to increase circulation rates. The entire displacement was modeled in VCS to ensure the proper flow regimes and contact times could be achieved within the limitations of the rig equipment.

The well cleaned up just a few cubic meters after the spacers cleared the surface. NTU values were within specification and the drill pipe was pulled out of the hole clean and water-wet with no trace of residual mud film. More than 18 hours of rig time was saved and on-site displacement chemical inventory requirements were cut in half. **OE**

Skarv – BP harsh-water FPSO

The Skarv FPSO is BP's first Norwegian greenfield project since 2001. **Elaine Maslin** explains the details.

Sitting just 50km from the Arctic Circle in 350-450m of harsh waters, the Skarv FPSO is a milestone for BP. It is the firm's first greenfield project in its Norwegian unit since the Tambar field came onstream in 2001 and is thought to be one of the most northerly of the group's global developments.

According to BP, it is the world's largest harsh-water floating production, storage and offloading vessel, at 295m long, 51m wide and weighing in at 74,000 tons. It has a storage capacity of 875,000 barrels, oil production capacity of 85,000 b/d and gas production capacity of 19MM cu m/d (670MMscf/d). It came onstream on December 31, with the first export of gas on January 6 and five wells producing by the end of February.

During the year, a total of 17 wells will be active, seven as oil producers and four as gas injection, with the first oil offtake by shuttle tanker expected during March. Production is expected to ramp up to about 125,000 boe/d per month within the first six months, reaching an expected maximum daily rate of about 165,000 boe/d by year end.

It has been a long time coming. The Skarv oil and gas field was discovered in 1998 followed by the nearby Idun field a year later. Together they are estimated to contain about 100MMbbl of oil and

condensate and about 48 billion cu m (1.5Tcf) of rich gas, according to BP. A NOK 30 billion PDO (plan for development and operation) was submitted in 2007 to jointly develop both fields, estimated to contain about 100MMbbl of oil and condensate and about 48 billion cu m (1.5Tcf) of rich gas.

Aker Solutions carried out front-end engineering design and detail engineering and procurement, cov-

ering the vessel's topsides (18,000 tons), hull (based on Aker's Tentech 975 design and weighing 49,000 tons) and living quarters. South Korea's Samsung Heavy Industries carried out the fabrication and installation of the hull and topsides. The turret and mooring system was designed by SBM Offshore and built at the Keppel Shipyard in Singapore.

The turret, weighing 7500 tons

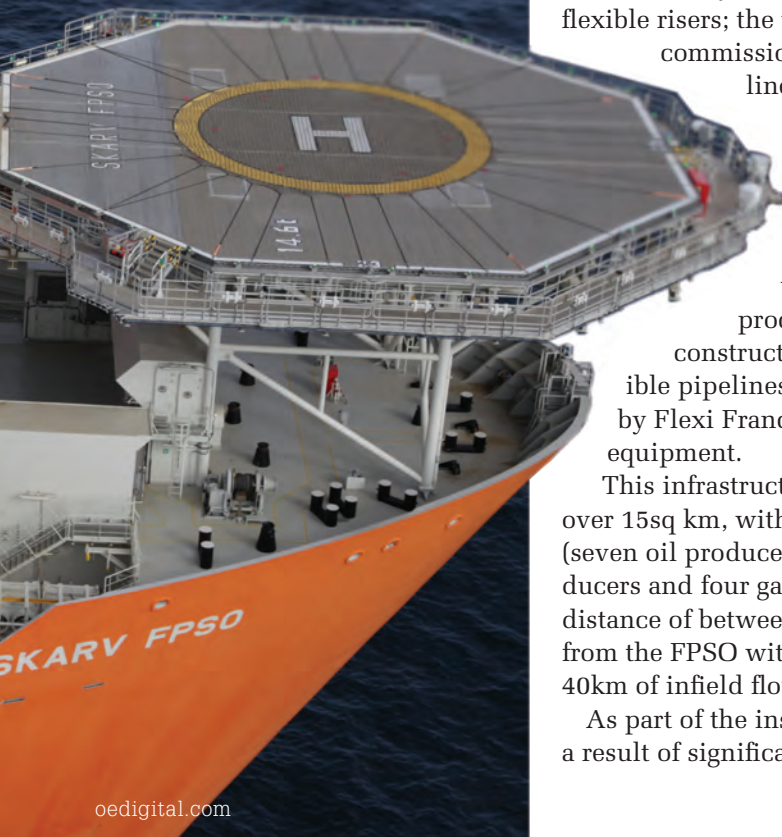


and standing 77.4m high, was designed to take mooring loads of 5500 tons and has 21 riser/umbilical slots (14 phase one and 8 spare). Keppel described it as “the largest internal turret in the world in terms of its rated mooring loads.”

The hull’s structure, turret and 15 mooring lines, hooked to suction anchors on the seabed, were all designed to withstand three combined potential eventualities: a total loss of power and therefore use of thrusters, 100-year storm conditions, and the vessel not being in optimal position to the prevailing weather conditions.

“The structural integrity of the FPSO and its mooring lines are designed to be maintained in all those circumstances,” said Pat McHugh, Skarv project director. “That is an unusual demand and what we have, therefore, is one of

The Skarv FPSO is 295m long, 51m wide and weighs 74,000 tons, with oil production capacity of 85,000 b/d and gas production capacity of 670MMscf/d.



the highest-strength mooring systems ever installed.”

While a large part of the Skarv development, the FPSO and mooring system is only 50% of the project – the rest is beneath the rough waves of the Norwegian Sea.

VetcoGray, a GE Oil & Gas business, and JP Kenny carried out the engineering, construction and testing of the project’s 17 wellheads and tree systems, five subsea templates with integrated manifolds (fabricated at Burntisland Fabricators), and an 85km, 26in. gas export pipeline system including: flowlines, control umbilicals, and control systems for workover and tie-in.

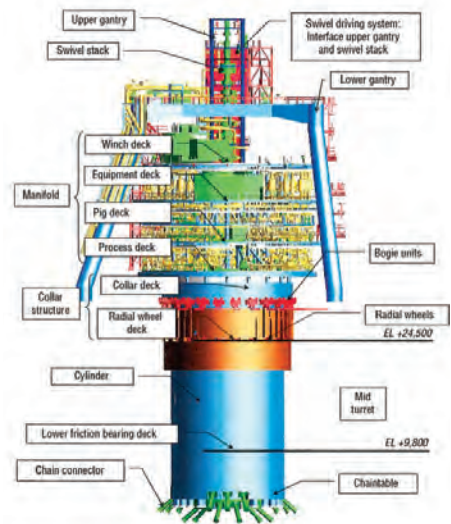
Subsea 7 and Acergy, before their merger, were awarded much of installation work. As Subsea 7, the firms carried out the engineering, fabrication, and installation of 42km of single flowlines, consisting of 35km, 12in. and 10in. diameter, clad, production flowlines and 7km, 10in. diameter, carbon-steel, gas-injection flowlines. A direct-electrical heating cable was also attached to the 13km Idun flowline.

Subsea 7 also carried out installation of subsea structures, control umbilicals, dynamic umbilical and flexible risers; the tie-in and pre-commissioning of all flowlines, risers, control umbilicals and the gas export pipeline.

Technip carried out the engineering, procurement, and construction of the flexible pipelines, manufactured by Flexi France, and associated equipment.

This infrastructure is spread over 15sq km, with the 17 wells (seven oil producers, five gas producers and four gas injectors) at a distance of between three and 14km from the FPSO with 13 risers and 40km of infield flowlines.

As part of the installation, and as a result of significant scouring on



The turret can take mooring loads of 5500 tons and has 21 riser/umbilical slots.

the seabed from fishing, some 1.25 million tons of rock dumping was required, prior to and post subsea infrastructure installation, with some 37,000 tons still to be deposited in the second quarter of this year.

Like many major projects, Skarv has had its set-backs. Production was originally planned to start in the third quarter of 2011.

The project started in earnest with first steel cutting of the hull at Samsung’s yard in 2008. The project remained on track through delivery of the main turret sub-assemblies to Korea, their installation, and the transport of the FPSO to Norway, which arrived on schedule March 1, 2011.

Production drilling started in the field in 2010 with Dolphin Drilling’s semisubmersible, *Borgland Dolphin*, and then Transcoean’s semisubmersible, *Polar Pioneer*, which will continue drilling this year.

However, McHugh said: “Once the FPSO arrived in Stord (the Aker Stord yard), we found that the finishing work was more extensive than expected because of some pipe work repairs, which had to be carried out. Consequently, we stayed in Stord for some weeks longer than initially planned.”

Corrective work included repairs to flange leaks in the turret and

topsides of the vessel, and repairs on the riser pull-in winch, but this then had a knock-on effect on the project.

“As a consequence of staying longer in Stord than had been expected, we did not get the FPSO moored in the field until late-August 2011,” said McHugh.

“This, in turn, meant that we rescheduled the pulling-in of flexible risers to start in September 2011. At this point, a combination of crane problems and bad weather conspired against us, such that by mid-November 2011 we had only managed to pull in three of the thirteen risers.

“Then the weather turned completely against us and we were unable to complete any more risers until mid-April 2012. By the end of May 2012, we had completed all of the riser connections and then progressed to complete commissioning, and started production by the end of 2012.

“With the exception of “rock dumping” activities to level out the undulating seabed, offshore work is difficult during the harsh winters

between October and April. But huge seas and high winds are liable to disrupt a work schedule at other times of year, too.”

Limited access to equipment and services were further unforeseen hindrances. Geir Edvardsen, Skarv transport and installation manager for BP, was reported as saying that engineering firms already working to full capacity was a prime result of the delay.

“In addition to the difficulty in getting hold of vessels and rigs, there is tremendous pressure on engineering services,” he said. “The vendors say they do not have the capacity to take on more assignments.”

In addition, there was a “challenging bed (space) situation due to extension of the scope of the project work in parallel with the needs for beds for ongoing routine vessel maintenance,” said BP.

Despite the delays, the project was carried out with an excellent safety record, said BP. With a total recordable injury rate of just 0.27, the project was seen as a huge success.

The expected field life is 25 years, but there are already additional prospects lined up to be exploited once ullage (storage) capacity is freed up on the FPSO, said BP.

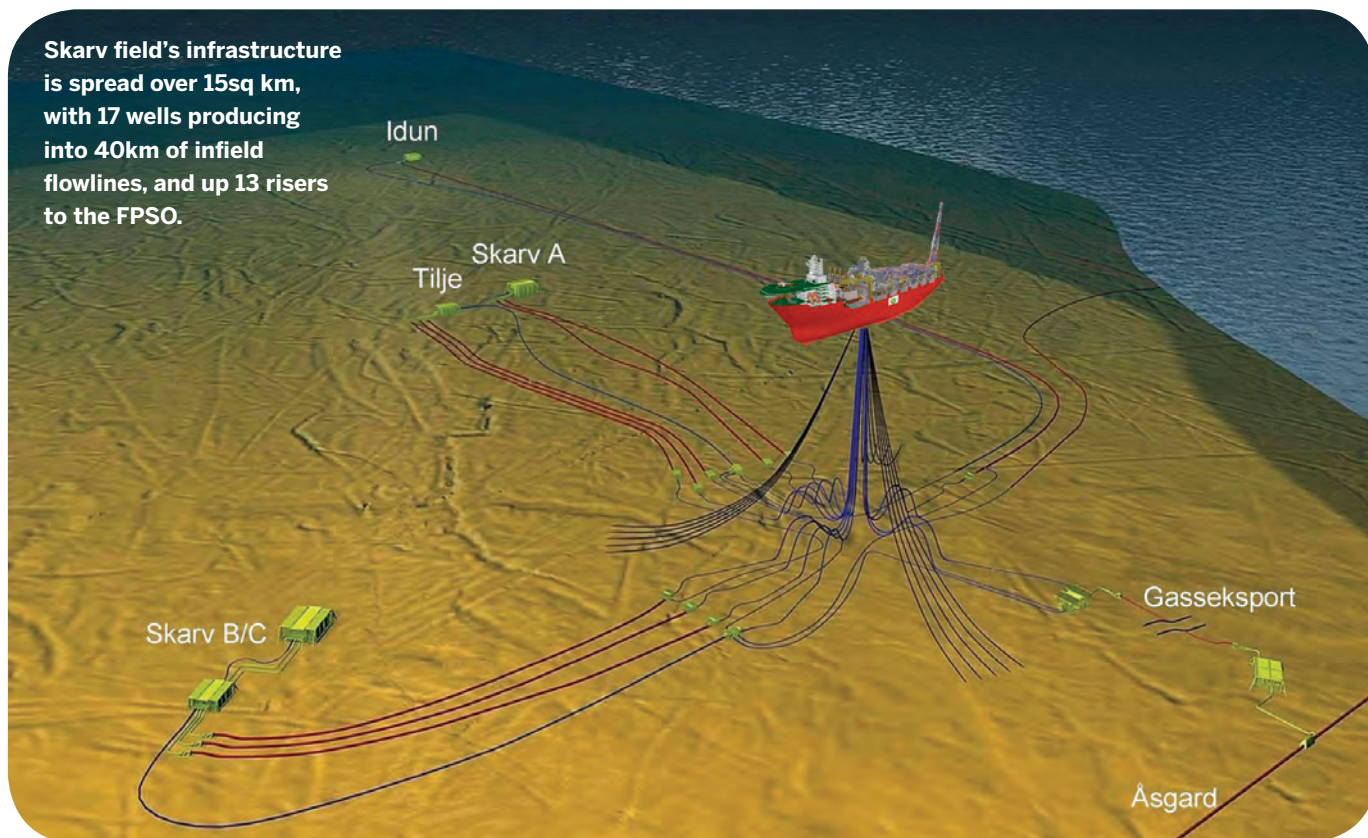
According to project partner PNGiG: “Including the volumes in the discoveries and mapped prospects, total recoverable resources within the Skarv area are estimated to be 20.5MM cu m oil and condensate and 76 billion cu m gas.”

Potential tie-ins include the discovered Snadd South, Snadd North and Grasel structures – all mostly gas – said PNGiG.

BP said: “There is additional exploration potential. Decision will follow once completion of interpretation of seismic survey for 2013 and the outcome of further studies.

“Timing of (additional) tie-ins is dependent on availability of gas processing/export capacity on Skarv and is scheduled for around 2020.”

BP Norway is operator and has a 23.84% interest with partners Statoil (36.17%), E.ON E&P Norge (28.08%) and PGNiG Norway (11.92%) holding the rest. **OE**



Skarv field's infrastructure is spread over 15sq km, with 17 wells producing into 40km of infield flowlines, and up 13 risers to the FPSO.

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Newbuild growth:

Brazil, Africa, SE Asia and Australia

The FPSO market appears to be emerging from the economic downturn stronger than ever, with new project awards and forecasted capital expenditure expected to gain momentum throughout the next five years.

owned by leasing contractors, with SBM leading the way in fleet additions and refurbishments.

Perhaps predictably, Keppel and its subsidiary Keppel Shipyard hold the dominant share of conversion projects taking place over the next five years. Specializing in fast-track modification and fabrication work, key clients include leading lease contractors SBM and BW Offshore. SembCorp Marine's Jurong Shipyard also has a tradition of specializing in conversion projects. In addition, with the FPSO sector expected to be heavily dominated by developments offshore Brazil over the next five years and beyond, Brazil's Odebrecht, alongside its Japanese partner Kawasaki Heavy Industries, is expected to emerge as a key player within the sector. It already secured Petrobras' conversion projects for four ultra-deepwater FPSOs, to be located in the pre-salt Santos Basin.

Awards for newbuild units have also witnessed an increase in recent years, with newbuild solutions generally favored by IOCs developing large fields with longer field life expectancies. Going forward, the newbuild market is expected to be predominately driven by the demand for new technologies and concepts to meet the challenges of harsh environments and challenging reservoir conditions. In addition, with operators turning their attentions toward the natural gas market, the FLNG concept has also emerged, and is likely to form a significant proportion of newbuild investment

over the forthcoming five years. Indeed, recent contracts, such as the one for Shell's Prelude FLNG FPSO that saw construction commence October 2012 at Samsung Heavy Industry's Geoje Shipyard in South Korea, represent a huge step within the emerging FLNG sector, and add impetus for similar developments to receive financial backing. Over the 2013-2017 period, Infield Systems expects four FLNG installations to take place, with additional capital expenditure expected on a possible further eight developments, to be installed during the course of 2018 and 2019.

Infield Systems expects the number of newbuild units entering the market to peak in 2016 and 2017, with Prelude likely to feature as the largest of these new installations. On a global level, the

While challenges certainly remain, strong driving forces, including the movement into deeper, more remote waters, the emergence of FLNG technology and the unwavering ambitions of Brazil's national oil company, are set to support the use of the FPSO concept within the offshore market for many years to come.

Conversions and Newbuilds

In terms of the global active fleet, converted and refurbished FPSOs form the majority share at 68% of operational units as of 1Q 2013. Despite a growth in FPSO developments anticipated to take place in more challenging environments and deeper waters; often necessitating the construction of a technology-specific new build unit, the converted FPSO sector is forecast to remain robust going forward to 2017, with FPSO leasing contractors further strengthening their place in the market. Indeed, of the 12 FPSOs currently under conversion, half are

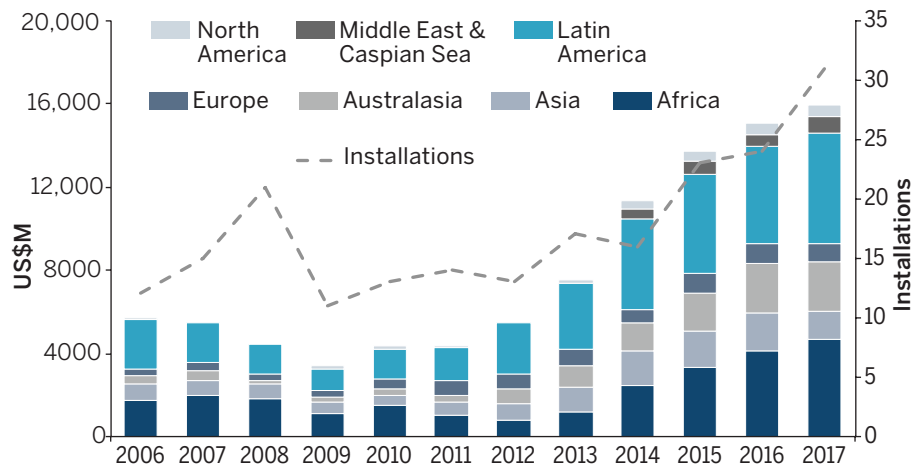


newbuild market will be primarily driven by the regions of Asia and Latin America, with key new-build projects including five units for the Lula area alone, offshore Brazil, Gendalo-Gehem (Indonesia), Rotan (Malaysia), and Su Tu Trang (Vietnam) offshore Asia, all of which are expected to demand significant capital expenditure over the forthcoming five years.

Regional Outlook

While Brazil is expected to remain dominant, holding a 33% share of FPSO global capex and up to 39 installations anticipated to take place before the close of 2017, significant challenges remain in meeting Petrobras' ambitious targets. The key issue facing contractors and operators looking to secure contracts and licences offshore Brazil is the local content (LC) requirements. For an FPSO construction, it has been calculated that about 64% of inputs can be sourced locally, although in reality it has been far less. However, with LC requirements around the 30-35% mark, as seen on the BM-S-9 development and Statoil's Peregrino, going forward local supplier capacity is expected to increase. Indeed, with the construction of 11 new shipyards to keep pace with Petrobras' expansion plans, the industry can

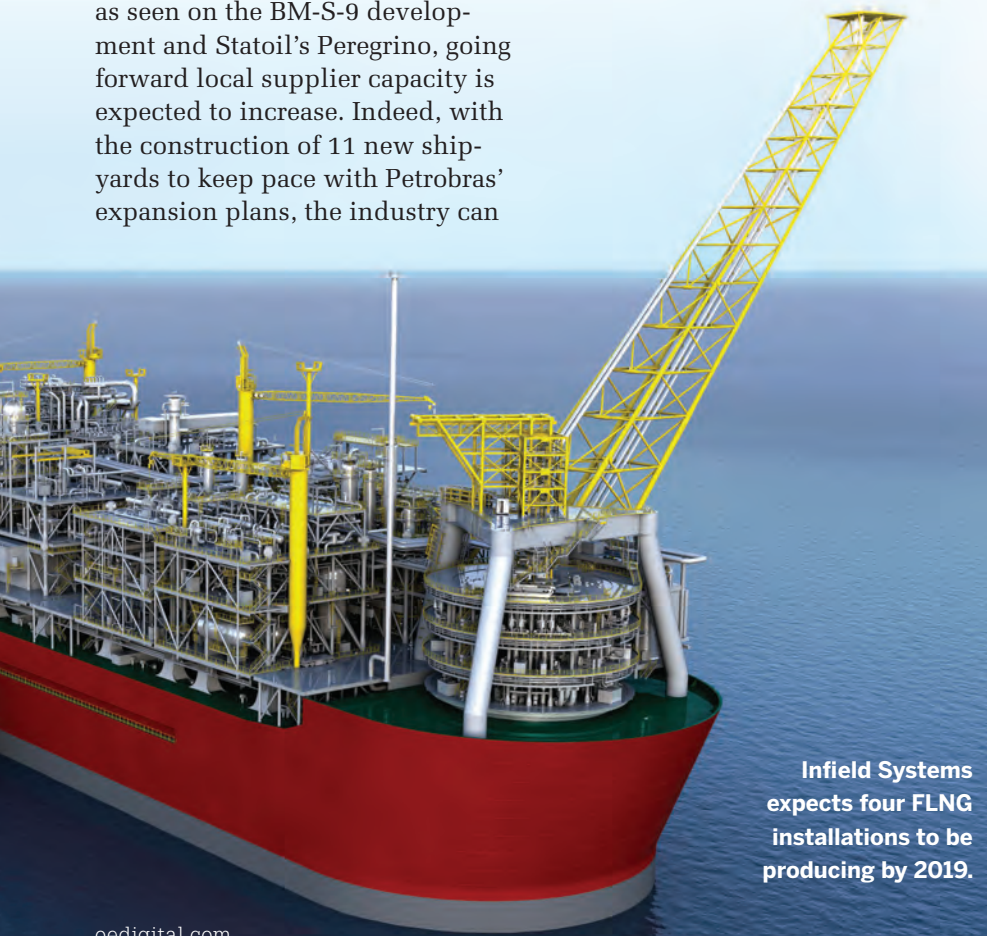
FPSO Installations: 2006-2017



expect the local content percentage of new FPSOs entering the market to increase dramatically over the decade, and the achievement of the Petrobras-set target of 75% LC by the end of the decade is not out of the question. Traditionally FPSO hull constructions have taken place outside the country, with topside fabrication and integration taking place at local yards. However, going forward hull construction is also likely to take place locally,

with eight units currently seeing both hull and topside construction planned at Brazilian yards.

With the scale of Petrobras's field development plans and notable local content requirements, developments within the market and a change of strategy by contractors and operators looking to secure a stake in Brazil's market have been noticeable over recent years. BG Group is one company working with Petrobras on taking a standardized modular approach to construction, which won them the 2010 contract award for eight "replicant" FPSOs. This approach benefits from scale and repeatability, the latter of which in turn enables a higher level of local content to be used, with the transfer of skills and the "learning by doing" effect easily realized. Through improving the efficiency during the construction phase of development, a fast-track to production can be achieved. This concept was most successfully seen through ExxonMobil's "design one, build multiple" approach to the development of the Kizomba A, B and C units, offshore Angola, which highlighted how both efficiency and LC requirements could be met. It is this strategy that is likely to best ensure Petrobras' high ambitions are achieved to timescale and to budget. The recent award of two virtually identical FPSO contracts to Keppel Fels Brazil for the fabrication and integration of the topside modules for the P-66 and P-69 FPSOs rep-



Infield Systems expects four FLNG installations to be producing by 2019.

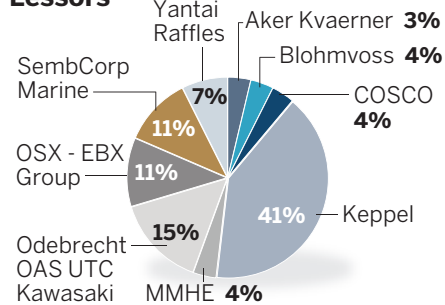
resents a further example of maximizing efficiency and LC demands going forward.

Somewhat surprisingly, with a total of nine new or redeployed FPSO units expected to witness installation offshore UK over the next five years, the country will be placed second only to Brazil in terms of numbers of FPSO installations, while in capex terms the UK is expected to be ranked fifth globally over the period. Despite February 2013 seeing the cancellation of Shell's FPSO development plans for the Fram field, which was set to use an SBM-owned vessel, recent months have also seen more positive news with regards to the future of the UK North Sea and the prospect of several FPSO development solutions taking place in the area. One example is the agreement between Hummingbird Production Ltd, a subsidiary of Teekay Production, for the lease of the Hummingbird Spirit FPSO on Antrim's Fyne Field, in November 2012. Over the next five years, Infield Systems expects leased FPSO units to dominate the UK's FPSO market, with Teekay currently holding three contracts for the aforementioned Fyne field, in addition to the Beechnut and Catcher developments. While converted leased units are expected to dominate, Infield Systems also forecasts two newbuilds to be installed offshore UK during the same period; on the KNOC operated Harris (Western Isles) field and BP's Schiehallion development. Elsewhere in the NWECS region, December 2012 also witnessed the start-up of BP's Skarv field, where a new-build harsh environment-adapted FPSO is expected to be operational for 25 years. Going forward to 2017, Infield Systems expects a further three FPSO units to see installation within Norwegian waters including the two newbuild units of Knarr and Goliat.

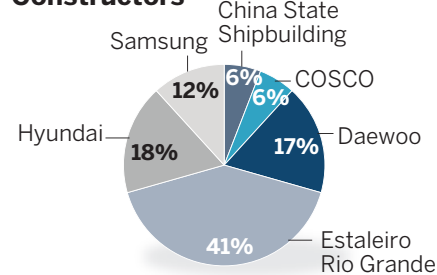
Offshore Asia 30 FPSO installations are expected to take place between 2013 and 2017, compared

with just seventeen installations between 2008 and 2012. In contrast to Latin American FPSO developments, where the average tonnage per unit is anticipated to be over 200,000m tonnes and is situated in an average water depth of almost 1600m, offshore Asia the average tonnage of FPSOs is expected to be around 120,000 tonnes over the period, with average water depths of just 160m. Currently one new-build unit is under construction; the Enping 24-2 FPSO at the Dalian

Lessors



Constructors

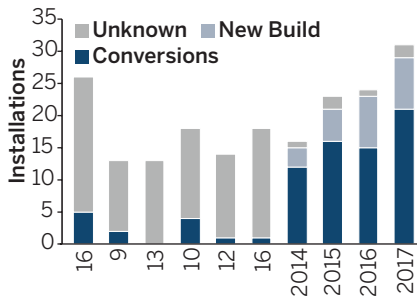


Shipbuilding yard in Liaoning, China. A further four FPSOs are currently undergoing conversion, with two units, the Cendor and Balai FPSOs to be installed offshore Malaysia during the course of 2013. The PetroVietnam operated Thang Long FPSO offshore Vietnam and ONGC's Mumbai D-01, offshore India, are also expected to see installation before the end of the year. Over the forthcoming five years, Malaysia and Indonesia are expected to continue to be the primary drivers of the FPSO market in Asia, each with eight units expected to see installation over the period. Offshore Malaysia key projects include two FLNG developments; the Petronas FLNG FPSO-1 and FPSO-2 to be located on the Kanowit and Rotan fields. June

2012 saw Petronas award a Technip-Daewoo Consortium a \$2 billion contract for the first of these units, which will include the engineering, procurement, installation and commissioning for the FLNG facility, with hull construction expected to take place at Daewoo's shipyard in South Korea.

Offshore Africa FPSO activity is also expected to remain strong; with Infield Systems forecasting 19 FPSO developments over the next five years. Here, Angola is anticipated to continue to dominate the FPSO market, with eight projects in the planning or construction phase, all of which are likely to be completed before the close of 2017, including the giant newbuild CLOV FPSO and the Gindungo (Kaombo1) FPSO, for which operator Total has selected a converted design. Nigeria is expected to see less activity than in the previous five years, with just three installations expected; matching the number of anticipated installations offshore Gabon across the same timeframe. Significant challenges for operators wishing to undertake capital intensive FPSO developments remain across the region, particularly offshore Nigeria, where local content demands and project risks continue. Furthermore, with the uncertainty surrounding the much delayed Petroleum Industry Bill (PIB), foreign companies are growing increasingly wary about committing to investments in new projects within the country. In addition, traditionally a large proportion of Nigerian exports have been destined for the North American market, but with the sudden rise of the shale gas market, exports to the USA are in decline. Elsewhere in the region offshore activity remains strong, with FPSOs destined for the Etame, Duffafu Ruche Marin and Iguega fields, offshore Gabon, and also planned for fields offshore Cameroon, Congo (Brazzaville) and in the north on the Cosmos South field, off Tunisia. Ghana's offshore development is anticipated to remain robust throughout

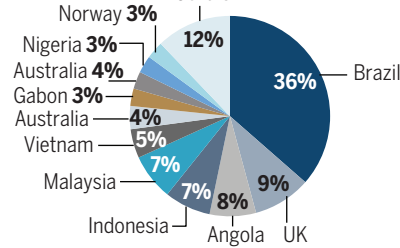
Build Type



the remainder of the decade, with Infield Systems forecasting an additional two FPSO units to be installed on the Tullow-operated TEN (Deepwater Tano) and Eni's Sankofa fields during 2015 and 2017 respectively.

In regions not traditionally associated with FPSO development, the coming five years are expected to witness several milestone projects, with the Australasian market in particular emerging as a hub for FLNG development. Indeed, over the 2013-2017 timeframe, FPSO capital expenditure within the Australasian region is expected to increase

Installation



from 9% to an 11% share of the global market, surpassing both Asia, despite its considerably larger share of installations (30 compared to Australasia's 4), and Europe.

Offshore North America, Infield Systems expects an additional FPSO to be installed within the Gulf of Mexico. This will occur on the ultra-deepwater, Shell-operated Stones field, following the Petrobras-operated Cascade FPSO in 2011, the first FPSO installation in the region. Offshore western Canada, the Douglas Channel FLNG FPSO is also expected to enter production before the end of

the period. Both developments are anticipated to be newbuild units, with North America forecast to form a 2% share of the FPSO global market in capital expenditure terms.

Offshore Middle East, a region with no prior FPSO development, Infield Systems expects for the South Pars FPSO, operated by the Petroiran Development Company (PEDCO) to see an installation during the period, while capital expenditure is also expected to commence on the Leviathan and Tamar FLNG FPSO developments, offshore Israel. **OE**

Catarina Podevyn has been an analyst with Infield Systems since 2008, has worked across various sectors, and authored numerous articles and publications. Her core expertise is the floating platform sector, and both the deepwater and ultra-deepwater markets, particularly offshore West Africa and Latin America.

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Asset integrity and life extension: Key themes at SNS

Elaine Maslin reports on the Southern North Sea 2013 Conference, organized by East of England Group

With a large fleet of often unmanned and aging platforms, operators in the predominantly gas producing Southern North Sea (SNS) are having to face asset integrity issues head on.

It is a complex task. Declining production and rising operational costs need to be balanced with maintaining infrastructure and its integrity while hunting for additional reserves and infill opportunities.

It is not all about decline either. There has recently been renewed optimism in the potential for mate-

rial new finds in the SNS - despite being the most mature area of the North Sea.

Last year the development of the Cygnus field was sanctioned. Cygnus is the largest find in the SNS in 25 years and will include five jackets when it comes onstream in 2015, contributing 5% of the UK's production.

Bill Cattanach, head of the Pilot secretariat, part of the UK Government's Department of Energy and Climate Change, said: "There is still a lot of opportunity in the SNS. There are six new developments in the medium term. We've still got 15% of the remaining UKCS reserves here. It is very mature, but we're still seeing new projects coming forward like Cygnus.

However, speaking at the

Southern North Sea Conference 2013, he added: "There are challenges. Wells are starting to lose pressure, water is starting to come in to wells and I think another issue is ensuring that we can find more innovative ways to get better contact between the well string and hydrocarbon sands. If we're successful in doing that, we will see the life of the SNS being extended considerably."

Perenco is the largest operator in the UK SNS, with 18 fields, 30 platforms, 210 wells (16 subsea), 1600km of subsea pipe work, and the Bacton Gas Terminal.

Tie-backs and marginal fields are becoming increasingly important for future production, making maintaining existing infrastructure crucial, said John Sewell, Perenco

Delivered in May 2011, the SWIFT10 independent-leg, cantilever jackup rig is now drilling off the Netherlands for NAM, a joint venture of Shell and ExxonMobil, under a 5-year contract.



UK operations manager. However, some of this existing infrastructure is around 40 years old and past its intended life span.

“I firmly believe there are another 20-30 years left in the SNS, if not beyond,” he said. “We have assets that are 40 years old and we want them to carry on for another 15-20 years. This does add costs. Integrity management in the SNS is about looking after a large number of assets, many unmanned, which makes the job harder.”

ONEgas, which has 90 producing fields and 50 jackets across the UK and Dutch sectors of the SNS, produces 200,000boe/d.

Ante Frens, ONEgas asset manager for Shell, said to extend life production and cost are key.

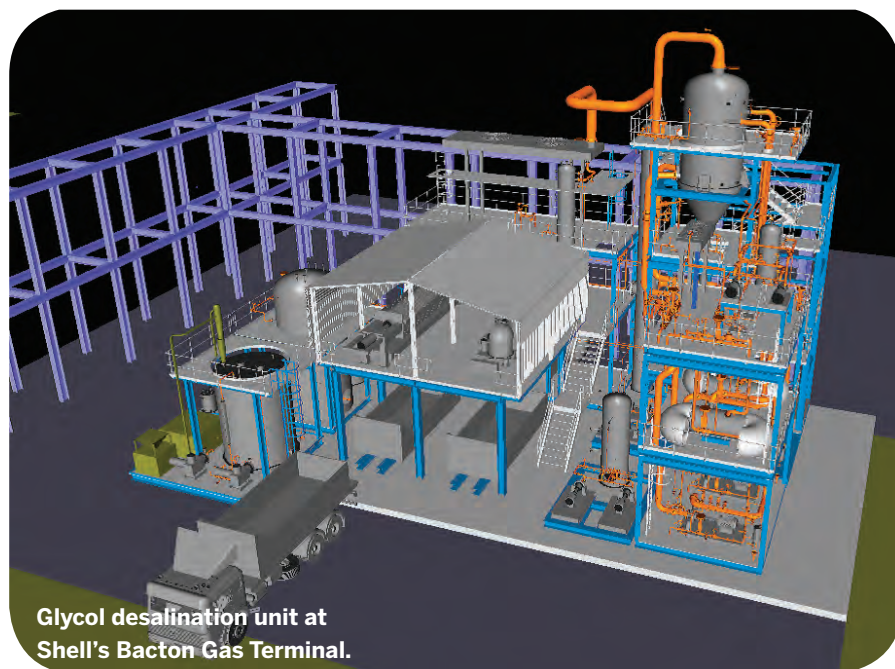
“We stop producing when the revenues start hitting the cost line,” he said. “So how do we extend field life? One, beating down cost and, two, increasing volumes.”

Consideration of asset management has led Shell to gradually reduce the scale of its assets offshore in the SNS over the years. In the early years large platforms with manned processing were built – “big plants, big wells.” But this has evolved into unmanned platforms, including monopoles and even some structures without helidecks, as well as subsea tie-backs - reducing the spread of assets needing maintenance right from day one.

For the existing assets, Shell’s strategy is also reducing what is infield, said Frens. “What we are doing more is actually taking kit away. It is something we learned onshore. It is called decomplexing. Up-time is better because the more kit there is, the more it breaks down (and), the more leaks you have. Taking stuff off is often a better idea than trying to fix it.”

An example was on one of its Dutch systems, operated by NAM (a joint venture between Shell and ExxonMobil), with 16 platforms, multiple satellites and 30MM cu m/d of processing capacity.

Facilities across a complex of



Glycol desalination unit at Shell's Bacton Gas Terminal.

linked platforms are being removed as part of the ONEcal project, in a joint development area operated by NAM with partners Oranje-Nassau Energie, NUON, Wintershall and EBN, including dehydration and compression systems.

In their place, a field-wide process automation system is being introduced. This will enable the de-manning of all but one platform in the group (K14-FA-1) remaining manned.

“We don’t need all of it but we need to maintain all of it,” said Frens. “So what we are going to do is take a whole bunch of it away. We are taking the pressure off, the dehydration, big glycol systems. As a result, you can take the people off. As a result, you can take the gas detection away for large parts, as a result etc.”

Shell is doing the same in the UK SNS sector, but here a new glycol desalination unit onshore is also helping unlock previously closed in gas fields (see story, page 61).

To beat down costs, ONEgas also decided that it was unnecessary to use large costly drilling units in the shallow and more benign SNS. Through NAM, it commissioned a new joint venture rig operator to have a new unit built specifically for use in the SNS. The *Swift 10*,

operated by Swift Drilling, a Van Es Group and Fabricom Oil & Gas joint venture, was launched in 2011. It has automated pipe handling, reduced crane movements, and requires just 50-60 people on board to run it, making operations on the SNS’ smaller fields more economic.

“There is no one ever on the drill floor, it is completely automated,” said Frens. “It is a way to get cheaper, faster holes in the southern North Sea. These innovations are necessary to get more volumes out of the SNS and this is how we are going to extend the lifetime. It’s what Shell is excited about and why we want to stay here.”

GDF Suez E&P UK, which is behind the Cygnus find, also agrees that securing cheaper rates for drilling new wells is crucial to the future of the SNS.

Pierre Girard, area development manager E&P, said: “The size of the remaining operations means we need cost efficient drilling and development solutions.”

Standardization of developments would help, he said. But another challenge is access to infrastructure for small fields. In the Dutch sector it takes three months for an operator to respond with full “sensible” terms and conditions, said Girard. In the UK it can take months.

Having existing infrastructure in place, to tie smaller finds back to, was also important. This makes life extension projects and asset integrity crucial, he said.

However, to maintain integrity, firms need to carry out regular inspections, which can be costly, said Sewell, of Perenco, especially with dozens of unmanned installations to look after.

“Inspection activity is key to asset integrity, but it is expensive and time consuming, especially when you have to build scaffolding or put people on ropes,” said Sewell. “One of the appeals to industry is – is there another way of doing it? Are there remote facilities we can use to do this integrity inspection work?”

Mick Bowery, business development manager offshore projects and operations at service firms Petrofac, suggested inspection activities should reflect where a field is in its life.

“What is the point of a five yearly

inspection on equipment if COP (cease of production) is in four years?” he said. “The strategy needs to be revised. It is the same for repairing or replacing equipment and process simplification. Also, how can we use equipment on more than one asset? We’re looking at federal contracts, sharing equipment across assets on almost a pay as you go basis.”

However, while operators are by definition managing these assets, it is more often than not service providers like Petrofac that come to carry out the extension or maintenance work, from dealing with corrosion or collision problems to subsidence or extension and modification projects.

Rowan Patterson, business development manager at Claxton Engineer, said to do this it was crucial for suppliers to have access to adequate records of a facility – of the original structure as well as any modifications made and changes to the safety case.

“We have seen in the past many places or platforms that had very few records at all and that involves a lot of additional work when it comes to modification and extending the life of an asset,” he said.

Tim Walsh, senior vice president global asset integrity, Lloyds Register, also said supply chain policies needed to be aligned to the aim of the particular asset.

He also said the industry could learn from other sectors where complete asset management systems and plans were more commonplace, such as in the utility and transport sectors. These looked at life extension and future uses - such as gas storage solutions in the SNS - early on, he said.

“Future gas storage plans should be part of an asset management plan, for example,” said Walsh. “A strong asset management plan will reflect a strong business performance but it needs to be joined up,” he added. **OE**

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New facility opens marginal fields

Formation water in older fields may require investment to unlock marginal fields. Shell's facilities in the southern North Sea apply both offshore solutions as well as onshore solutions, to manage the water and salt.

Now Rob Nibbelke, plant installation manager for Shell at the Bacton gas terminal, is working on what is within Shell globally the largest glycol desalination plant – and likely the largest of its kind in the industry.

It is due to be up and running in 2014 and will enable the start-up of a number of older fields, which had been shut in and in which Shell expects there to be formation water, as well as giving Shell more flexibility in how it deals with formation water in its business there.

The new unit will be able to remove 50 tons per week of salt. It will also be a two-step process,

taking calcium ions out as well as sodium chloride.

"Historically a lot more processing was done offshore," said Nibbelke. "For example, in the SEAL system feeding the Shell Bacton plant all processing is done offshore. These days, new projects tend to aim to minimize offshore processing by transferring all well fluids onshore. Examples are Ormen Lange, Pluto and Gorgon."

Formation water, and how it is dealt with, is an increasing problem in the basin.

"It is an example of where we are challenged at the end of field life, our operations can become more difficult," said Nibbelke. "Water can enter the well from the side or from the bottom of the reservoir." "First of all it is hard to predict when it will occur and by what amount and second it is highly saline, which means you have a lot of salt to handle as

well as the water."

Shell's variety of southern North Sea assets, stretching from satellite platforms to hubs and an onshore terminal, offer a number of solutions.

"One option, the ideal, it to remove the salt at source," said Nibbelke. "But this is not always technically available to do in an effective manner."

On some platforms the formation water can be reinjected or pumped overboard if it meets regulatory approvals.

"You could route the water to a nodal (hub) platform and take it out there, which we do at the Sean platform," said Nibbelke. "Sean was installed with a TEG deep dehydration system from the start of its life. You could also route water all the way to the gas plant and take the water and salt out at that time. We are using all these options depending on the constraints and circumstances." **OE**



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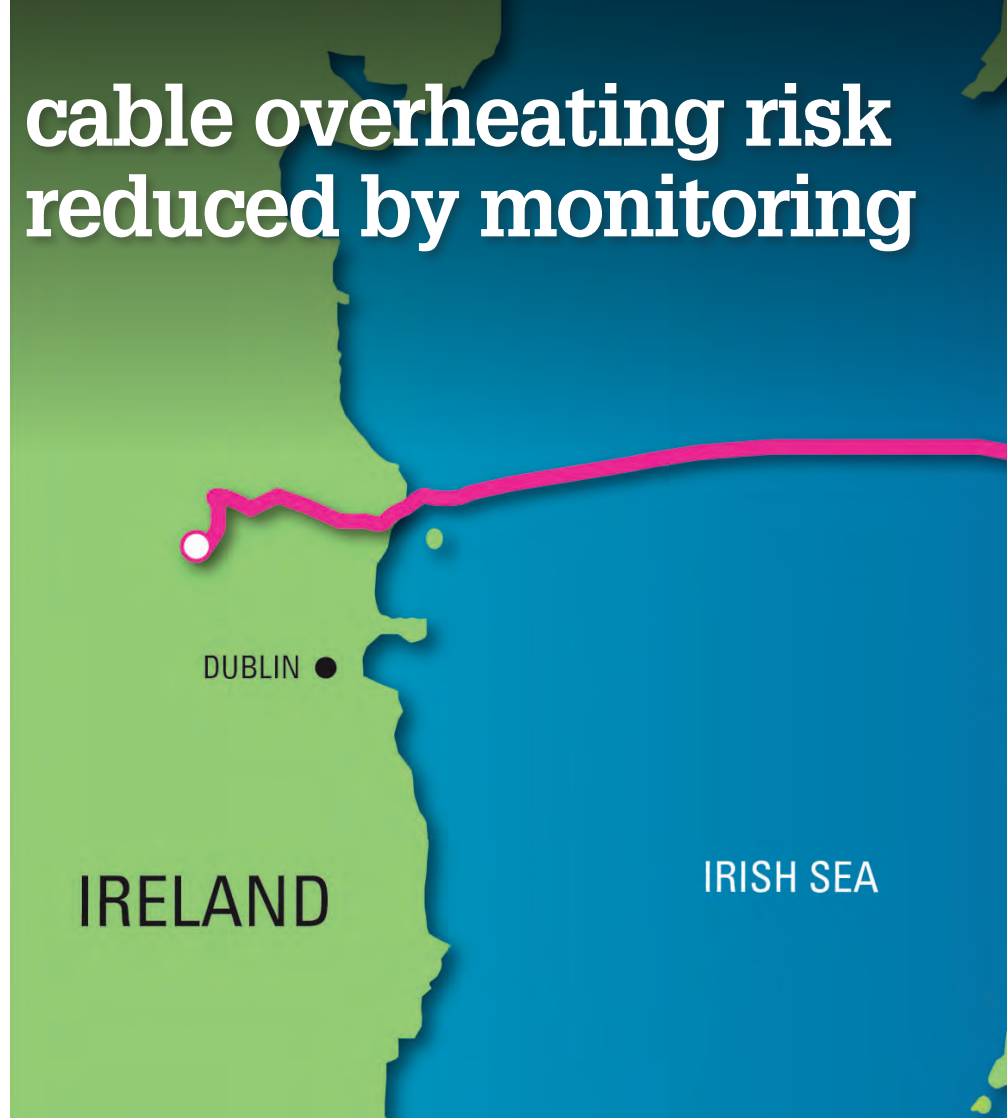
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Subsea cable overheating risk reduced by monitoring

A 278km-long high-voltage power cable was recently installed between Ireland and Wales. **Gary Parker** of Sensa, a Schlumberger company, describes how a distributed temperature sensor (DTS) system is monitoring the performance and safety of critical parts of the cable in real-time.



Large subsea cable installations such as the country-to-country interconnectors and cables used to power subsea oil fields, are high value assets costing hundreds of millions of dollars. If these assets fail due to overheating, the results can be catastrophic. Knowing the temperature of the cable allows operators to extend its life by reducing the power load in the event of an over-temperature.

Additionally, with the assurance that the cable is operating within safe temperature limits, operators can increase and optimize cable utilization.

Power cable temperature

Although rare, there have been several examples of failures in power cables due to operation at excessive temperatures caused by high loads.

This can result in catastrophic

damage to the cable and possible blackouts.

Every shutdown has a major impact on revenue.

A classic example of over-temperature occurred in 1998 in Auckland, New Zealand, when a 110kV cable overheated and caused a blackout in the city for about a month. It is probable that this failure could have been avoided by monitoring cable temperature.

Monitoring provides other advantages, including:

- Maximizing power cable utilization: Cables are typically rated conservatively; often well below their effective capacity. If temperature is continuously monitored, it may be possible to safely load a cable above its nominal loading rating.
- Hot spot detection: The appearance of new hot spots in a cable can indicate changing



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are simple to operate and are reasonably accurate. Resistance temperature detectors (RTDs) are another common type of sensor. They offer higher precision than thermocouples, but are more expensive and are relatively fragile. In cable-rating, a resolution of $\pm 1^\circ\text{C}$ is often more than adequate, therefore higher resolution provides no benefit.

One disadvantage of thermocouples and RTDs is that they are susceptible to electromagnetic interference (EMI), which may distort the temperature reading. An alternative is to use thermo-optical temperature sensors. Semiconductor-based temperature sensors, which can also use infrared, are not affected by EMI and are more suitable for cable monitoring.

A key disadvantage inherent to monitoring the temperature of a long cable with point measurements is that they only detect the temperature at discrete locations. The cable temperature is unknown where there is no sensor. If, for example, seabed sand was deposited on part of the cable causing a localized hotspot that could lead to permanent damage, this would not be detected unless a sensor was located on that particular part of the cable.

Distributed temperature sensing (DTS) systems use an optical fiber that can provide a temperature reading every 1-2m along the entire cable length, overcoming gaps in a point measurement temperature profile. The location of the fiber is important; the closer it is to the cable conductor, the more accurate the measurement will be. An advantage of optical fiber is that it can be located inside the insulation of the power cable, which is close to the core.

If this is not possible, good results can still be obtained when the fiber is strapped to the outside of the cable.

DTS systems can measure temperatures over very long

conditions that should be investigated.

- Power overload management: Systems in which one cable can be safely loaded above its usual rate while another cable is out of service.
- Plotting seasonal/yearly trends: Cable temperature data can be compared to historical records.
- Deferring capital expenditure on new cables.
- Detecting and locating faults in a cable.

In 2011, a failure occurred in the power supply provided by a cable running through an umbilical line to the Kupe offshore platform located in the Taranaki Basin, offshore New Zealand. The operator of the field lodged a warranty claim due to the cable failure. In addition, an insurance claim for US\$95 million was lodged relating to the failure.

If the operator had used cable

temperature monitoring, it could have established in court whether the cable was truly at fault.

Temperature detection

There are two measurement methodologies for measuring temperature: point measurements and distributed measurements.

Point measurements can provide the most accurate method of monitoring temperature, particularly when directly measuring the copper core of the conductor. However, when the conductor carries large electrical currents, direct measurement is only suitable for safe laboratory applications and is not practical for field installations. The alternative is to install a temperature sensor on the external surface of the cable.

Thermocouples are the most commonly used external temperature sensors. They

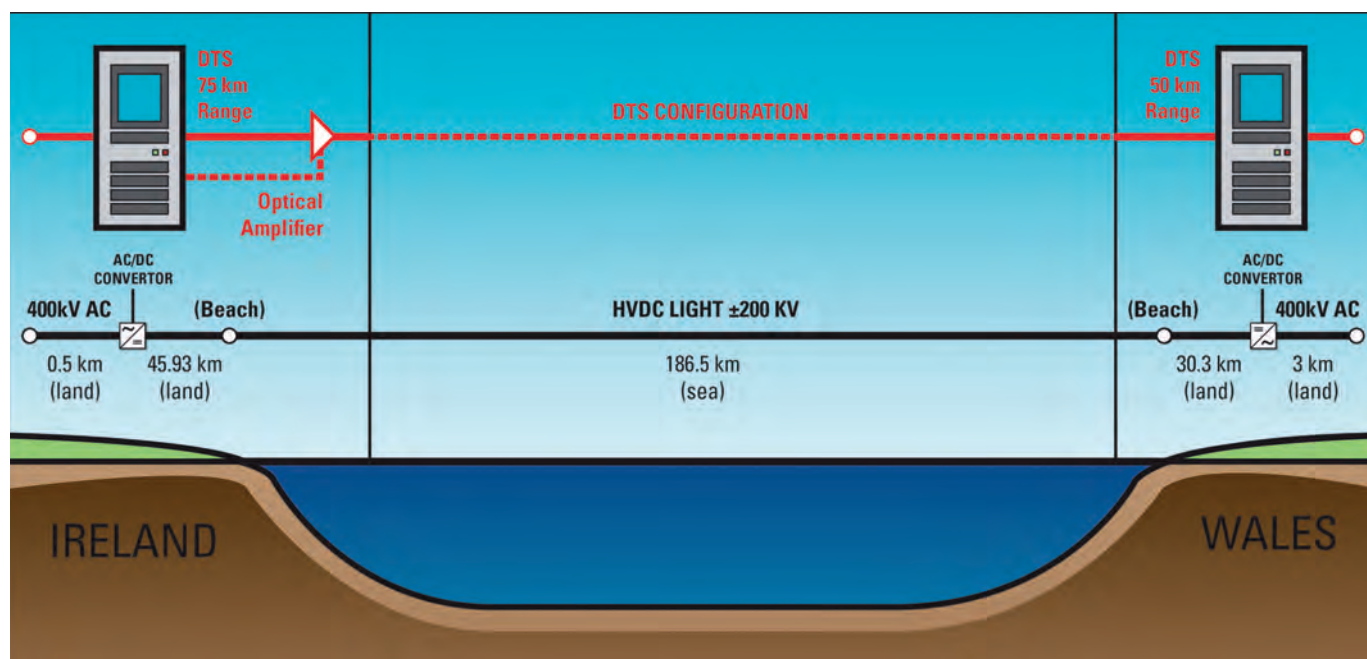


Figure 1. The DTS was installed during 2012 and was commissioned last October. In Ireland, it includes an optical amplifier. The HVDC cable is in black and the DTS system is in red.

distances. No electrical power is used around the measurement zone; therefore they are intrinsically safe. The fiber is a practical and robust material that can be installed to measure temperature in a wide variety of locations.

Cable between Ireland and Wales

Ireland is currently taking some of its older coal-burning power stations offline. A subsea cable has been installed to allow the country to purchase base-load power from the UK. Additionally, when local weather conditions lead to one or the other country producing an excess of renewable energy, it will be possible to sell that energy to the other country.

ABB Sweden was awarded a turnkey contract by EirGrid, operator of Ireland's national electricity grid, to supply and install the high-voltage, direct-current (HVDC) power cable between Ireland and Wales. Known as the East-West Interconnector, this underground and undersea link has the capacity to transport 500MW – enough energy to power 300,000 homes. ABB asked Sensa to provide a solution to monitor temperature at critical points along the cable, which is

about 278km long. Sensa is the inventor of DTS technology and has been designing, manufacturing, and supplying systems to power transmission and distribution markets worldwide since 1991. For the East-West Interconnector, the company deployed its Sensa Prime integrated long-range power cable monitoring system for temperature and strain to provide a temperature reading at 2m intervals all along the cable, which is a much finer sampling interval than can practically be achieved with classic temperature probes.

The maximum measurement range of a single-fiber optics DTS system is currently about 50km. On the Irish side, ABB wanted the DTS control hardware to be within an electrical substation located 45km inland and to be able to measure the temperature of the cable for a further 25km subsea from the shoreline. This would mean a single measurement length of 70km, which was beyond the range of a normal DTS system. The solution from Sensa was to include an optical amplifier that extended the range of the DTS system by the required 20km.

The amplifier has no electrical or

mechanical parts; it simply transfers light from a donor fiber to the signal fiber, thereby boosting the signal. The amplifier itself is compact, with dimensions similar to a DVD disc. Two optical fibers enter the amplifier and one fiber leaves. The amplifier had previously only been supplied by Sensa for use in monitoring oil and gas pipelines, but the experience gained in the oilfield proved to be transferrable to this commercial power transmission project.

Specific requirements for monitoring the East-West Interconnector included storing three months of hourly cable temperature measurements taken at 2m intervals along the route. Graphs of the cable temperature profile can be plotted for any given set of readings. The DTS can be remotely programmed and interrogated. The system, which is self-monitoring, was successfully designed and installed, and was commissioned in October 2012 (Figure 1).

The DTS system provides the 3D function of temperature, distance, and time. The actual temperature data of the East-West Interconnector cable is confidential, so the example DTS data presented in this article

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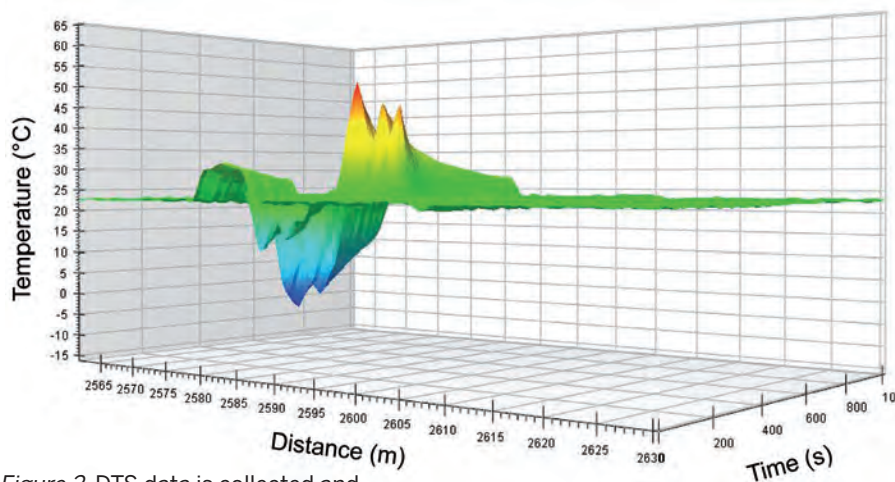


Figure 2. DTS data is collected and displayed as a 3D function of temperature, distance, and time.

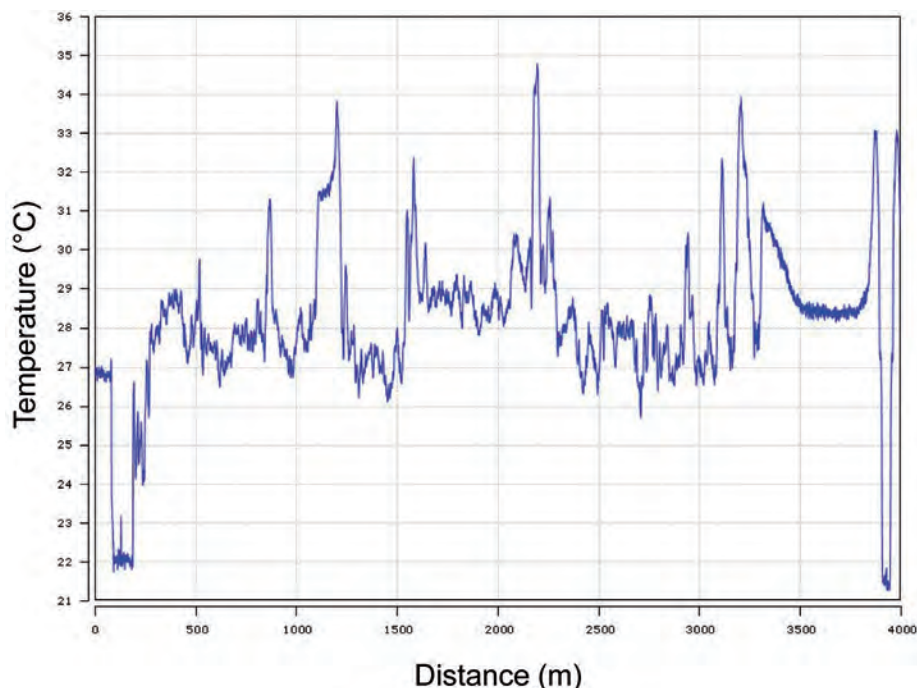


Figure 3. This DTS example from another installation demonstrates how easily hotspots can be identified to guide workers to within 2m of any problem.

are from other installations. However, the data demonstrate how hotspots can be easily identified so that, if necessary, an investigation team can be guided to within 2m of the correct location (Figures 2 and 3).

The DTS system is providing EirGrid with valuable data on the health of its East-West Interconnector cable. The measurements enable the cyclic (daily, monthly, and yearly) behavior of the cable to be established, providing a basis from which variations in its usual thermal behavior can be analyzed. The system can be programed to

trigger an alarm message if the cable temperature in a particular zone exceeds a predetermined temperature limit. The DTS information will allow the company to extend the life of the cable by reducing the power load in the event of an over-temperature. Alternatively, with continuous monitoring, utilization of the cable can be increased with the assurance that it is operating within safe temperature limits.

Realizing the value of assets such as power cables requires using them at their optimum capacity. Real-time temperature monitoring enables the prediction and

detection of possible problems such as thermal runaway. Appropriate action can then be taken to reduce the load. DTS systems are also useful for locating hot spots on the cable. Once identified, these can be rectified, so that the cables can be operated at their nominal temperature. Temperature trends identified from the DTS measurements enable the power distributor to maximize the use of a circuit during periods of peak loading such as mid-summer.

Future considerations

The hardware already installed in this DTS application has the potential for several enhanced functions.

One of these is a real-time rating system that would allow the operator to automatically generate cable power/load calculations, based on the real-time cable temperature. Using the same fiber optics, it is also possible to install intervention monitoring systems that will inform the operator when a third party is performing an action that may damage the cable. For example, it could detect if a ship has dropped its anchor above the cable.

Similar systems have been used to find short circuits, and can inform the operator where the fault is to within a few meters. **OE**



Gary Parker is a technical sales manager at Sensa, a Schlumberger company, focusing on providing solutions to the power transmission industry in Europe and the CIS. His responsibilities include developing opportunities in emerging markets. Parker holds a Bachelors degree in electrical engineering from the University of Lincoln, UK, and a Masters degree in electronics from the University of Lyon, France. He is a member of the Institution of Engineering & Technology (IET).

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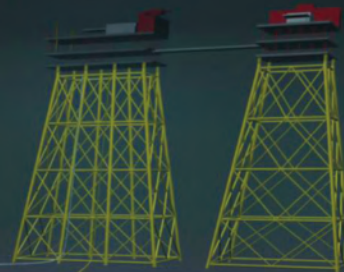
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Subsea tiebacks: The latest strategies



Après the moratorium of deepwater drilling in the Gulf of Mexico, operators are once again exploring for opportunities offshore. Yet, escalating costs for production facilities can prohibit the profitability of some marginal fields. **Jeannie Stell** explains why innovative subsea tieback technologies and strategies make all the difference.

The energy industry is entering a period of profound transformation as new technologies and innovations reshape the landscape. In fact, “the one constant in the industry will be innovation,” according to Daniel Yergin, vice chairman of IHS and author of *The Quest: Energy, Security and the Remaking of the Modern World*.

Supporting the innovation trend is some \$223 billion expected to be spent on deepwater projects and technology during the next five years. According to a recent report by consulting firm Douglas-Westwood, the expected capex is a large increase over the firm’s previous estimate of \$139 billion-spend for 2012 through 2016.

Yet, challenges lie ahead, especially for long-offset and deepwater wells. High-cost platforms and spars can havoc with tight economics as field architecture favors fewer count wells with extraordinary productivity spread out over larger sea floor areas. As a result, subsea tiebacks, and new innovations thereof, are becoming increasingly attractive. Even the surface-breathing hardware for gathering, initial processing and metering are giving way to sea floor mounted equipment, doing the same job, next to the field and

with far less cost than that of the bottom founded or floating support structure. Many E&P companies are turning to subsea tiebacks to link multiple wells to a single facility/hub, either their own or those owned by third-party operators, to enhance efficiency and economics.

Innovative riser

In March 2012, Anadarko and its partners in the Caesar-Tonga play achieved first oil from their deepwater project in the Green Canyon of the Gulf of Mexico while using new technology—the lazy wave riser—to move some 50,000b/d of oil and 50mmcf/d of gas from three producing wells. The field’s reservoirs are Miocene age and subsalt.

Caesar-Tonga wells are drilled through as much as 15,000 feet of salt canopy before exiting into rock formations just above the reservoir. In fourth-quarter 2012, Anadarko finished drilling its fourth development well in the field, which it expects to complete and bring on line in second-quarter 2013.

The company is using new lazy wave riser technology to great advantage in the play. The steel lazy wave riser, specifically designed for the Caesar-Tonga project, is not a

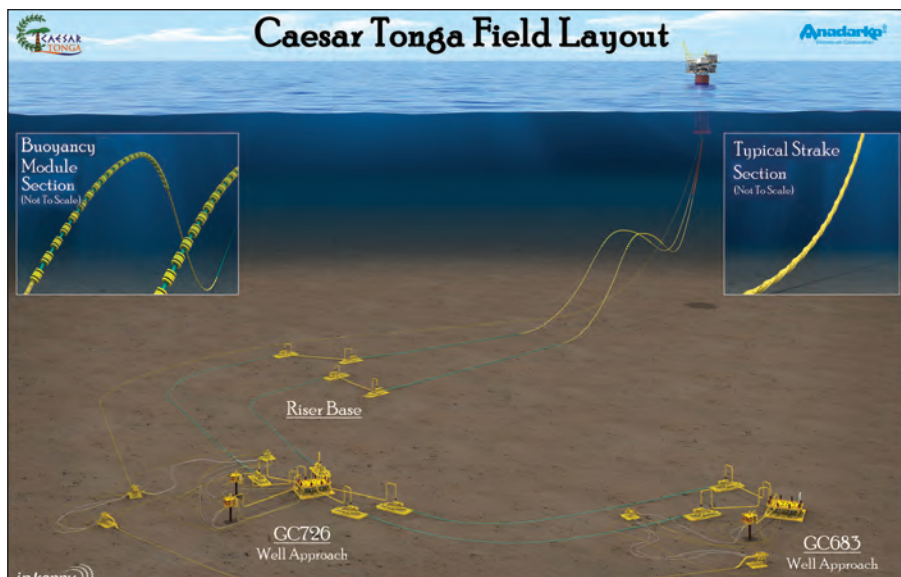
DGE Condor subsea tieback: Parker Energy Products supplied the umbilical depicted for DGE’s Condor subsea tieback.

true steel catenary riser, but rather a variation on the steel catenary riser theme with added buoyancy and flexibility.

Among the innovative components of the project, the riser flow lines utilize pipe-in-pipe technology in which a specialized insulation layer is placed in the space between the two pipes. This high-strength steel pipe-in-pipe technology acts as the fluid conduit with a number of buoyancy modules to create an arch in the riser. The arch improves the flow lines’ performance by keeping stresses in the pipe within allowable limits as the spar moves under the influence of external forces.

To create the arch, 160 discrete buoyancy modules were installed on these risers. The risers must depart the spar at a slight angle and gradually curve across and up to form the arch. The riser shape then takes a downward bend until it touches the seafloor.

“Operating in 5,000 feet of water is a challenge that requires experience, confidence and a safety-first mindset,” says Mike Beattie,



Source: Anadarko Petroleum Corp.

The steel lazy wave riser, specifically designed for the Caesar-Tonga project, is not a true steel catenary riser, but rather a variation with added buoyancy and flexibility.

Anadarko’s general manager of Gulf of Mexico deepwater facilities. “That also contributes to the primary engineering challenge of successfully delivering the Caesar-Tonga project, as it required a

deepwater riser system that would safely overcome the challenges of a complex deepwater environment and that could operate under the high producing pressures expected from the Caesar-Tonga reservoirs.”

The partnership was also challenged to significantly expand the capacity of its existing Constitution spar floating production facility with the addition of nearly 1,300 tons of processing equipment to the topsides of the facility. In response, the project team designed the two riser systems, the flexible riser and the steel lazy wave riser, concurrently.

The project design team also required that flow lines, risers, manifolds, trees and multi-phase flow meters accommodate an environmental pressure of nearly 13,000 psi. After qualification testing, the partnership selected the steel lazy wave riser design, making this the first application of such technology in the Gulf of Mexico and only the second application of this technology in the world.

“The Caesar-Tonga mega project provides an illustration of the value of Anadarko’s hub-and-spoke philosophy, as it was able to avoid

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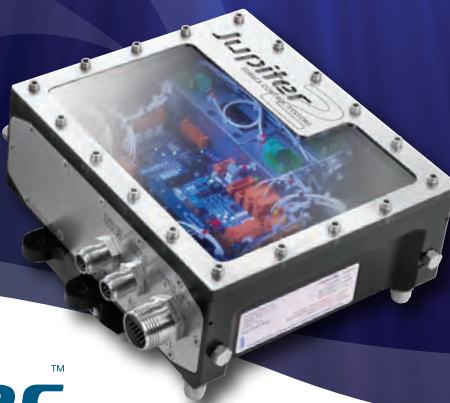
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“LLOG uses tiebacks because many of its prospects would not support their own floating production systems.”

— Rick Fowler,
vice president of deepwater projects, LLOG.



almost \$1 billion of capital investments that would have been associated with the construction and installation of a new host production facility,” says Beattie. “Anadarko’s hub-and-spoke approach to develop area-specific oil and natural gas fields involves making an initial investment in a host facility and producing those discovered reserves as the base project.”

Anadarko’s 100%-owned Constitution spar, the hub in this development, began producing in 2006 from the Constitution and Ticonderoga deepwater fields. Future discoveries will also tie back to the existing infrastructure, sav-

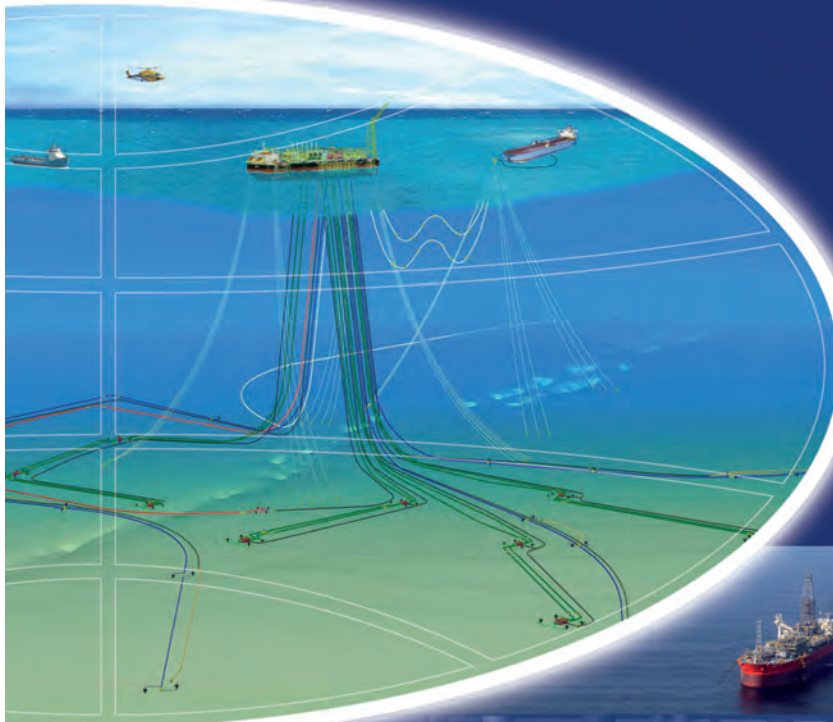
ing significant time and capital. By leveraging the Constitution spar, the company also increased the facility’s production capabilities from a declining asset with 10,000b/d of production to up to 60,000b/d from the three existing subsea wells in the Caesar-Tonga field and the nearly completed fourth. Also, the tieback option enabled production from the field to come online two years earlier that would have been possible with a newly constructed facility.

Subsea experience

Elsewhere, LLOG, one of the top ten privately owned E&Ps in the

US, has been involved in 17 subsea tieback projects during its history, and seeks new, proven technology to continue its success. Currently, its Who Dat development in Mississippi Canyon 503/504/547 is tied back to its own floating production system, which is the only privately owned floating production system in the world. There, LLOG is ramping production up to 20,000b/d of oil and about 22mmcf/d of gas from its three existing wells. Nine more wells are planned. The floating production system can handle about 60,000b/d and 150mmcf/d.

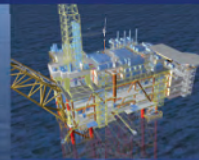
LLOG’s Mandy project in Mississippi Canyon 199 and Goose project in Mississippi Canyon 751 also utilize the technology and are tied back to Total’s Matterhorn platform. The three-well Mandy field is tied back to Matterhorn, and Goose is a single well that is remotely tied into another one of LLOG’s existing subsea systems at MC707, which



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ultimately flows into the Williams-owned Grand Isle 115 platform.

“We also participate in Green Canyon 448, also known as Condor, and Green Canyon 141, which also use subsea tiebacks,” says Rick Fowler, vice president of deepwater projects for LLOG.

In the past, LLOG used subsea tiebacks because many of its prospects would not support their own floating production systems, he says. Today, other metrics continue

to make subsea tieback technology a good choice for the company.

LLOG chose subsea tieback technology rather than using dry trees for its Who Dat field for several reasons. “First, we didn’t feel that the intervention savings were going to be worth it to build a dry-tree solution,” he says. “Second, we bought the Who Dat floating production system on spec, so it was already built and we were able to get it on production a year earlier than with

any other options we were considering. And third, for Delta House, a new development which we operate for ArcLight Capital Partners and is under construction right now, we also chose to go with a wet-tree solution because we plan to centrally locate that floating production system between three other fields that will be tied back.”

Typically, LLOG uses Super Duplex or 19D Duplex stainless steel umbilicals in its systems, and most of its umbilicals are static. “We do have a couple of dynamic umbilicals that typically involve a number of tubes and some quads. In general, our preference is to use proven technology wherever possible.”

LLOG has an alliance with FMC Technologies to provide LLOG’s control systems for all of its subsea projects. Many operators bid out among multiple providers of control systems, but LLOG sees an advantage with sticking with FMC. “We consider that an advantage because we can learn one system and we have one set of contacts with our suppliers. If there is a problem, we are very familiar with the system because we use it everywhere,” said Fowler.

Flow assurance

The company also spends significant time on flow assurance, which is one of the big challenges with long subsea tiebacks, he says. LLOG’s Grand Canyon 448 field is connected with a 34-mile umbilical—the second longest oil subsea tieback in the world.

“When it comes to flow assurance, we have to worry about wax, asphaltenes and hydrates,” says Fowler. “With Grand Canyon 448, we are blessed with good fluid with very small wax content. Otherwise it would be extremely difficult, if not impossible, to maintain flow and temperature above cloud point at ambient sea temperature.”

As a further preventative measure against blockages, the company uses methanol and low-dosage hydrate inhibitors to prevent hydrates,



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where necessary. In the rare case of wax deposits, LLOG has used chemical solutions to reduce the cloud point or minimize wax deposits in the lines. “Thankfully, we’ve never really had to deal with any significant asphaltene problems,” he says.

To detect blockages, LLOG monitors its operations in real time and pays close attention to pressures by using subsea gauges at the wellhead and platform, among other procedures. “We typically install a piggable loop where possible to facilitate the remediation of either a hydrate or a wax plug. If it’s a hydrate, we can blow that out from both sides. For wax, we can use the loop to circulate hot oil.”

Typically, LLOG integrates expandability into its system. For example, if a subsea manifold is required, the company will install a four-slot manifold, although only two wells are imminently planned. “That’s also useful for operations,” Fowler says. “Every once in a while, we might get one tube of the umbilicals that won’t work. Designing the system to be expandable gives us redundancy.”

At Who Dat, the company installed four flexible risers with a two-loop system. During the project, one of the flexible risers was not available. By building in the loop system, LLOG was able to begin production as scheduled without waiting to solve the riser problem.

Third-party hosts

Going forward, Fowler sees possible constraints of third-party host production facility capacities. Many deepwater oil producers pay production facility owners a processing and handling fee, about \$3 to \$5 per barrel, to process, store and offload their production.

“We’ve seen a lot of upward pressure on PHA fees,” says Fowler. “Recently, negotiations for firm capacity have been challenging. Due to the current favorable oil prices, the companies that own host facilities might want to keep that capacity for their own wells, even if there is only

a marginal chance they might need it. It’s better to get \$100 per barrel for your own oil than to get \$4 per barrel for processing someone else’s. That can create a difficult situation for tieback producers.”

Conversely, some host facilities are being designed larger than necessary for the current slate of wells, he says. The overbuilds are likely due to host facility owners looking to gain third-party PHA fees without giving up capacity needed for

their own production. “We are also seeing more host facilities owned by midstream companies, as opposed to operators, for those reasons as well,” he says.

Rick Rainey, spokesperson for Enterprise Products Partners LP, agrees. The company’s Gulf of Mexico Independence Hub platform serves producers with a processing capacity of 800mmcf/d and its gas-volume capacity on its Independence Trail pipeline is about 1bcf/d.

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“This allows the development of these fields because we provide the infrastructure that is already in place to connect to other systems that provide access to the markets,” he says.

Pumping and compression

To support LLOG and its other clients in their subsea-development efforts, FMC Technologies continues to invest in research and development projects for deepwater and harsh environments. “The focus of many of FMC’s current projects is to revitalize old fields or help new fields achieve better flow and production rates and manage longer offsets,” says FMC Technologies’ emerging technologies director, Brian Skeels.

“We continue to incrementally add more to our kit for subsea processing and pressure boosting. We are working to stair-step our pumping technology with liquids and multi-phase flow so we can learn how to do gas decompression better



Umbilical distribution manifold at LLOG’s Who Dat development is tied back to its own floating production system, the only privately owned floating production system in the world.

for the future. Gas is a harder nut to crack than liquids,” he says.

To enhance subsea liquids production, the company has been collaborating with Sulzer Pumps Ltd. to fully qualify a new multiphase 3.2-MW, 5,000-psi helico-axial pump system for subsea high-boost applications. The technology marries Sulzer Pumps’ pump hydraulics with FMC’s high-speed permanent-magnetic motor technology. The new equipment includes

helico-axial multiphase pumps, hybrid pumps and single-phase centrifugal pumps.

Along with new boosting and compression capabilities, FMC is looking to bring more efficient and smaller footprint power and processing to subsea operations, says Skeels. “One difference between pumping liquids and gas is significant increase in power requirements. If it takes 1 MW of power to operate a liquid pump, it takes 10 MW to operate a gas compressor.”

Another challenge is to reduce communication lag time between the subsea control and sensor equipment and operators, which could be several minutes. “Given some extremely long offsets, like going under the ice in places such as offshore Norway and Russia, operators will need to rely more on autonomous and feedback controls at the subsea field to instantly react to changing process conditions, augmenting the command-and control station far away on a spar or plat-

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form. The lag time associated with the remote distance, sometimes as much as 200 km away, could influence the amount of time the operator has to diagnose and react to a problem or changing situation.”

To reduce lag time and losses associated with electric and fluid transmission over long offsets and ultra deepwater, FMC Technology is working on new-generation subsea power and control systems.

“We are working toward what Tyler Schilling coined as the ‘silicon seafloor,’ where resident ROVs service electric-actuated processing valves and localized hydraulic power units at the subsea factory.”

Electric power lines will power and control subsea processing and pumping directly while subsea controls, either electric or electro-hydraulic, will branch off to operate subsea trees and manifolds, he says. “We are still in the early stages, but we see exciting days ahead through the use of ROV robotics, to be a force multiplier of technologies to

give our customers a wide range of flexible platforms to work from.”

Riser technology

Another challenge is the need for new monitoring technology, says Skeels. “In deepwater current and extreme weather places, like the North Sea, where the ocean acts like a washing machine, drilling, workover and production risers are subjected to an increasing number of bending cycles and adverse loads over longer durations. These loads often find their way into foundations of subsea wells while attached to a drilling rig, spar or floating facility.”

Traditionally, wells were drilled and accessed for only a couple of months, then left structurally static on the sea floor while the well was producing. Now, operators are focused on the wells for far longer periods, drilling deeper and performing much more complicated horizontal drilling and completion maneuvers. All of this time under

cyclic loads will eventually fatigue and wear out even the most robust equipment. Risers, wellheads, connectors and casing all have a finite fatigue life, but it depends on the cyclic frequency and amplitude.

“This is where monitoring comes in. Risers soon will need robust, long-term instrumentation to give manufacturers, contractors and operators a real-time scorecard on the cyclic abuse Mother Nature has dished out, and how much remaining life is in their equipment as a result,” says Skeels. “This will give everyone a better understanding of when and where to repair and replace hardware and, more importantly, avoid unforeseen calamities.”

Riser configurations are also evolving. All flexible pipe, top-tensioned steel, flexible risers, and steel-catenary risers are used to tie back to increasing numbers of floating facilities in ever deeper and remote locations. Although the application drives the decision of which type of riser to be used, oper-

ators and fabricators are looking to more novel concepts as fields move into deepwater with field pressures as high as 10,000 to 15,000 psi. The cycle count from harsher environments and higher internal working pressures are demanding thick-walled risers, which can be very heavy. “Just trying to hold them up with a floating surface vessel is approaching technical limits.”

As such, the equipment industry is working to develop new riser materials such as carbon-fiber composites to reduce riser weight. “These new materials seem to have incredible weigh-savings, but we know little about how they react with wellbore fluids or chemical treatment cocktails, nor how they behave mechanically over a long period of time. And we have little indication of what the tell-tale signs are when their end-of-life is near,” says Skeels.

The industry needs to gear up on monitoring technology during the next few years, to quantify the effects that motion and internal wellbore production has on riser performance in general, and new materials in particular. As the number of HP-HT fields increase, the effects of temperature and pressure spikes will need to be added to the data collected from the fatigue by water motion and vessel movement.

“Drilling and production risers,

pipelines and multiphase equipment, and anything that can expand and contract as equipment is turned on and off will have to be monitored for maintenance management. In fact, regulatory entities will probably demand it as time progresses. Materials-monitoring will be one of the new industries in the future.”

While deepwater production operations are exposed to high temperature and pressures, the trees, manifolds, jumpers and other subsea hardware also experience rapid cool-down during shut-in or initial start-up procedures, so the application of very robust insulation is necessary to prevent the formation of hydrates and wax blockage in flowlines. “We have been working hard to push the envelope on that,” Skeel says.

To help protect risers and subsea tiebacks, FMC Technologies continues its research on high-temperature versions of wet insulation. “We’ve been showing our Novalastic HT product, a glass-bead-impregnated foam, at the Offshore Technology Conference and other shows. Current applications can work with wellbore temperatures up to 300 °F. And we are looking at pushing performance to work in long-term applications at even higher temperatures,” he says.

Also, FMC Technologies continues its efforts to increase its modu-

lar approach to subsea equipment field architecture. “I think of these as building blocks,” says Skeels. “We try to make these systems in small blocks so that operators can build whatever they need and deploy those from smaller vessels. Modular design started catching hold in the late 1990s, but now it seems to be more important than ever. So we keep pushing to improve that.”

Going forward, the industry is going to continue to push the limits of technology, forecasts Skeels. “The industry is almost reinventing itself for HP-HT technology. All of the subsea equipment is interrelated, so improvement in efficiencies and controls in every aspect will become increasingly important.”

Parker Energy Products, a division of Parker Hannifan Corp., also supplies tieback technology to LLOG and other deepwater developers, with tieback lengths ranging from 300 ft to more than 25 mi. installed in the Deep Gulf Condor development. The company supplies 316L tubing for shallow water applications, Nitronic 19D zinc-coated tubing, seam-welded super-duplex tubing for steel-tube flying leads and control umbilicals. Parker has worked with LLOG since the company’s first subsea project and continues to supply its Mississippi Canyon development.

“We run the traps to determine the specific characteristics of the field and life requirements, then make a case for the best material, best delivery, and cost-benefit ratio,” explains Craig Anderson, general manager for Parker. “There is a very limited supply of seamless, coiled super-duplex tubing in the world, and again, based on the parameters of the field, that material can be overkill. The seam-welded materials, which are more readily available, are slowly being accepted by the operators as they get more use in the water. Proper welding techniques and better inspection processes show that this can compete against the seamless material.” **OE**



Anadarko’s 100%-owned Constitution spar is the hub for the Caesar-Tonga field development.

Source: Anadarko Petroleum Corp.

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Get ready

for a new phase of West African development

Exploration is expanding from West Africa's Sierra Leone to Namibia, explains **Bruce Nichols**, led by sustained high oil prices, improving technology, relative political stability and a more supportive operating environment.

projects, but the sizes are reduced to six, nine wells rather than the 30, 40 we're currently seeing," says Jim Tait, FMC Technologies sales manager for the Caspian and Africa region.

Even Cobalt's Cameia pre-salt discovery – heralded as possibly the first of a new herd of elephant finds — could have a counterintuitive impact. As big as it could be, it could actually mean fewer wells and more centralized production, experts say.

The reason: pre-salt development is deeper and will allow greater directional drilling reach. The post-salt West African geology is shallower and has yielded big finds but has dictated sprawling fields

with many wells because reservoirs are too shallow to turn drill bits safely and strike oil from a distance.

"When I think of deeper reservoirs, I do think of the ability to have fewer drill centers and potentially promote a single deepwater facility, which could be a better answer because you can be right over the wells. This may permit lower development and life-of-field costs per barrel, offsetting the higher drilling costs," says Dennis McLaughlin, a veteran of deepwater development in the Gulf of Mexico and off Africa.

"But until you have a real application, and run the technical, commercial, risk and timing tradeoffs, it's not so easy to say

Cobalt's potentially huge Cameia discovery in the deep pre-salt off Angola is one sign. There are smaller, shallower finds by Eni, Hess, Kosmos and others off Ghana, discoveries that will be tied together around hubs or linked to existing infrastructure to make their production financially viable.

Expanding exploration from Sierra Leone to Namibia, outside the West African offshore oil heartland in the Gulf of Guinea, is stretching the province's boundaries. Ever-larger production systems under construction by Total and BP are adding infrastructure.

Growing maturity is taking hold off West Africa, and with it will come tighter focus on more efficient, more complete recovery of the oil and gas. And that means more projects of all sizes and new ways of doing things.

"Once the infrastructure is built... we suspect that as Africa moves forward, the elephant projects will begin to slow down, and there'll be increased focus on smaller satellite projects. We'll see many more

The Cameia discovery in the deep, pre-salt trend off Angola by Cobalt is one sign of a new phase of West African development.





The rifted margins of South America and Africa have similar oil producing basins.

145 million years ago, creating the South Atlantic Ocean.

The coastlines fit together like pieces of a puzzle and have similar oil-bearing geology, a key reason that the US Geological Survey estimates that sub-Saharan Africa contains more than 71 billion boe, much of it under waters off West Africa.

Cameia is the hardest evidence yet of that potential.

“Cameia is truly the first of its kind in West African deepwater pre-salt,” says Jim Farnsworth, chief exploration officer at Cobalt International Energy, adding that it “confirmed the presence of a world-class petroleum system and highly productive reservoirs in the pre-salt.”

Lots of work remains to make the pre-salt productive. Farnsworth said that “2013 will be the year where we move beyond proof of concept wells that de-risked the play, to testing multiple giant structures within the core of this new province.”

Smaller discoveries in overlooked parts of the post-salt also are important. Developments with acronyms for names – CLOV, PSVM, TEN, which combine the first letters of multiple fields – point the way to more complete recovery using a hub and spoke system.

Recent announcements fit that pattern.

In March, Italy’s Eni announced its ninth post-salt discovery off the coast of Angola, Vandumbu. The company described the find in modest terms, but said it increases the resource base of its West Hub.

In 2012, Hess had seven discoveries off Ghana. The company has declined to discuss their size or

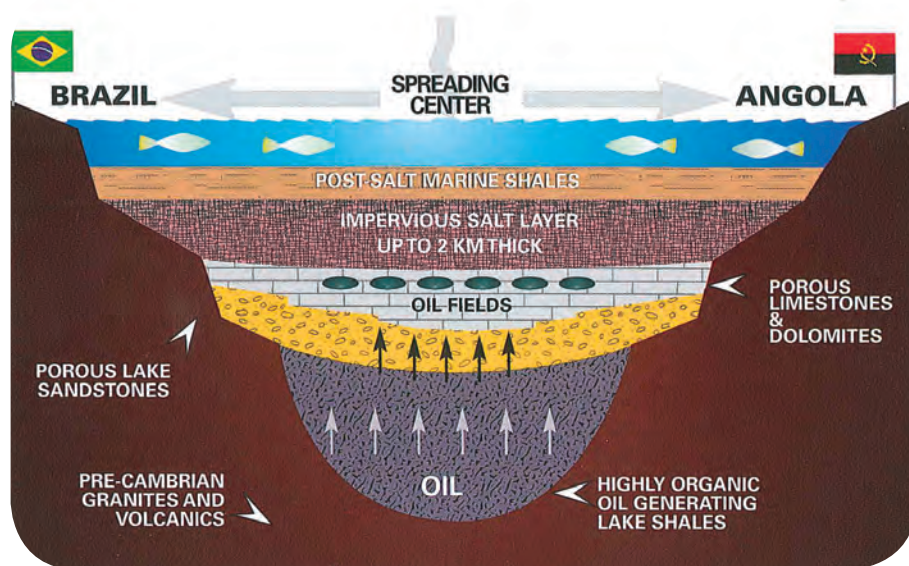
what will be the best development plan. It’s pretty hard sometimes to say absolutely this is going to turn out to be the best approach,” says McLaughlin, now retired, who was a Kosmos senior vice president and was project director for the big Jubilee field off Ghana.

A lot remains to be proved. Cobalt has great hopes for its pre-salt discovery, which has generated considerable excitement. Companies have flirted with the pre-salt in the past. There’s even an onshore pre-salt field in production. But there has been nothing of this scale and development potential.

Analysts say Cameia could contain 1.7 billion barrels of oil equivalent (boe). This is smaller than the 7.5-billion-bbl Tupi pre-salt find off Brazil in 2006 but much larger than the biggest discoveries off West Africa.

Parallel basins along the east coast of Brazil and the west coast of Africa developed after a split apart





Geology on either side of the Mid-Atlantic Rift reflects common depositional processes, which are yielding large hydrocarbon reserves.

details of development plans but has made clear that the discoveries will be commercial grouped into a hub.

“We’re progressing pre-development studies, so I think that’s a clue that we believe we have enough for a commercial hub there to begin development,” Greg Hill, a Hess senior executive, said during an earnings call in March.

Kosmos has had strikes off Ghana at Akasa and at Wawa, and anticipates tying Akasa into its Jubilee hub and Wawa into its TEN development, which is named for the Tweneboa, Enyenra and Ntomme discoveries that it will produce.

Off Ghana, Tullow’s TEN development plan calls for 23 production and injection wells, a leased FPSO and a total investment of \$4.5 billion. First production is targeted for 2015 with a peak rate of 100,000 bpd by 2018.

The industry is building more places to tie in, filling in the blanks in the

infrastructure map in areas beyond the thicket of projects and pipelines off Nigeria.

Ghana

Jubilee, a 600-million-boe field in a previously unexplored part of the post-salt section off Ghana, shows how far the industry has come in

building large production centers to which smaller fields can be added.

Tullow and its partners — Kosmos, Anadarko, Ghana National Petroleum and Sabre — brought 17-well, 120,000-b/d Jubilee Phase 1 on line in 42 months, from discovery in 2006 to first oil in 2010. The industry average is seven years.

It was a major accomplishment, says McLaughlin, who led the project.

Like most West African offshore projects, Jubilee relies on a floating production, storage and offloading system to get its oil to market. But they hope to pipe ashore the natural gas that is produced with the oil, a new infrastructure trend to reduce environmentally unfriendly flaring and costly re-injection of gas back underground.

There’s a step-change in size, as well as speed, of developments. Billions of dollars are being invested in sprawling projects off Angola and Ghana, demonstrating industry capacity to execute engineering and construction on a huge scale, thousands of miles from major manufacturing and design centers.

Angola

The 220,000-bpd Pazflor project features what Total describes as “a vast subsea gathering network, the most complex ever built in Angola.” It includes 49 subsea wells, 180

km of lines and 10,000 tonnes of equipment linked to an FPSO. First oil: 2011. Budgeted cost: \$9 billion.

Total, which has already spent billions building the Dalia and Girassol FPSO systems in Block 17, is now adding CLOV, which joins the Cravo, Lirio, Orquidea and Violeta discoveries. CLOV involves 34 subsea wells and an FPSO scheduled for delivery later this spring. Production start: 2014. Peak: 160,000 b/d.

Just to the northwest, in Block 31, BP is developing a project it calls PSVM. It joins the Plutao, Saturno, Venus and Marte fields around another FPSO. The plan calls for 48 wells. The first three wells delivered first oil in January, and they are producing about 60,000 b/d. FPSO peak capacity is 157,000 b/d.

Cost is undisclosed, but BP by some estimates will spend \$15 billion over 10 years on PSVM and other developments in Block 31. BP also is studying addition of Phase 3 to Greater Plutonio in Block 18 off Angola.

Exxon Mobil is planning Kizomba Satellites Phase 2 in Angola’s Block 15, building on Phase 1 where it started production last July. Phase 1 is an 18-well undertaking expected to produce 100,000 b/d at peak. Details of Phase 2 are still in development.

Onshore

Onshore support for offshore development is growing.

Kizomba is an example of the region’s growing manufacturing and service capability, encouraged by the host countries with “local content” rules, but also favored by companies needing suppliers closer to projects. Exxon Mobil says \$1.5 billion worth of services and equipment were Angola-sourced.

The \$10 billion Angola LNG plant, much-delayed but finally set to start up this year, is an example of new infrastructure helping maximize production. It will receive approximately 1 Bcf/d of

gas from offshore oil fields and produce 5.2 million tones/y of LNG and related gas liquids. Some of that will be used to meet Angola's domestic needs.

To help feed the LNG plant, the Congo River Crossing pipeline project, will deliver 250 MMc/d from offshore Blocks 0 and 14 through a new pipeline. Because Blocks 0 and 14 are in the Cabinda enclave north of the river mouth, and the plant, located at Soyo, is on the south side of the river, a 140-km segment of the pipeline has to go through an undersea canyon scoured out by the river's massive outflow. Chevron is leading the construction project.

Exploration and development success off West Africa has been helped along by relatively benign weather and metocean conditions, which meant that well-established engineering and technological approaches met most needs.



Total has pioneered a number of riser improvements, including bundled risers.

But the lack of local infrastructure and underdeveloped onshore energy markets has necessitated region-specific innovations. Companies have perfected the use of FPSOs, and a spinoff of reliance on FPSOs is advances in riser technology.

Total has pioneered a number

of riser improvements, including bundled risers at Girassol (2001) and Dalia's flexible bundled risers (2006). Most recently, Total has demonstrated seafloor gas-liquids separation at Pazflor (2011).

Typically lower reservoir pressures and temperatures in shallow post-salt fields allowed the use of technology developed in the Gulf of Mexico, but the conditions also required greater use of water injection to boost pressures and heating of flowlines to forestall clogging with wax and hydrates.

Added technological challenges likely will come with pre-salt production, assuming commercial development. For example, pre-salt reservoir pressures and temperatures will likely be higher than the post-salt reservoirs already produced.

In any case, there will be plenty of opportunities to address pre-salt challenges.

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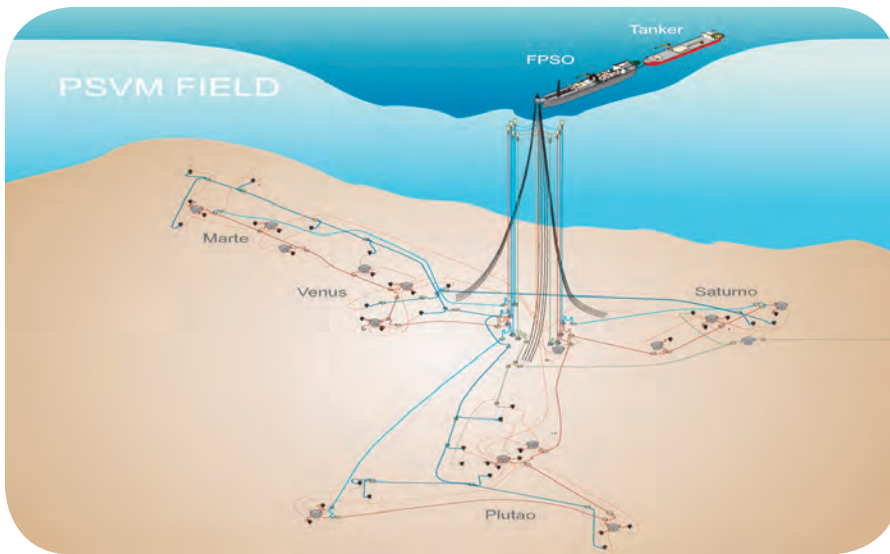
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In Angola Block 31, BP is developing the PSVM project, joining Plutao, Saturno, Venus and Marte fields, producing into one FPSO.

2014, we believe drilling activity levels are set to soar,” wrote Bank of America Merrill Lynch analysts in a February report.

Continuing high oil prices, improving technology, relative political stability and — despite delays still seen in the approval of some projects — a more supportive operating environment are driving the boom, the analysts say.

They forecast 15 to 20 wells in the pre-salt play in 2013-14, most of those off Angola, by Cobalt, Chevron, Maersk, Total, Statoil, Eni and Repsol. ConocoPhillips has said it plans to drill four exploration wells starting in 2014.

Setting the pace, Cobalt-led

partnerships plan several wells.

“Our Cameia success gives us great confidence in our West Africa strategy and our portfolio,” Cobalt Chairman and CEO Joe Bryant said, adding that “2013 will be jam packed for us in West Africa.”

There’s still a lot of work to be done in the post-salt, as the Jubilee discovery off Ghana demonstrated. Information and consulting giant IHS and others see expanded activity in the post-salt plays from Sierra Leone to Benin.

“There is still potential in the two main plays, namely the Upper Cretaceous and the Lower Cretaceous, and companies are looking to the Ghana success story.

Nigeria also remains prospective despite above-ground issues,” IHS analysts say.

Namibia — underexplored but, like other parts of West Africa, geologically linked to Brazil — is getting increased attention. HRT, Chariot, and Repsol have pre-salt drilling ambitions in the country on the southern end of the pre-salt zone. Namibia’s sole discovery was the Kudu gas field back in 1974, which still awaits development.

And smaller companies are playing a role from one end of the West African offshore oil province to the other. Australia-based Africa Petroleum, for example, has had discoveries off Liberia.

Other lesser-known operators include Ophir (planning to drill offshore Ghana, Gabon and Equatorial Guinea), Harvest (Gabon), Nazaki (Angola), AFREN (Nigeria, Congo) and Bowleven (Cameroon),

It all adds up to an exciting outlook for offshore West Africa, says Marc Blaizot, Total’s senior vice president for exploration. “I think 2013 will be a very great — very great year for Africa,” he says. **OE**

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NW Africa's potential displayed off Morocco

The North African Atlantic Shelf continues to be a region of intense academic activity, and recently, E&P companies such as Repsol and Chevron have renewed their interest in the hydrocarbon potential of its deeply buried sediments. As deepwater-drilling technologies have evolved and our understanding of lower-slope geology has improved, the favorability of new deepwater exploration targets has grown. Passive continental margins, particularly those in salt provinces, have proven to be some of the best areas where structural geology, stratigraphy, and salt tectonics can combine to form intricate hydrocarbon traps with inherently complicated drilling strategies.

Offshore Morocco is a good example of a geologically rich, yet underdeveloped, hydrocarbon province. In the Essaouria Basin west of the Moroccan coastal city of Safi, 3D mapping of a single seismic dataset uncovered a variety of geomorphologic features that highlight a range of ancient depositional environments. The most interesting of these features is a 500m-thick debris flow that marks a large, Late Cretaceous, shelfal collapse.

Imaged inside the debris flow are megablocks that are as much as 4cu km in volume, with embedded, stacked, anastomosing channels. Although the debris flow

is survey-wide, it has a core of thicker, blocky material that came to rest after passing over the distal-most edge of the Triassic-age salt province, found along much of the Atlantic margin.

Salt diapirs pepper the survey with shallow salt pillows, obstructing subsalt stratigraphy, actively subsiding minibasins, salt bridges between diapirs, and a distal, deep-seated, toe-thrust salt body. This toe-thrust diapir formed a paleohigh during the Jurassic that led to adjacent, large, 120m-thick, fine-grained contourites, which were deposited as bottom currents became concentrated near the paleohigh. Furthermore, there is a well-imaged paleo-volcano that had a positive seafloor expression from the Late Jurassic through Late Cretaceous.

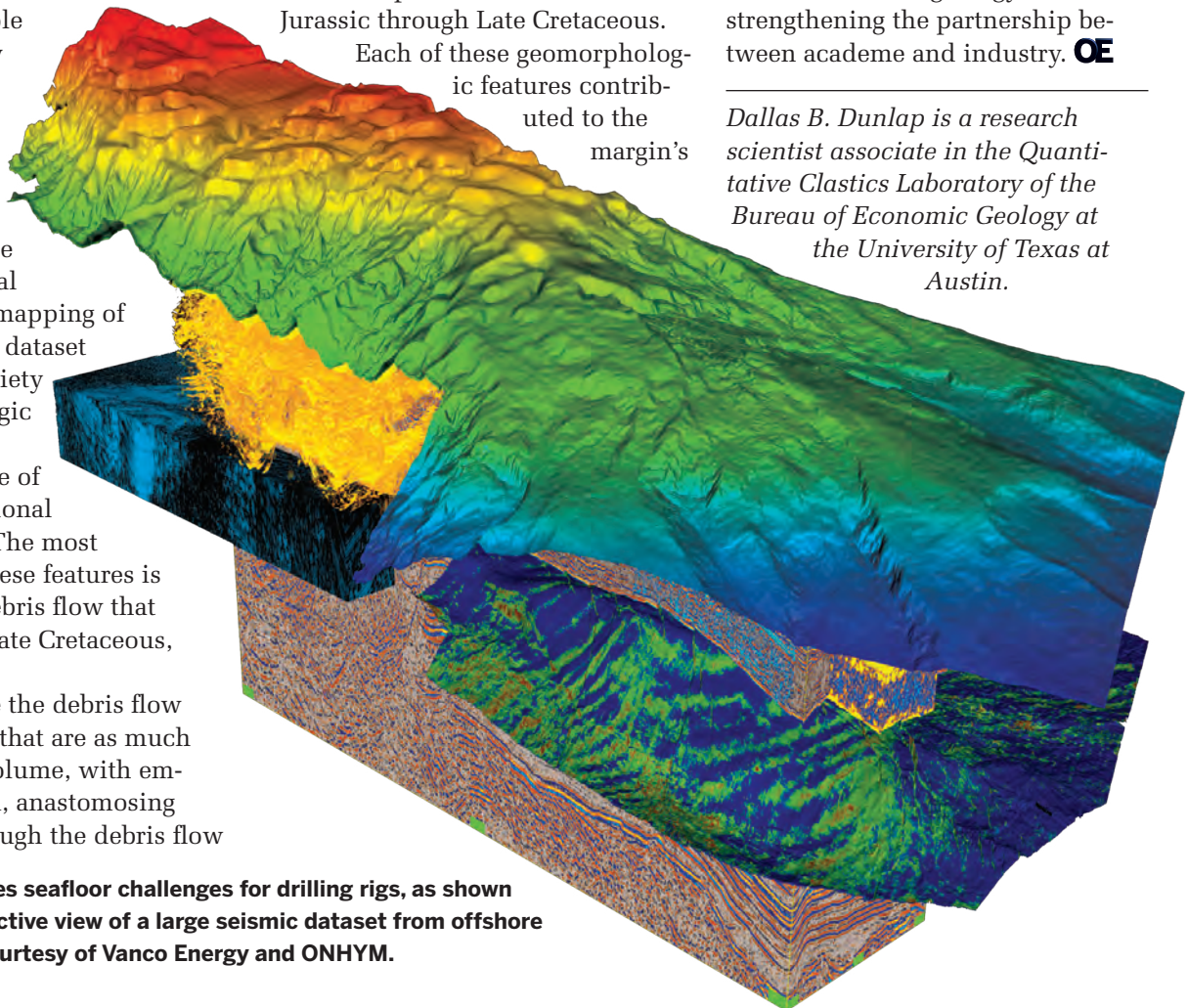
Each of these geomorphologic features contributed to the margin's

complex stratigraphic succession.

In some of the earliest deposits, found just above the rifted basement rock, we see a series of Jurassic-age fans with high-amplitude seismic responses. Discrete inner and outer fans form the boundaries of the complex, which is overlain by small distributary channels. Larger canyons originate updip and cross over the basement half-grabens.

Since only a few of these features were previously penetrated by well bores, new deepwater-exploration activities will not only lead to new drilling technologies and documented reserves for offshore NW Africa, but also have the potential to greatly expand our knowledge of the subsurface geology, while strengthening the partnership between academe and industry. **OE**

Dallas B. Dunlap is a research scientist associate in the Quantitative Clastics Laboratory of the Bureau of Economic Geology at the University of Texas at Austin.



Mobile salt creates seafloor challenges for drilling rigs, as shown in this 3D prospective view of a large seismic dataset from offshore Morocco. Data courtesy of Vanco Energy and ONHYM.



IP Week

highlights West African plays

Exploration activities in deepwater West Africa recorded the highest number of successes in the world during 2007 to 2012, Seplat Petroleum Development Co. MD/CEO Austin Avuru told delegates at Energy Institute's International Petroleum Week, London 2013.

He said that in the 50 years since first production in Nigeria there are many investment opportunities in the West Africa sub-region, from exploration in frontier areas to acquisition of mature assets, where secondary discoveries (deeper plays and by-passed plays) have been successful.

Significant growth potential exists in the sub-region. According to Wood Mackenzie, there are about 40 billion barrels of discovered but undeveloped reserves, plus 55 billion barrels of yet-to-find (the

second biggest region in the world after Latin America). Africa currently supplies about 9% of total world oil, but this is set to grow to about 15% of the world oil supply in 2020 due to new discoveries in the continent especially in West Africa and East Africa.

The plays in the West Africa Transform Margin, deepwater West Africa, and offshore East Africa, are the areas currently attracting the most exploration interest. Since the Jubilee discovery in Ghana in 2007, companies are exploring other parts of the region (Ghana to Mauritania), looking for analogous Cretaceous turbidite prospects. Offshore explorations in Sierra Leone and the Côte d'Ivoire are all promising.

Oil and gas activity in West Africa extends from Mauritania to Angola. Nigeria and Angola have

Seplat CEO Austin Avuru spoke at IP Week, London.

the largest reserves base, accounting for around 86% of the total sub-region's reserves as of January 2012, according to the *BP Statistical Review 2012*. In recent years, new production countries: Chad, Ghana, Côte d'Ivoire, and Mauritania have joined Nigeria, Angola, Cameroon and others in the sub-region that have discovered oil in commercial quantities.

For the mature basins, as in the Niger Delta in Nigeria, a combination of promising geology and available acreage through acquisitions has attracted a range of companies. For instance, Shell Petroleum Development Nigeria has divested itself of eight blocks in the past four years to consortia made up of foreign and local partners. Further opportunities for divestment are expected over the coming years as larger companies give way to smaller independents and indigenous companies due to local content policies. Mergers and acquisitions will continue to increase. As opportunities are squeezed, consolidation across the sector will increase.

Avuru said that security risks, war and political tensions were some of the issues preventing growth in the sector. Market price constraints, lack of enabling infrastructure for investment to thrive, and the threat of cost inflation were also limiting factors. **-Meg Chesshyre**

New gas for Ghana

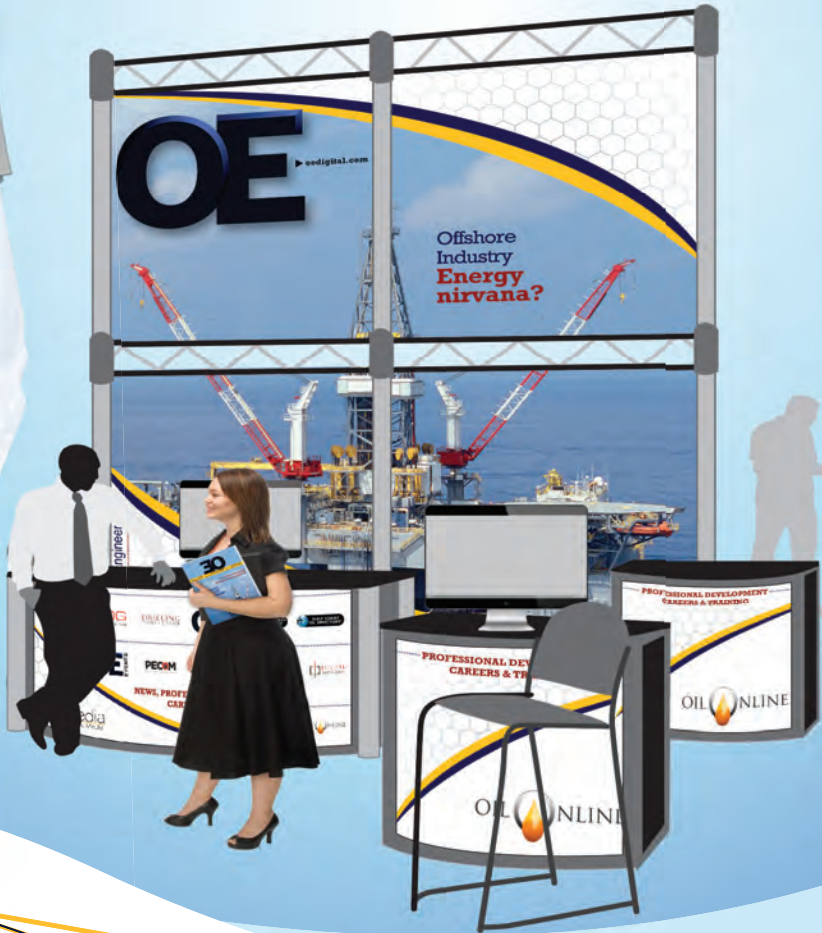
Gasol's affiliate, African Power Generation (AfGen), has signed a memorandum of understanding with Ghana National Gas in relation to the development of a number of specific projects aimed at providing additional gas to Ghana, as well as supporting, in a complementary manner, the longer term security of gas supply needed to address the nation's power generation deficit.

Under the memorandum of understanding, AfGen and Ghana Gas propose to explore the establishment of various joint venture arrangements for the supply of imported natural gas into Ghana, as well as the downstream sale and marketing of gas to power generators and industrial/mineral processing enterprises in Ghana. Gasol has already entered

into similar arrangements for the marketing of natural gas in other West African countries, including Benin and Togo, and will work with AfGen to create a strategic and mutually supportive partnership with Ghana Gas.

Alan Buxton, COO at Gasol, says: "We are very pleased that Ghana Gas has agreed to explore collaboration with AfGen in a broadly defined partnership, including the importation and supply of non-indigenous gas to customers in Ghana, thereby assisting in bridging the Ghanaian gas deficit for power generation, serving industrial/mining users and assisting in progressing the government of Ghana's Better Ghana Agenda. We look forward to developing the relationship established which is a platform for building a mutually beneficial and long-term partnership." **OE**

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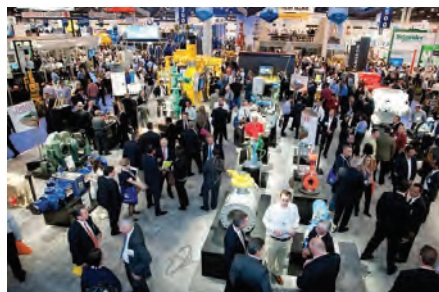


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OTC 2013 combines star power with fire power

The 45th annual Offshore Technology Conference in Houston places the spotlight on the latest technological advances plus industry stars such as new head of BP Upstream Lamar McKay and PEMEX's E&P director Carlos Morales-Gil.



OTC returns to Houston's Reliant Park complex May 6-9, 2013, and attendees have multiple options to hear keynote speeches by senior oil and gas executives.

Technical breakfasts, scheduled Monday through Thursday, will feature BP's CEO of Upstream Lamar McKay, NOIA President Randall Luthi, PEMEX's General Director of Exploration and Production Carlos Morales-Gil, and Anadarko's Mozambique facilities Project Manager Cory Weinbel. Luncheon speakers will include Saudi Aramco's Vice President of Petroleum Engineering & Development Khaled Buraik, Semcorp Marine Ltd.'s President and CEO Weng Sun Wong, Shell's Executive Vice President of Innovation, R&D and CTO Gerald

Schotman, and James Watson, the Director of the US Bureau of Safety and Environmental Enforcement.

New for this year are applications and solutions on topics such as subsalt geosciences, safety and environmental management systems, unconventional subsea exploration and mining, deepwater HP/HT well construction, fiber optics, marine geohazards, and pore pressure prediction.

OTC draws more than 89,000 participants from 110 countries, and includes 2,500 exhibiting companies annually. This year's conference has eight panel sessions, feature 29 executive keynote presentations, and make available 300 technical papers.

Other program highlights include discussions on offshore regula-

tions, and the expanding role of national oil companies, which will include a panel featuring executives from Brazil's Petrobras, Malaysia's Petronas, and Mexico's Pemex. Other discussions will focus on the latest developments regarding major projects such as Petrobras' Gulf of Mexico development, Cascade and Chinook; BPZ Energy's CX-15 buoyant tower platform off Peru, Husky's South China Sea deepwater Liwan project, and Woodside's Pluto Greenfield LNG development.

In addition to its technical program, since 2004, OTC has offered its Spotlight on New Technology Awards (see accompanying article on page 90) recognizing innovative advancements in ocean resources development. Since 2006, OTC played host to the Next Wave program where young professionals under 35 learn about responsibilities and challenges facing the industry in the decades to come.

OTC is sponsored by 12 organizations including the American Association of Petroleum Geologists (AAPG); American Institute of Chemical Engineers (AIChE); American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME); American Society of Civil Engineers (ASCE); ASME International Petroleum Technology Institute (ASME-PD); Institute of Electrical and Electronics Engineers – Oceanic Engineering Society (IEEE-OES); Marine Technology Society (MTS); Society of Exploration Geophysicists (SEG); Society of Mining, Metallurgy, and Exploration Inc. (SME); Society of Naval Architects and Marine Engineers (SNAME); Society of Petroleum Engineers (SPE); The Minerals, Metals, and Materials Society (TMS). **OE**



Schlumberger at OTC 2013

At this year's OTC event Schlumberger is featuring technologies, services, and methodologies ranging from exploration to well completions for reducing drilling risk in deepwater environments. Several case histories will be presented at the booth demonstrating how the right combination of people, processes, and technologies can improve success rates in deepwater drilling.

The presentation "Understanding your operational window for well control" shows how advanced software that combines real-time drilling and formation evaluation data with the reservoir model—and uses appropriate interpretation techniques to quickly analyze the data—helps avoid kicks from over-pressured zones. Meanwhile, by matching formation evaluation measurements from logging-while-drilling (LWD) tools to the reservoir model in real time, and adjusting the well path based on the new information, wells can be positioned in the optimum location to maximize production and recovery.

The company is featuring its Stinger* conical diamond technology, launched in March of this year. It enables high-point loading to fracture rock more efficiently during drilling for increased rate of penetration and durability. When centrally positioned in a PDC drillbit cutting structure, the Stinger element improves performance by crushing formation core at the borehole center, increasing drilling speed and reducing the number of bits used in each well. The company's drilling group is also highlighting the Rhino XC* on-demand reamer, which eliminates time-consuming pumpdown activation devices and can be placed anywhere in the drillstring for increased operational flexibility. Featured LWD capabilities include the NeoScope* sourceless formation evaluation-while-drilling system, which reduces risk by eliminating the need for chemical sources. The service uses unique pulsed neutron generator technology in the shortest multifunction LWD collar available.

The booth features a demonstration of the Losseal* family of reinforced composite mat pills. An innovative blend of fibers and sized solids, these engineered pills bridge thief zones that can lead to lost circulation while drilling and

cementing. The system creates a strong, impermeable grid that stops mud from flowing into high-permeability and naturally fractured zones. It is designed to withstand additional pressure from mud density increases and any future drilling or cementing operations. The treatment saves thousands of barrels of fluid during placement and reduces nonproductive time caused by lost circulation.

Featured wireline technology includes the Saturn* 3D radial probe, which extends formation testing to previously inaccessible fluids and reservoir environments. Saturn's drain assembly positions four self-sealing suction probes at 90° intervals against the borehole wall to pull fluid circumferentially from the reservoir. Because fluid is extracted across a large cross sectional surface flow area, flow is readily induced and sustained for viscous fluids and in low-mobility formations or uncemented matrix. The high flow rate allows filtrate to quickly be removed to draw in uncontaminated formation fluid for downhole fluid analysis and sampling.

The booth also features an application of the compact SenTURIAN* subsea landing string electrohydraulic operating system, designed to quickly operate subsea equipment performance with less risk and reduced rig-up time. The system operates in all subsea applications, including deep water, high pressure, and high temperature.

Highlighted completions equipment includes the FORTRESS* isolation barrier valve, which isolates reservoir fluids in a lower completion and allows operators to transition from a lower to upper completion without intervention. The valve is designed to withstand severe debris environments and optimize the available actuation energy predictably, consistently, and reliably. The company is also presenting gas lift valve systems qualified to meet international requirements for performance as effective reservoir pressure barriers.

In addition to deepwater applications, the Schlumberger booth features presentations and experts on drilling, stimulation, and completions for optimizing production from shales.

*Mark of Schlumberger

The Schlumberger logo, consisting of the word "Schlumberger" in a bold, blue, sans-serif font.

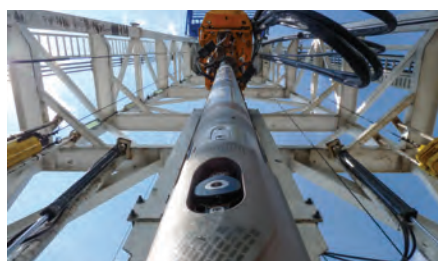
Innovation is highlighted by OTC Spotlight Award Winners

This year's group of Spotlight Award winners brings advances in all areas of offshore activity. Advances were generated in drilling, logging, operational control, robotic intervention and more. Each advance creates improves safety, enhances efficiency, improves processes, or adds productivity to offshore operations. Congratulations to this year's winners!



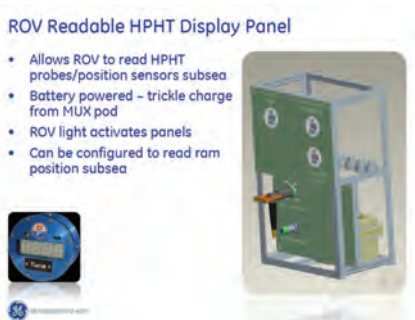
Multiphase Subsea Boosting System

FMC Technologies, Inc. and Sulzer Pumps Ltd. won a Spotlight Award for developing a new high-speed, helico-axial multiphase subsea boosting system optimized for subsea applications. This system combines field-proven pump hydraulics with FMC Technologies' permanent magnet technology from Direct Drive Systems for less maintenance with greater speed, efficiency and power. Visit them in Booth 1941.



FASTrak™ LWD

Baker Hughes won a Spotlight Award for the FASTrak™ logging-while-drilling (LWD) fluid analysis sampling and testing service. It provides knowledge of reservoir fluid properties to enhance critical decision-making about the reservoir. FASTrak addresses the growing need to acquire fluid samples in LWD environments, resulting in significant time and cost savings. Visit them in Booth 3731.



RamTel™ Plus System and ROV Subsea Display Panel

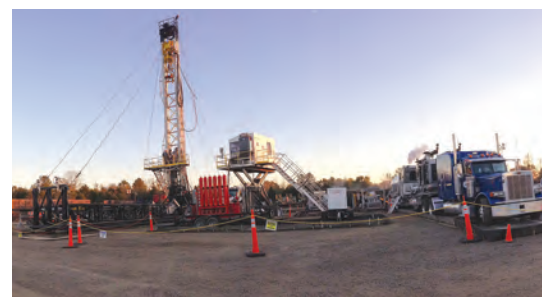
GE Oil & Gas won a Spotlight Award for its RamTel™ Plus. The system provides operators with a direct method of determining ram position (shear and/or sealing elements), important to know when closing in a well using a BOP. GE's ROV display allows the ROV to read stack sensor data, including wellbore temperature and ram position subsea indicators. Visit them in Booth 3163.



Onboard DC-Grid

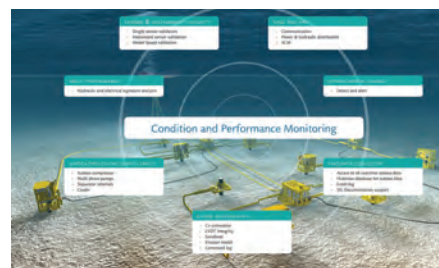
ABB Inc. won a Spotlight Award for the Onboard DC-Grid, an innovative marine technology that uses direct current to transport energy to different consumers onboard a vessel. It enables variable-speed operation of generator sets, significantly reduced fuel oil

consumption, improved emission reduction, reduced maintenance, and new operational modes. Visit them in Booth 3917.



Complete Automated Technology System

Superior Energy Services won a Spotlight Award for its Complete Automated Technology Systems (CATS). CATS is an onshore and offshore completion services rig that uses remotely-operated or pre-programmed robotics to control completion components, including a snubbing unit, BOP/well control stack, pumps, circulation tanks, top drive, closing systems, and pipe handling systems as part of one unit. Visit them in Booth 5833.



Condition & Performance Monitoring

FMC Technologies won a Spotlight Award for its condition and performance monitoring (CPM) surveillance system. CPM combines

FMC Technologies

FMC Technologies is a leading global provider of technology solutions for the energy industry. Named by FORTUNE® Magazine as the World's Most Admired Oil and Gas Equipment, Service Company in multiple years, **FMC Technologies** designs, manufactures and services technologically sophisticated systems and products such as subsea production and processing systems, surface wellhead and fluid control equipment, measurement solutions, marine loading systems, and remotely operated vehicles (ROVs). The company also offers subsea services and shale completion services for the oil and gas industry. For more information, visit www.fmctechnologies.com

continuous monitoring of sensors and subsea instrumentation with a historic database to identify fault condition and deviations from normal operating conditions. This enables proactive maintenance of subsea production and processing systems within a 24/7 collaborative environment for diagnosis and problem solving. Visit them in Booth 1941.



DOW NEPTUNE™

Bayou Wasco Insulation, Trelleborg Offshore, Dow Oil & Gas, and PIH share a Spotlight award for the DOW NEPTUNE™ advanced subsea flow assurance insulation system. It is a simple, robust, end-to-end flow assurance solution, protecting equipment, line pipe and field joints across the widest application and in-service temperature range of any wet insulation system (-40°C to 160°C, or -40°F to 320°F). It can withstand hydrostatic compression of ≥400 bar (4,000 m), and offers enhanced performance safety with a simple, two-layer application. Visit Bayou Wasco Insulation in Booth 3920 and Trelleborg Offshore in Booth 5255.



Well Cutter®

Welltec won a Spotlight Award for its innovative Well Cutter® that enables efficient drill pipe and casing recovery without explosives.

A smooth, polished surface remains after the cut without generating shavings, and e-line conveyance ensures accurate depth control. The Well Cutter® offers a safer, faster, more reliable and cost-effective approach to cutting drill pipe and casing. Visit them in Booth 1453.



RDM-R system

Reelwell AS won a Spotlight Award for the Reelwell drilling method riserless (RDM-R) System that enables 3rd generation drilling units to drilling in 3000m of water, because of cuttings weight removed from the riser. Cuttings are transported to surface inside the dual drill string. Visit them in Booth 5241.



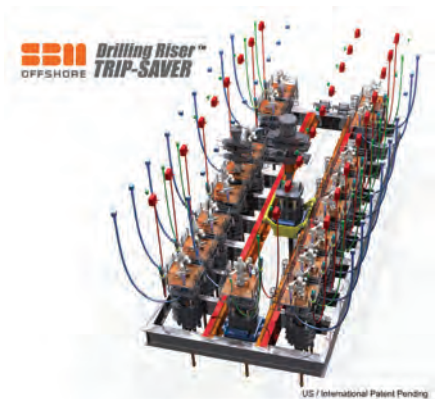
Continuous Motion Rig (CMR)

WeST Drilling products AS won a Spotlight Award for its Continuous Motion Rig (CMR), which offers the world's first continuous drilling operation, and is also the world's first fully-robotized rig. CMR reduces drilling time up to 50%, and facilitates managed pressure drilling. Visit them in Booth 5241.



Deepwater BOP Blind Shear Ram

GE Oil & Gas also won a Spotlight Award for developing new technology for shearing and sealing wellbore tubulars. The Blind Shear Ram is designed for use in GE's ram blowout preventers used in offshore drilling. It provides an industry-first capability to shear some 6-5/8 in. drillpipe tool joints, while sealing up to 15,000 psi pressure differential. Visit them in Booth 3163.



Drilling Riser Trip Saver™

SBM Offshore won a Spotlight Award for its rail-mounted transport system, Drilling Riser Trip Saver™, which relocates a suspended drilling riser with a drilling riser tensioner system and surface blowout preventer in-place. This innovative apparatus and method for drilling multiple subsea wells consecutively, saves time and money, and reduces risk by avoiding removal of the suspended drilling riser from the well bay. Visit them in Booth 4141.



Mobile Robotic Cutback System

Bredero ShawCor Ltd. won a Spotlight Award for its Mobile Robotic Cutback System. The system is an innovative, end-machining technology for insulated pipe. It replaces manual wire brushing, grinding, and scraping to form the cutback. The new technology is safer, quieter, requires less labor, and produces consistent, high-quality cutback profiles, while generating recyclable waste. Visit them in Booth 3355.

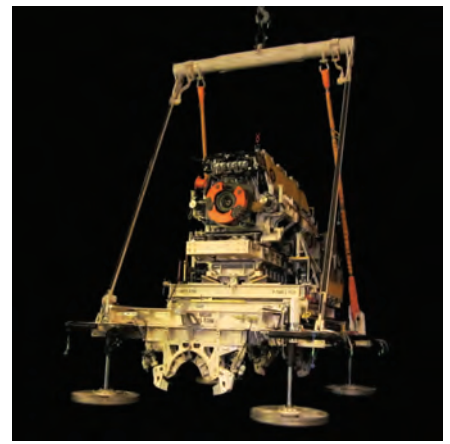


Wärtsilä GasReformer

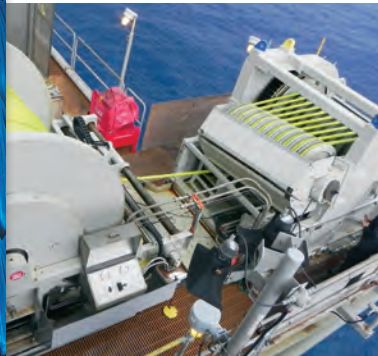
Wärtsilä Corporation won a Spotlight Award for its Wärtsilä GasReformer that turns waste gas: volatile organic compounds or associated gas, into a valuable energy source. It enables self-sustaining power generation for offshore operations. It provides environmental sustainability and cost savings. Visit them in Booth 1325.

Retrofit Subsea Hot Tap Tee

Statoil ASA won a Spotlight Award for its remotely-welded, Retrofit Subsea Hot Tap Tee. While gas is flowing through a pipeline, a remote-controlled, hot tap operation begins by having a robot weld a T-piece onto the pipe. Next, a remote-controlled, drilling machine cuts holes in the pipeline, without affecting pressure or production. Visit them in Booth 430.



COMPANY PROFILE



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Norway celebrates 40 years at OTC

By Elaine Maslin

Norwegian innovation in the oil and gas industry will be celebrated in Houston with the marking of a major milestone this year. Norway is marking its 40th anniversary of attending the Offshore Technology conference with an impressive line-up of 65 technology companies due to feature in the Norwegian Pavilion.

To help mark the event, Norway's Royal Crown Prince and Royal Crown Princess will be attending the event and officially opening the pavilion. In addition, Innovation Norway will hold its 2nd Annual Technology Night Live during the evening of May 7 during OTC week.

Innovation Norway is a Norwegian government organization focused on promoting Norway's industrial development. It assists small to medium sized Norwegian enterprises access business opportunities outside Norway, with its primary focus for OTC being business opportunities in the North American oil & gas industry.

Innovation Norway has already helped some 150 Norway-related companies do business in Houston through support during their establishment overseas. On average, it helps about 10 Norwegian companies a year get established in the Gulf of Mexico region and in total about

50 companies are helped each year through its Houston office.

"Our Houston office concentrates on the oil and gas industry throughout the Gulf of Mexico and the offshore maritime service industry in Louisiana," said Bjørn Tormod Akselsen, Innovation Norway director. "The overall goal is to help reduce the risk when Norwegian companies are establishing themselves in the North American market."

One such company is Noreq – a small company with big aspirations. Headquartered in Husnes, Norway, it now has offices in Singapore, Denmark, Dubai, Brazil, and since 2010, Houston. The company manufactures lifesaving appliances, cranes, and fenders.

Noreq has had help from organizations like Innovation Norway to enter new markets. "They provide valuable knowledge and resources to enable Noreq to concentrate on marketing our products and grow our presence in foreign markets,"

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said Bernardo Cuellar, Noreq's sales manager in Houston. Innovation Norway helps firms by providing detailed market analysis as well as business development and establishment assistance. It also runs roadshow programs. These introduce Norwegian oil & gas technology companies with relevant products and services to the Louisiana market.

"Louisiana is a critical logistics and supply hub for Gulf of Mexico activity, both shallow and deep-water, making it a key market for Norwegian companies working with the maintenance, modification, and operations segments," said Akselsen.

"These roadshows provide companies with critical insight in how to do business in Louisiana as well as expand their network of contacts, and provide access to some of the key players active in the region."

The Technology Night Live is a networking reception to help small to medium-sized Norwegian oil and gas technology companies develop and



Noreq offers totally enclosed lifeboats and davit systems

01/27/2013 09:12

expand their network of key contacts in the Houston area.

Its focus will be connecting sponsorship companies with key local contacts with experience and expertise relevant for their innovative technologies. Last year's event had close to 200

individuals in attendance as well as 15 Norwegian key sponsor companies.

Globally, Innovation Norway is represented in more than 30 countries worldwide and is closely affiliated with the Norwegian embassies and consulates. **OE**

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The Magnetic Level Indicator is an alternative to leakage-prone sight glasses, a traditional but fragile means to achieve liquid level indication. Unlike hard-to-read sight glasses, the Aurora MLI, equipped with the new *Reveal*[™] indicator, offers safety, reliability, and high visibility from great distances.

The Eclipse[®] Model 706 transmitter from Magnetrol[®] introduces the latest advancements in GWR technology and is available now! Contact your local Orion Instruments Sales Representative for more information.

About Orion Instruments

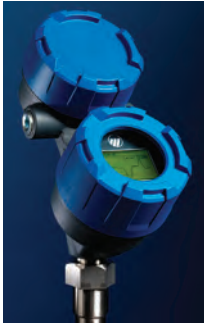
Orion Instruments, a wholly owned subsidiary of Magnetrol International, specializes in the custom manufacturing of magnetic liquid level indication. Since 2001, Orion has built itself on custom engineered solutions and exceptional customer service. Based along the U.S. Gulf Coast in Baton Rouge, Louisiana, Orion Instruments serves all major industrial segments, including Oil & Gas, Power Generation, Chemical Processing, Water Treatment, Military Applications, and many others.



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Magnetrol International, Incorporated has launched the ECLIPSE Model 706 guided wave radar (GWR) transmitter, a best-in-class level control solution that advances guided wave radar technology with improved performance for a wide range of level and interface control applications. The ECLIPSE Model 706 is designed to provide outstanding accuracy, reliability and safety for virtually all process industries.

to ensure plug-and-play transmitter commissioning and automatic capture of echo curve during upsets. The Eclipse Model 706 transmitter provides safe, efficient and cost-effective liquid level and interface control and is virtually unaffected by fluctuating process conditions including density, dielectric, viscosity and specific gravity. The ECLIPSE Model 706 introduction represents the latest GWR innovation from Magnetrol, the company that introduced the original ECLIPSE Model 705 – the very first two-wire, loop-powered GWR transmitter for industrial liquid level applications. For more information about the ECLIPSE Model 706, call 1-800-624-8765 or visit: www.eclipse.magnetrol.com.

Latest-generation features include:

Enhanced Signal Performance – The ECLIPSE Model 706 innovative GWR circuitry achieves both a higher transmit pulse amplitude and improved receiver sensitivity, resulting in a signal-to-noise ratio (SNR) that is nearly three times higher than competitive GWR devices. This assures precise, dependable control for every level application, including extremely low dielectric media, extended measuring ranges, and punishing conditions where foaming, boiling or flashing can occur.

Overfill Capable Probes – Magnetrol offers the only guided wave radar transmitter on the market with a complete line of overfill capable probes. Unlike other GWR transmitters that use algorithms to infer level readings in top-of-the-probe dead zones, the ECLIPSE Model 706 measures true level to within specification all the way up to the process flange. Coaxial and single rod overfill capable probes can be installed in various configurations on the vessel, even when the risk of flooding exists.

Advanced Diagnostics – The ECLIPSE Model 706 takes the user interface experience to new levels of convenience and functionality. The LCD diagnostics convey critical real-time waveform and trend data with outstanding ease of use. Additionally, the ECLIPSE Model 706 can be preconfigured online prior to shipment,

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AVOIDING SLIPPERY SLOPES

Fugro Uses Cutting-Edge Techniques to Optimize Pipeline Routes

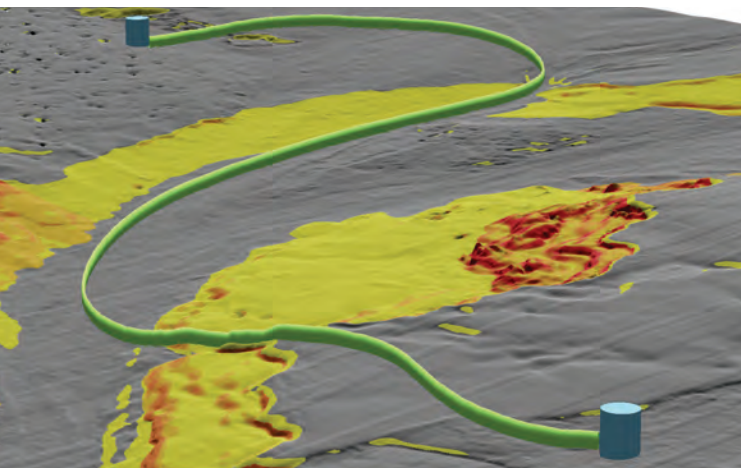
*William C. Haneberg and Brittany Bruce
Fugro GeoConsulting, Inc.*

You need to plan an offshore pipeline route. How do you best define your course? The shortest route would be a straight line from one terminus to the other, but that wouldn't account for complications like seafloor geohazards and infrastructure. Manually sketching a route that considers these constraints is a first step, but not nearly enough in today's world of complicated deepwater development projects that put billions of dollars of capital at risk.

Mapping Hazards

Take slope instability. Traditional qualitative slope failure maps (created by interpreting evidence of past slope failures) offer important information about seafloor geohazards that might affect pipeline routes. Failures with sharp edges and rough internal surfaces might be indicative of younger and potentially more hazardous events than those with rounded edges and smooth surfaces. Relative ages can sometimes be improved by core sampling and dating. Even with absolute ages identified, however, empirical slope failure maps are limited in their ability to predict future failures.

This limitation is especially true when failure is triggered by a rare or unprecedented event. For example, if a magnitude 4 earthquake had been the largest to occur in recent geological history, it would be difficult to empirically infer, in any detail, the effects of a magnitude 7 earthquake.



3-D rendering of an optimized pipeline route between two termini 47 km apart and separated by a variety of slope hazards. Warm colors represent areas of high geohazard cost as defined by a combination of empirical qualitative and probabilistic slope failure maps, including the effects of a moderate earthquake in the probabilistic map. Gray portions of the project area without coloration represent areas of low hazard.

Modeling Uncertainties

To address these limitations, Fugro is incorporating quantitative map-based and GIS-compatible slope stability models into its pipeline route planning. One class of models—called rational probabilistic models—combines physics-based evaluations of slope stability with randomly distributed input variables and elements of probability theory. This approach allows Fugro to incorporate natural variability and uncertainty into calculations and avoid the observational bias that can plague visual and qualitative interpretations. Results comprise a map showing the probability of failure for a trigger such as a major earthquake with a specified recurrence interval.

The Optimal Solution

Qualitative slope hazard maps and quantitative slope stability models are combined with other datasets to create a composite geocost map. Depending on the project, the other data may include maps showing fault scarps, pockmarks, active seafloor channels or other geomorphological features; quantitative seafloor gradient, roughness and radius of curvature maps (the latter being useful for predicting pipeline span potential); and cultural or biological maps.

The route that accumulates the lowest total geocost is determined using GIS least-cost routing algorithms. This corridor will surely be longer than the straight line option, but in terms of geohazards encountered, it will also be less expensive.

The selected route will still need to be surveyed and analyzed in design-level detail. But now this work can be done with the confidence that the route was chosen using the best available methods and with a full appreciation of potential perils.

Author Information

William C. Haneberg, Ph.D., P.G., is a consultant and Brittany Bruce is a project engineer and GIS analyst, both at Fugro GeoConsulting in Houston. **They will offer a technical presentation on the same topic during this year's Offshore Technology Conference (OTC paper 23980).**



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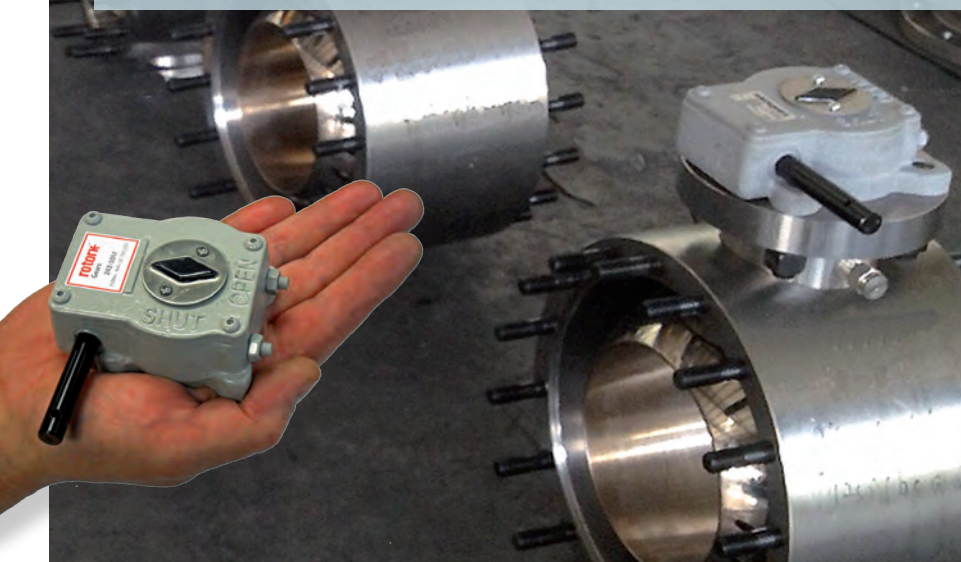
Solutions

SPOTLIGHT

Manual gear operators for Chinese natural gas project

Rotork's compact 242 Series manual gear operators are entering deployment in China. The company received orders from China Valves Hanwei for an undisclosed natural gas project. The 242 Series manual quarter-turn gear operators are ideal for low-torque applications. They feature a cast iron IP67 watertight enclosure, a ductile iron wormwheel, polytetrafluoroethylene (PTFE) thrustwashers, and adjustable end stop screws. Rotork says the gear operators are suitable for operating ball, butterfly, and plug valves.

www.rotork.comwww.eidesvik.no

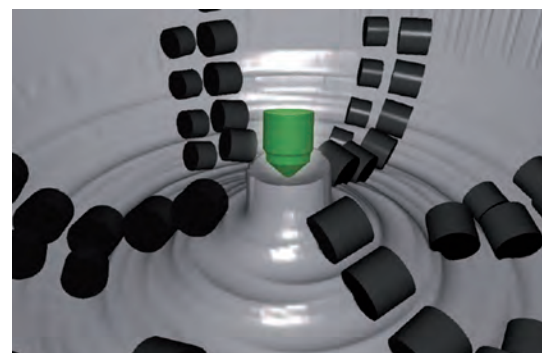


Conical diamond technology

Smith Bits, a Schlumberger company, introduced the Stinger conical diamond technology last month. The bit features an ultra-thick polycrystalline diamond layer that is thicker than conventional PDC cutters. The Stinger element enables high-point loading to fracture rock more efficiently, thereby increasing ROP in sandstone, shale, and limestone.

A recent Bakken case study showed a 46% increase in ROP when SHARC PDC bits were fitted with Stinger and 16mm cutters. Run on a directional BHA, the bits drilled 8³/₄in vertical sections between 6209ft and 6477ft in single trips. The bits attained an average ROP of 168ft/h that included a run with an average ROP of 203ft/h.

www.slb.com/stinger



Subsea thermal insulation

Dow Corning presented its new XTI-1003 RTV Silicone Rubber Insulation at the 2013 Subsea Tieback Forum & Exhibition held last month in San Antonio, Texas.

The technology is a solid, non-syntactic thermal insulation solution designed for HPHT deepwater equipment applications. The XTI-1003 boasts an easy to mix and apply formulation that cures to a durable, flexible translucent rubber.

Some of the benefits tied to the XTI-1003 technology are increased joint strength, flexibility, and thermal stability, Dow Corning says.

www.dowcorning.com

Tapered stress joint

A new tapered-stress joint is under development by UK-based pipe design and manufacturing firm Magma Global. The company is working alongside major oil companies Chevron, ExxonMobil, Shell, Statoil, and Petrobras, to develop the joint using Magma's m-pipe technology.

The project will focus on a 15,000psi 8in. taper stress joint made by combining polyetheretherketone (PEEK) polymer and carbon fibers to create a high-strength, lightweight pipe that is resistant to corrosion and fatigue.

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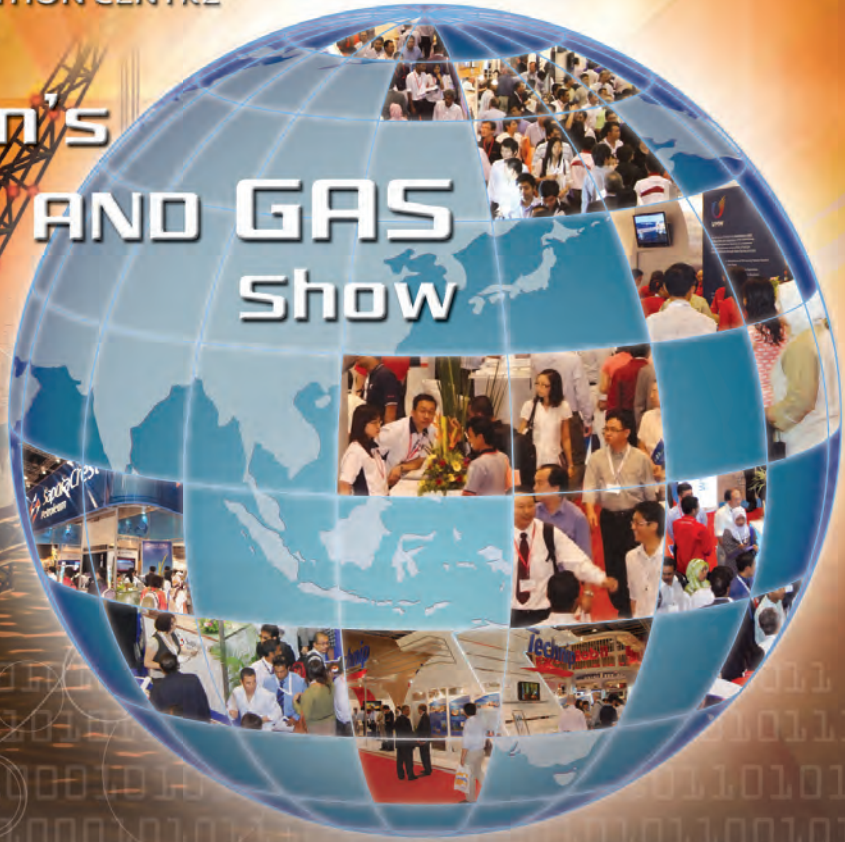
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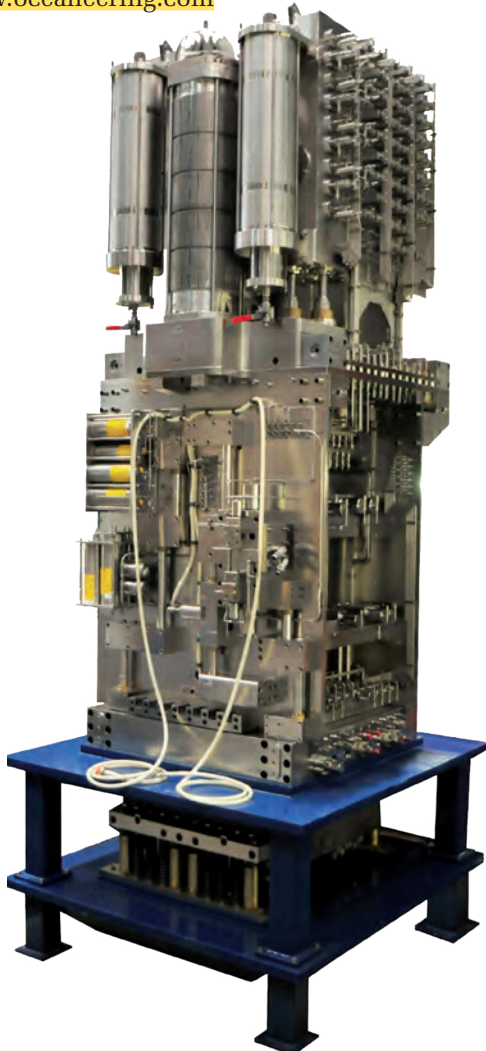
BOP control systems

Oilfield services provider Oceaneering International is to provide a Transocean subsidiary with subsea blowout preventer control systems for three existing semisubmersibles. The contracts cover three discrete hydraulic systems.

Transocean sought out Oceaneering's BOP line in order to comply with regulation API 53, which requires subsea BOPs with a single shear ram to be upgraded or replaced. Oceaneering expects to deliver the systems 1Q 2014.

Oceaneering's multiplex control pod consists of electronics modules (SEM) two electro-hydraulic housings, and the lower valve unit. The unit is capable of operating in 12,500ft of water and has several paths of redundancy to minimize the potential for single-point failures.

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Activity



SPOTLIGHT

Pipe-manufacturing center

Russia-based **OMK** held a ribbon-cutting ceremony to open its new pipe-manufacturing facility, which sits on 75 acres in Houston. The US\$100 million investment was made in response to rising demand for oil country tubular goods (OCTG), especially by strong demand in North America's shale plays.

WorleyParsons agreed to acquire Norwegian engineering firm **Bergen Group Rosenberg** for a cash consideration of Nkr1 billion including more than Nkr200 million of acquired cash. "The impressive history, capability and depth of client relationships of Rosenberg provide the ideal platform for us to expand our presence in the Norwegian Continental Shelf offshore oil and gas market," said WorleyParsons CEO Andrew Wood.

Marine service group **James Fisher & Sons** is to buy diving equipment firm **Divex** for up to £33 million. The deal will see UK-based James Fisher & Sons pay an initial consideration of £20 million in cash plus a further maximum additional consideration of £13 million linked to future profitability targets. Divex is based in Aberdeen with operations in Australia, South Africa and Dubai and employs about 240 people. **Technip** signed two agreements with state

corporation **Russian Technologies** (Rostec) in Moscow in February. One agreement, with Rostec subsidiary RT-Chemcomposite Holding Company, would create a joint venture concerning Russian subsea activities. A second agreement between Technip and Rustechexport would create a jointly-owned company based in Russia to provide engineering, design, and turnkey construction for oil refinery, petrochemical, and gas production proj-

ects, including facilities for offshore oil fields.

Not-for-profit group **ITF**, the global technology facilitator, has signed three new members to its international group of 32 oil and gas operators and service companies. CNR International, the international division of Canadian Natural Resources, will join service companies, Aberdeen-headquartered Expro and Houston-based FMC Technologies.

North Sea independent exploration firm **Ithaca Energy** has agreed a deal to buy fellow London AIM-listed explorer **Valiant Petroleum**. Ithaca said the deal, which values Valiant at about US\$309 million, would establish it as "a leading mid cap North Sea oil and gas operator" with 2P reserves of about 74mboe. It would also more than double Ithaca's current forecast 2013 production to 14-16,000boe/d (90% oil), rising to approximately 27,000boe/d in 2015.



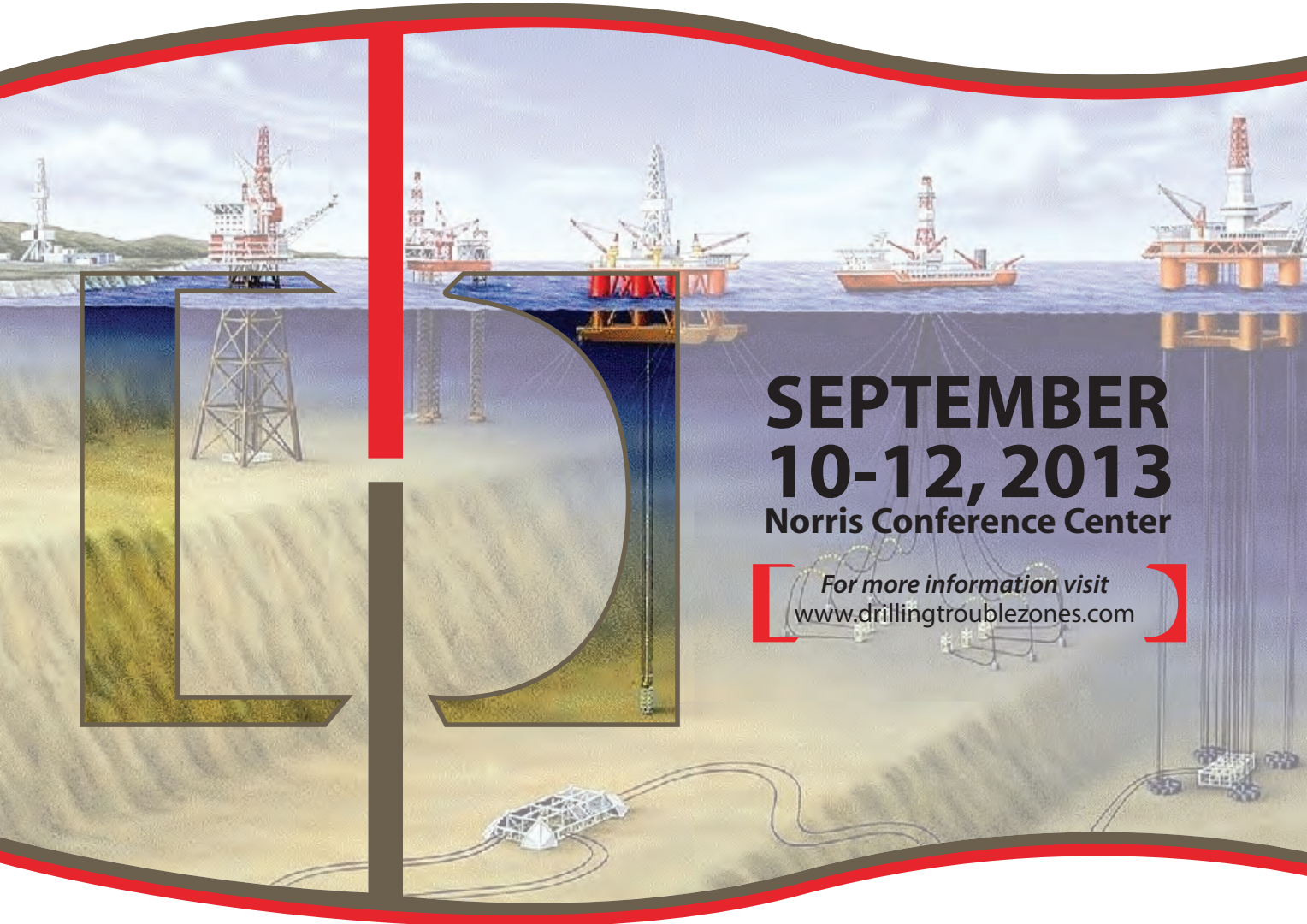
Petrofac Training Services

has launched a new eLearning course, Introduction to Oil & Gas, developed by Oilennium, recently acquired by Petrofac. The user-friendly course can be accessed any time online. This course features full voiceover guidance and 3D animations, and is interactive. When a module is successfully completed, a certificate is issued. Over the 12-module course, a user will gain a good understanding of how hydrocarbon fields are found and developed, industry terminology, and technical know-how.

Rosneft and **Eni** signed a strategic agreement to develop trading and logistics opportunities. Rosneft president Igor Sechin and CEO of Eni Trading & Shipping (ETS), Marco Alverà, met in Rome to sign the agreement, which will develop cooperation between the two firms' logistic infrastructure networks.



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On the Move

Promoting from within

Houston-based service company

TAM International elevated **Mike Machowski** to chief operating officer in February. Machowski previously served as TAM's vice president and director of Canadian operations. In his new role Machowski said his first goal in his new capacity will be to improve communications across all international business units.



"Our success is dependent upon excellence at the well site; this excellence can only be achieved with clear and consistent or 'common' communications," Machowski says.

Machowski says it is an exciting time to be a part of the global energy industry.

"[TAMs] is not limited to any one geographic area. Our operations in Latin America, Canada, Asia Pacific, Europe, and the Middle East, are all expanding, showing and presenting additional and enhanced opportunities."

Houston-based growth

Chicago-headquartered global energy law firm Mayer Brown brought **William T Heller IV** and **Harry R Beaudry** onboard its legal team in January. The pair will be based out of Mayer Brown's Houston Corporate & Securities practice. Heller and Beaudry, formerly partners at Thompson & Knight, joined Mayer Brown for two reasons: people and platform.

"It starts with people," Heller says. "And secondly, the platform; seeing



what's happening in the Houston market and the energy industry in general, I became a big believer in a firm that has global capabilities."

Beaudry agrees. "I was impressed by [Mayer Brown's] commitment to growing its presence in Houston and the energy market," he says.

Heller and Beaudry, who have a combined 30+ years experience in the energy industry, specialize in energy mergers and acquisitions, and capital markets.

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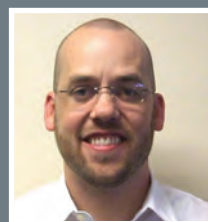
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Patrick Zirnhelt is vice president for Energy and Asset Management (EAM) for IFS North America. He has almost 20 years experience working with enterprise systems, including software development, implementation, and sales. He is a professional engineer registered

in Ontario, and earned both an MBA specializing in management information systems from the York University Schulich School of Business in Toronto and a B.S. degree in mechanical engineering from Queens University, Kingston, Ontario.



Jeremiah Woodford is responsible for growing IFS North America's EAM footprint in the American oil and gas sector, with a special emphasis on offshore drilling companies and oilfield service companies.

He has more than 10 years experience in information technology and operations & maintenance management software. He earned a B.S. degree in computer science from Lamar University in Beaumont, Texas.

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NORTH AMERICA

Bill Krull
Phone: 713-535-1521
bkrull@atcomedia.com

Diana Smith
Phone: 713-874-2212
dsmith@atcomedia.com

John Lauletta
Phone: 713-874-2220
jlauletta@atcomedia.com

Rhonda Warren
Phone: 713-285-5072
rwarren@atcomedia.com

UNITED KINGDOM

Neil Levett, Mike Cramp
Alad Ltd
Ph: +44 01732 459683
Fax: +44 01732 455837
neil@aladltd.co.uk
mike@aladltd.co.uk

NORWAY/DENMARK/ SWEDEN/FINLAND

Brenda Homewood, Alad Ltd
Ph: +44 01732 459683
Fax: +44 01732 455837
brenda@aladltdco.uk

ITALY

Fabio Potesta,
Media Point & Communications
Ph: +39 010 570-4948
Fax: +39 010 553-00885
info@mediapointsrl.it

NETHERLANDS/AUSTRIA/GERMANY

Arthur Schavemaker, Kenter & Co. BV
Ph: +31 547-275 005
Fax: +31 547-271 831
arthur@kenter.nl

FRANCE/SPAIN

Paul Thornhill
Ph: 01732 459683
paul@aladltd.co.ukk

MALAYSIA

Koh Earn Soo,
Market Intelligence (M) Sdn Bhd
Ph: +60 12 389 0675
Fax: (603) - 6274 7660
kes.marketintelligence@gmail.com

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Numerology

1992

The year, prior to 2012, that US crude oil production last exceeded 7mmb/d.

(Source: US Energy Information Administration)



2015

The year that Asgard's subsea gas compression system will start up.

(Source: Statoil)

350°

For Project 20KTM, Maersk Drilling will design rigs capable of withstanding HPHT environments up to 20,000psi and 350°F.

(Source: BP)

9,200,000

The number of US jobs that the oil & gas industry supports. (Source: Chevron)

#8

Coral 3 is the eighth well drilled in Area 4, off Mozambique. It encountered 117m of gas pay and added 4tcf in reserves to the Mamba complex.

(Source: Eni)

120,000

Tonnes of steel used to build Total's Pazflor FPSO.

▶ See Geographic Focus, page 78.



LAURENT PASCAL

278

Length, in kilometers, of a subsea power cable installed between Ireland and Wales.

▶ See Sensa story, page 62.

600,000

Tons of seamless pipe that Tenaris plans to produce annually at its Bay City, Texas, facility. (Source: Tenaris)

90,700,000


The global oil demand estimate, in b/d, for 2013.

(Source: International Energy Agency)



2500

The weight, in tons, of the CX-15 buoyant tower hull installed off Peru in September 2012. (Source: Wison Offshore & Marine)

A high-angle photograph of two children playing on a sandy beach. The child on the left is wearing a yellow shirt and blue shorts, and the child on the right is wearing a green shirt and blue jeans. They are both using sticks to draw various shapes and patterns in the sand. The text 'Safeguarding life, property and the environment' is overlaid in the top left corner of the image.

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