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Asset Integrity special report 34

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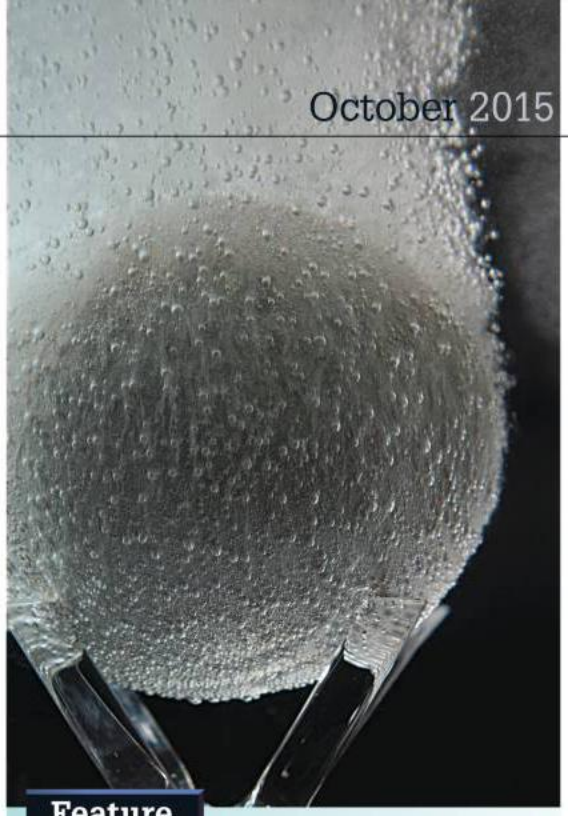

Feature

Nanotechnology

ON THE COVER

Hustle & bustle. This month's *OE* highlight's Brazil Offshore sector. InterMoor supplied 15 conductors for the Papa Terra project in 2012, examined on page 66. The cover photo, provided by InterMoor, shows well conductors for Papa Terra being loaded on a barge for installation at the Port of Rio de Janeiro.

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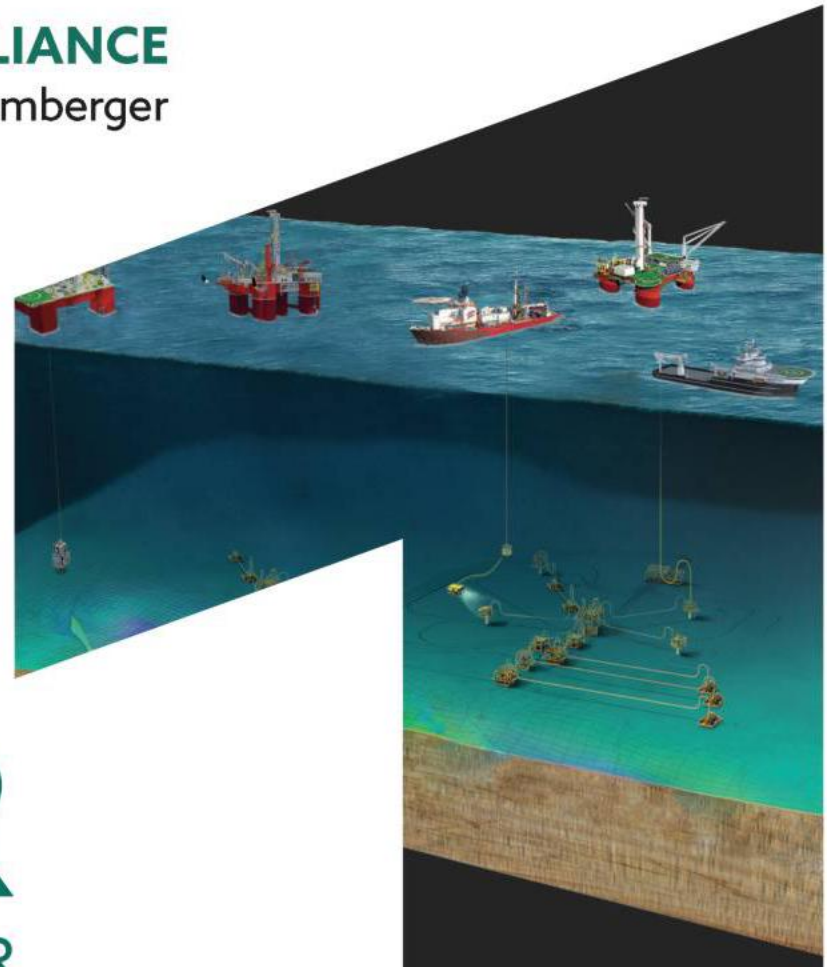

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Online Exclusive

Tracking ROVs

Elaine Maslin reports on the ROV market outlook and technology trends from this year's Subsea UK's ROV conference.

What's Trending

Big deals

- World's first subsea compression online
- Schlumberger to acquire Cameron for $14.8 billion
- Petrobras reveals historic production levels

People

Ex-Petrobras exec joins Aker Solutions

José Formigli, former exploration and production director at Brazilian national Petrobras, has been picked by Aker Solutions to serve as an adviser for overall strategic decisions and to join its innovation board. "We are delighted to have [Formigli] join our team. His input as a former operator and strong track record in the offshore and deepwater market will be of immense value," said Aker Solutions CEO Luis Araujo.

OE WEBINAR: Proving the industrial internet of things

Asset integrity is all about continuously monitoring equipment and process health. Analytics gathered through the Industrial Internet of Things (IIoT) can change work flows from reactive to proactive, head off problems before they become big issues, help eliminate unplanned downtime and improve asset performance and safety. Join Honeywell Process Solutions' Dan O'Brien and OE Automation Editor Greg Hale as they discuss how these solutions could be a game-changer.

Tune in 10:00 – 11:00 a.m. CST Thursday, 5 November 2015.

Register now at OEdigital.com.

Sponsored by Honeywell

A string of deals for Culzean

Maersk Oil's UK North Sea business has inked a contract with MODEC for the supply of a floating storage and offloading (FSO) vessel for the US$4.5 billion high-pressure, high-temperature Culzean development. This deal joins ones made previously with Heerema Fabrication Group, Sembcorp Marine, Subsea 7, and Tata Steel.

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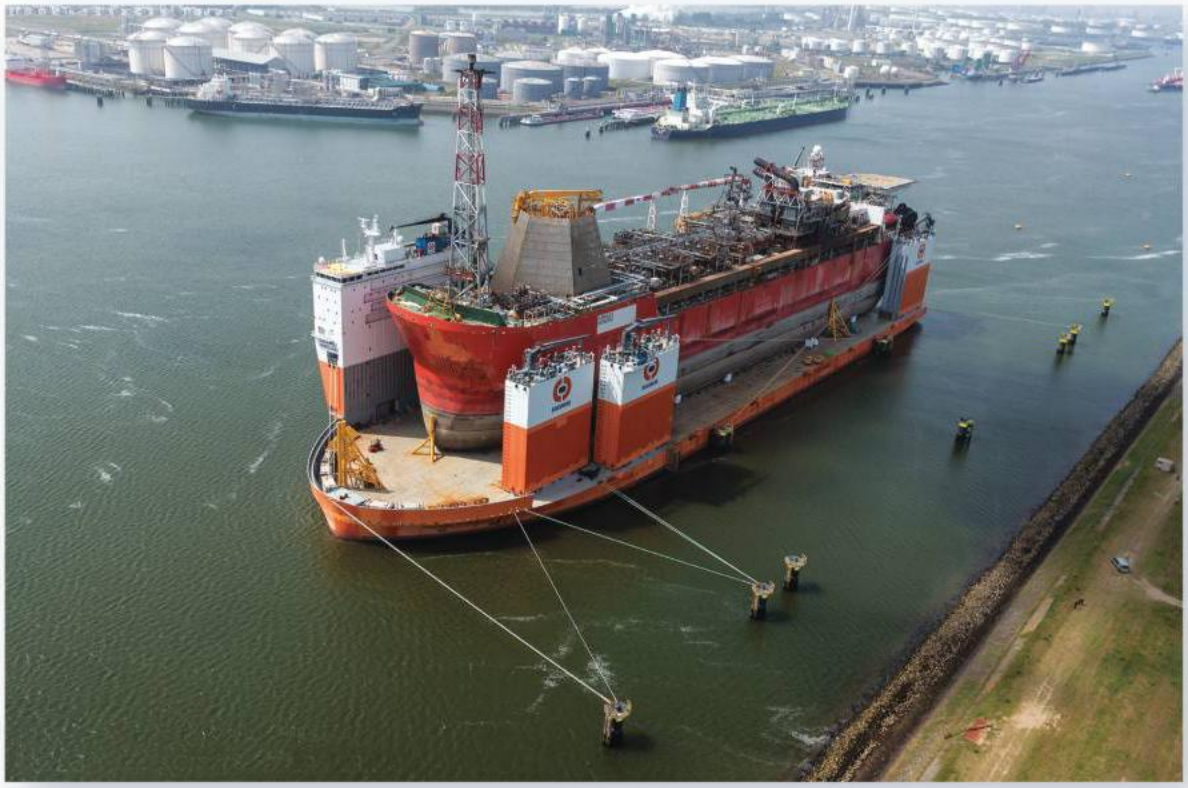

We want YOU
(to submit your photos)!

Since 1975, *OE (Offshore Engineer)* has enjoyed being close to the offshore action. In the past, we've encouraged you to send in your photos. As it's our 40th birthday this year, we like to do so again. Send us your photos from offshore, or even the fabrication yard or manufacturing facility (subject to company approval!).

We will feature the best in the magazine, over the coming months, with a selection of the top shots to be featured in our anniversary year end issue in December and online.

See if you can do better than these fantastic shots from Hans Elbers – taken by attaching a camera to a kite – in the Caland Canal, Rotterdam, which show the *Dockwise Vanguard* heavy transport vessel loaded with the *Armada Intrepid* floating production, storage and offloading (FPSO) vessel before it sailed to Indonesia.

Send your photos to **news@oedigital.com**.

All photos Hans Elbers, www.fotovlieger.nl

Undercurrents

Prelude to a KISS

Should we stop agonizing and just start kissing? It might be a good idea, although maybe not quite what you would think, at first glance.

"Keep It Simple, Stupid" (KISS), is a phrase ***OE*** staff heard at a recent industry event, which discussed how engineering design decisions can impact operations.

At first, it gave us a giggle (it was an evening talk after all), but then it got us wondering about how the industry might also need to focus on simplifying some of the language we use to discuss it those technologies and the industry at large.

Here's a recent example from ***OE***'s inbox: "The lubricant's pseudoplastic rheology means that shear or agitation causes a reduction in dynamic viscosity, which allows maximum penetration into umbilicals and wire ropes, as well as increasing pumpability during application to minimize blockages."

Offer such a line to a non-industry person, or even someone in the industry, and it might offer up a chortle (a non-industry friend of an ***OE*** staffer suggested that minus the words "into umbilicals and wire ropes," this could be a marketing line for a product available at a high-street adult shop).

So, why do we end up with these wordy descriptions? Keeping it simple certainly isn't a strong suit in the oil and gas industry. We're an industry that accuses itself of "gold-plating," over-engineering and, worse still, engineering for engineering's sake, shock horror.

In terms of the language used, it would appear the aim is to outline the highest possible specification product with all bells and whistles with a dollop of science behind it (pumpability).

The contractor, service provider, product developer, wants to be taken seriously. But, that can lead to over complicating matters and potentially situations where some, if not all, in the room lost the thread of the pitch 20 minutes ago and are now too scared to put their hand up and ask what x, y, z means. The result then cascades to the end user who when he asks up the chain how that product works cannot find someone able to explain.

There's also a broader impact. We risk alienating outsiders – the next generation even – who would be fascinated by the amazing feats of engineering, scale, depths, pressures, etc., in which we work because we can't convey it in simple terms.

Perhaps, in the cost-cutting, efficiency drive, E&P2.0 era we're now in, there might be a chance to get back to basics – communication 2.0, to steal a metaphor used by 2015 SPE President Helge Hove Haldorsen.

So who is up for some KISSing? **OE**

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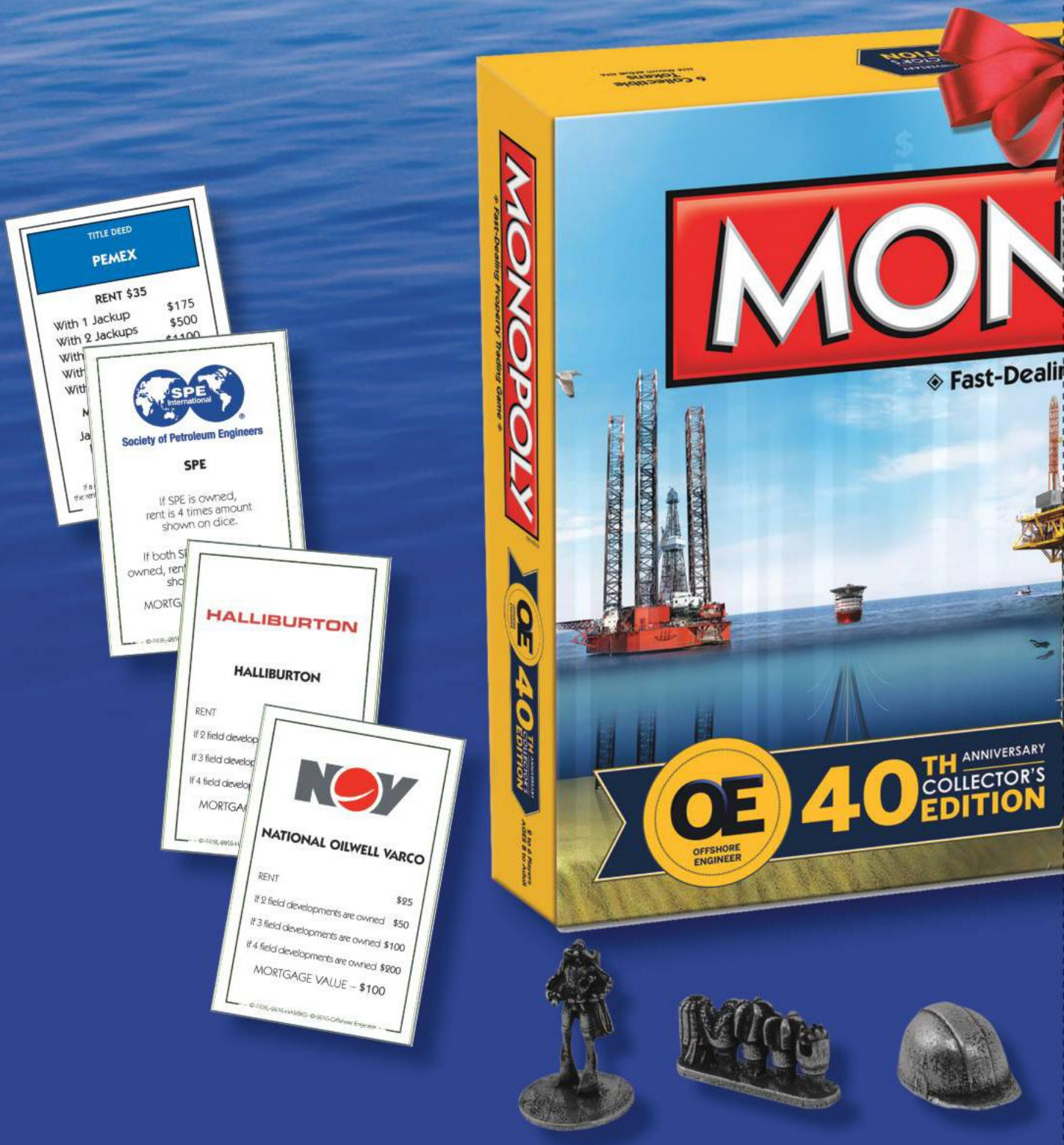

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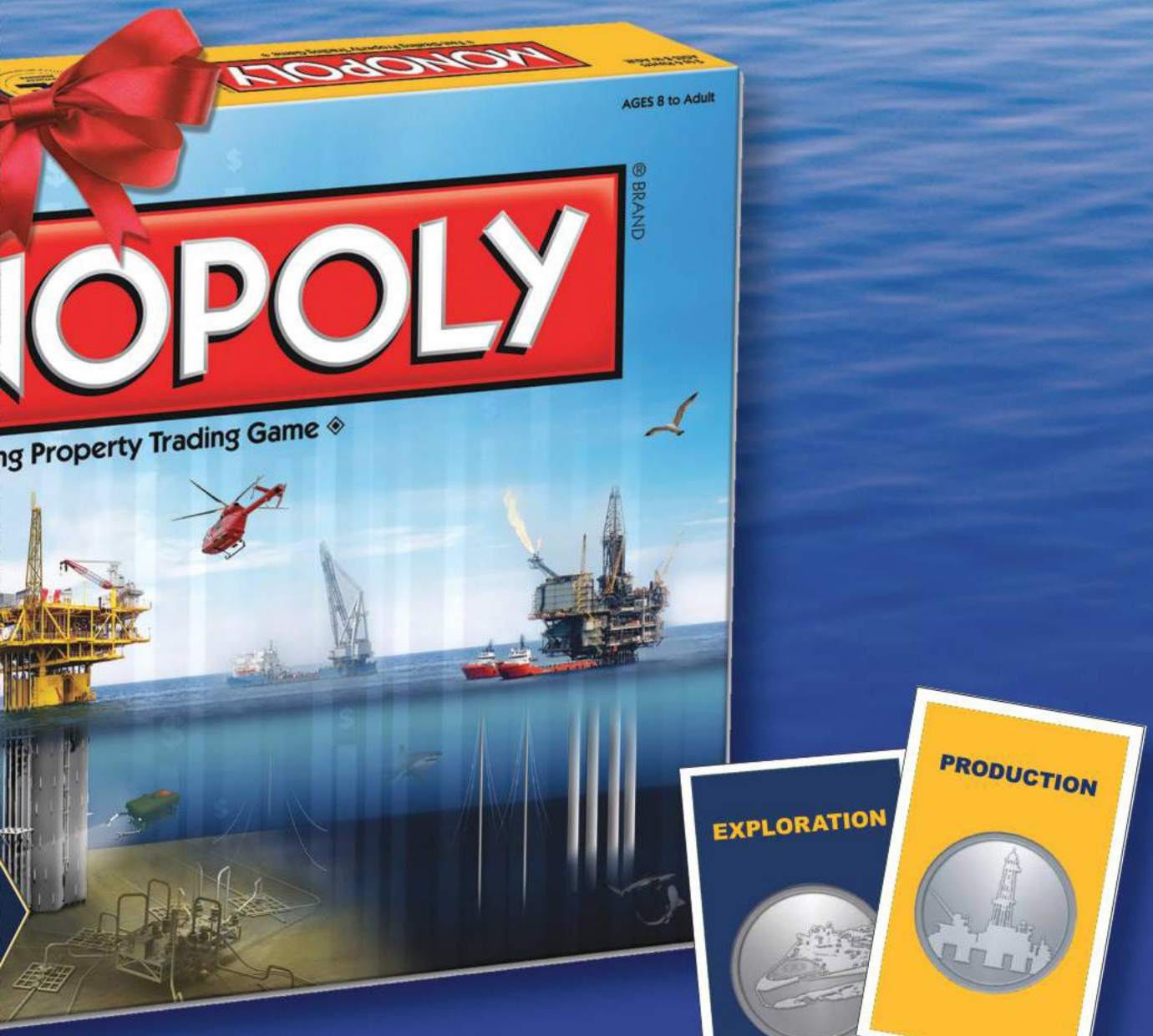

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Abdalla Awara, Halliburton

ThoughtStream

Innovation is the key to Brazil's deepwater reserves

Today, deepwater reserves are a key part of the world's oil and natural gas needs, accounting for roughly 11% of global production. Over the past five years, two-thirds of discoveries occurred in deepwater, and Brazil has been the preeminent site of this trend. The country's pre-salt finds alone account for about 38% of the total. Looking ahead, IHS projects that by 2020 deepwater could account for approximately 20% of new source production. For both national and international oil companies, deepwater will figure prominently in their future portfolios.

So, why has deepwater exploration been *decreasing* lately in Brazil and around the world? Even before the current market conditions arose, investment in deepwater exploration was challenged by high costs and fewer than expected successes. Now, with the decline in the price of oil, the challenge is even greater.

As one might expect in the current market, many companies elected to drill development wells in proven areas to ensure productive returns. Brazil is no exception to this strategy. Even with the recent reduction in exploration and production costs, to break even, many projects in Brazil would still need the oil price to be well above where it sits today. In the abundant Santos Basin, for example, average water depth is about 2100m (7000ft) and average reservoir depth is 5800m (19,000ft), conditions that drive up the cost of exploration and development (IHS 2015).

Given these circumstances, why then are future projections still pointing to significant deepwater production contribution over the next five years? In my view, there are two answers. The first is because a high percentage of the discovered, but undeveloped reserves, are in deepwater, 61% of oil and 53% of gas (IHS 2015). As operators ramp up development on proven reserves, these sources will start significantly contributing to overall global production. The second is because exploration activity, though scaled back to accommodate today's market, will soon recover. Exploration drilling is the machine that fuels new oil reserves. Slow it down and, eventually, new reserves discovery slows. Since deepwater will remain a main source for new reserves, the return to exploration is inevitable.

"Looking ahead, IHS projects that by 2020 deepwater could account for approximately 20% of new source production."

Clearly, the biggest challenge is the high cost of exploration and development in deepwater. Certain pricing concessions can help generate work, particularly on high-cost items like rigs and subsea equipment. But more substantial, deepwater long-term gains will come through operators internal cost optimization and industry efficiencies driven by technological innovation. Consider two pioneering Halliburton technologies that can help increase reliability and reduce uncertainty to ultimately contribute to the improvement of well economics.

The Halliburton RezConnect well testing system is the industry's first fully acoustic-activated drill stem test (DST) system. It provides comprehensive acoustic control of DST tools, with measurement and analysis of test data in real-time, allowing operators to have a dialogue with their reservoirs to make informed decisions faster and thereby reduce costly rig time. In Brazil, the RezConnect system recently saved an operator five days of rig time.

Another innovative technology is the Halliburton ESTMZ enhanced single-trip multi-zone completion system. Designed specifically for deepwater and ultra-deepwater completions, it enables isolation and treatment of several well intervals using a high-rate frac pack in a single trip of the work string. In a lower tertiary, five-zone, 1400ft production interval, for example, the ESTMZ system could reduce rig time by as much as 42 days, and a US$1 million spread would see a savings of up to $42 million.

Innovations like these are central to maintain the competitive edge in deepwater markets and restoring exploration activities. Although the market in Brazil and around the world has shifted to development for the near-term, exploration will continue to play a pivotal role if we continue to bring savings through our innovation — and Brazil will remain the major source of deepwater activity in the coming decade. OE

Abdalla Awara *is Vice President of the Testing and Subsea product service line at Halliburton. Previously, he led the strategic marketing team within the Drilling and Evaluation division. Awara began his career as a well testing field engineer at Halliburton in 1987.*

Two years later he moved to Geoservices International and progressed through a series of roles, including overall responsibility in Nigeria, Libya, Canada, Asia Pacific, CIS and West Africa. In 2004, he joined Power Well Services (now Expro) through an acquisition to become the Europe and West Africa Regional Vice President, and was named Regional Vice President of Europe and CIS, based in Aberdeen, in 2008.

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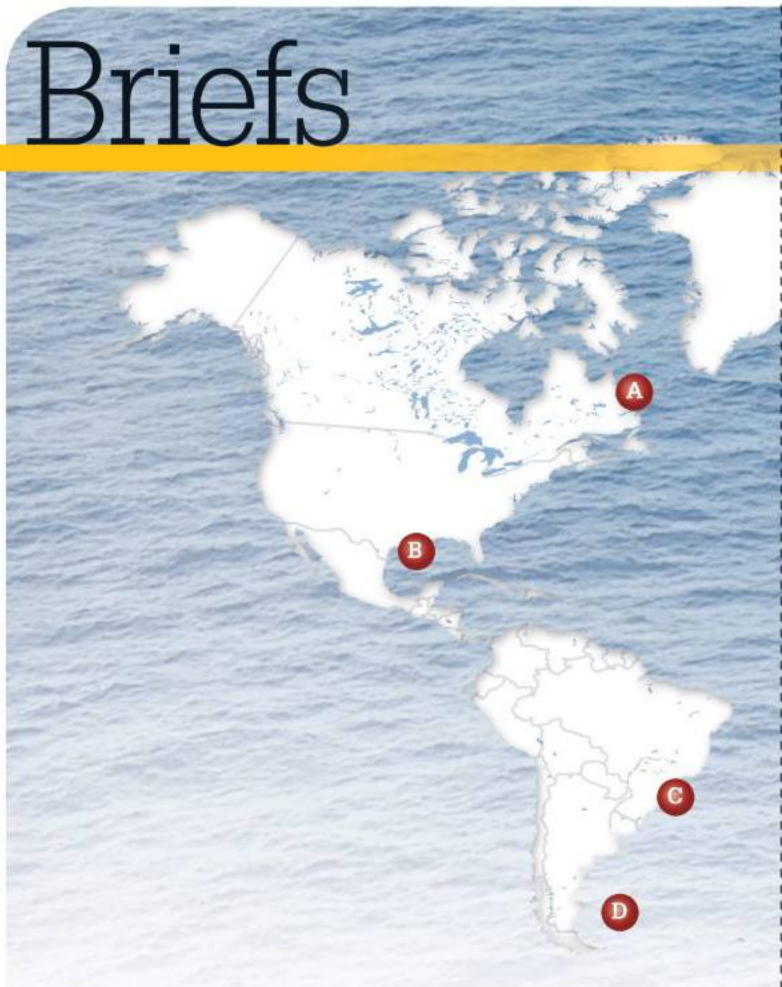


A Husky boosts South White Rose production

Husky Energy has commenced production from a second oil well at the South White Rose extension drill center offshore Newfoundland and Labrador.

Production, tied back to the *SeaRose* FPSO, is expected to ramp up to a combined net peak production of 15,000 b/d.

Husky operates the satellite field with 68.875% interest.

B Five bid in lease sale

Lease Sale 246 in western Gulf of Mexico attracted only US$22.7 million in bids, the lowest since 1986. The sale offered 4083 unleased blocks, covering about 21.9 million acres.

A total of five offshore energy companies submitted 33 bids on 33 tracts, covering about 190,080 acres. The five bidders were BHP Billiton (26 bids), Ecopetrol (four bids), Anadarko Petroleum (three bids), Peregrine Oil and Gas II (two bids), and BP (one bid).

Ecopetrol submitted the single highest bid for one block, $2.8 million for East Breaks 685, which sits just east of Corpus Christi and south of Galveston Island, Texas. BP's sole bid was for Keathley Canyon block 139 for $887,552.

C Kangaroo falls

Karoon Gas Australia revised its 2C resources at the Kangaroo field in the Santos basin offshore Brazil. The original 88 MMbbl estimate has decreased nearly 39% to 54 MMbbl. However, estimates at the Echidna field, a 2015 discovery, have been placed at 75 MMbbl, bringing to total 2C resource estimate in the area to 129 MMbbl.

D Noble delayed on Falklands Humpback

Noble Energy's Humpback exploration well has experienced a series of unforeseen equipment and operational issues that will delay results by about a month.

According to partner Falkland Oil and Gas (FOGL), Humpback could contain an estimated 510 MMbbl mid-case gross unrisked prospective resources, with the Diomedea fan complex in the Fitzroy sub-basin potentially containing more than 1.7 billion bbl mid-case gross prospective resources.

E Eni makes giant find

Eni has encountered a massive discovery at the deepwater Zohr field, offshore Egypt, which the Italian explorer says could hold up to 30 Tcf of lean gas in place (or 5.5 billion boe) over some 100sq km.

The discovery well, Zohr 1X NFW, was drilled in the Shorouk Block (Block 9) to approximately 13,553ft (4131m) TD and hit 2067ft (630m) of hydrocarbon column in a carbonate sequence of Miocene age with excellent reservoir characteristics

Zohr's structure also has a deeper Cretaceous upside that will be targeted in the future with a dedicated well.

Eni says it will now appraise the field with the aim of accelerating a fast track development.

F Erha North hits first oil

ExxonMobil subsidiary Esso E&P Nigeria achieved first oil at the Erha North Phase 2 deepwater subsea development project, 60mi offshore Nigeria in 3300ft water depth. The project is aims to develop an additional 165 MMbbl from the currently producing Erha North field, 4mi south. Peak production from the expansion is estimated at 65,000 b/d, which will increase the field's production to about 90,000 b/d.

The project includes seven wells from three drill centers tied back to the existing Erha North FPSO.

G YFP hits pay off Nigeria

Nigerian operator Yinka Folawiyo Petroleum (YFP) has hit pay at the Aje-5 production well, according to partner Panoro Energy.

The Saipem *Scarabeo 3* semisubmersible drilled the well to 3255m depth into the Cenomanian oil reservoir where 19.4m (true vertical measurement) of gross oil-bearing reservoir was encountered. The rig has set a 7in production liner and the Aje-5 is currently being completed as a Cenomanian subsea oil production well.

H Erin Energy completes Gambia seismic

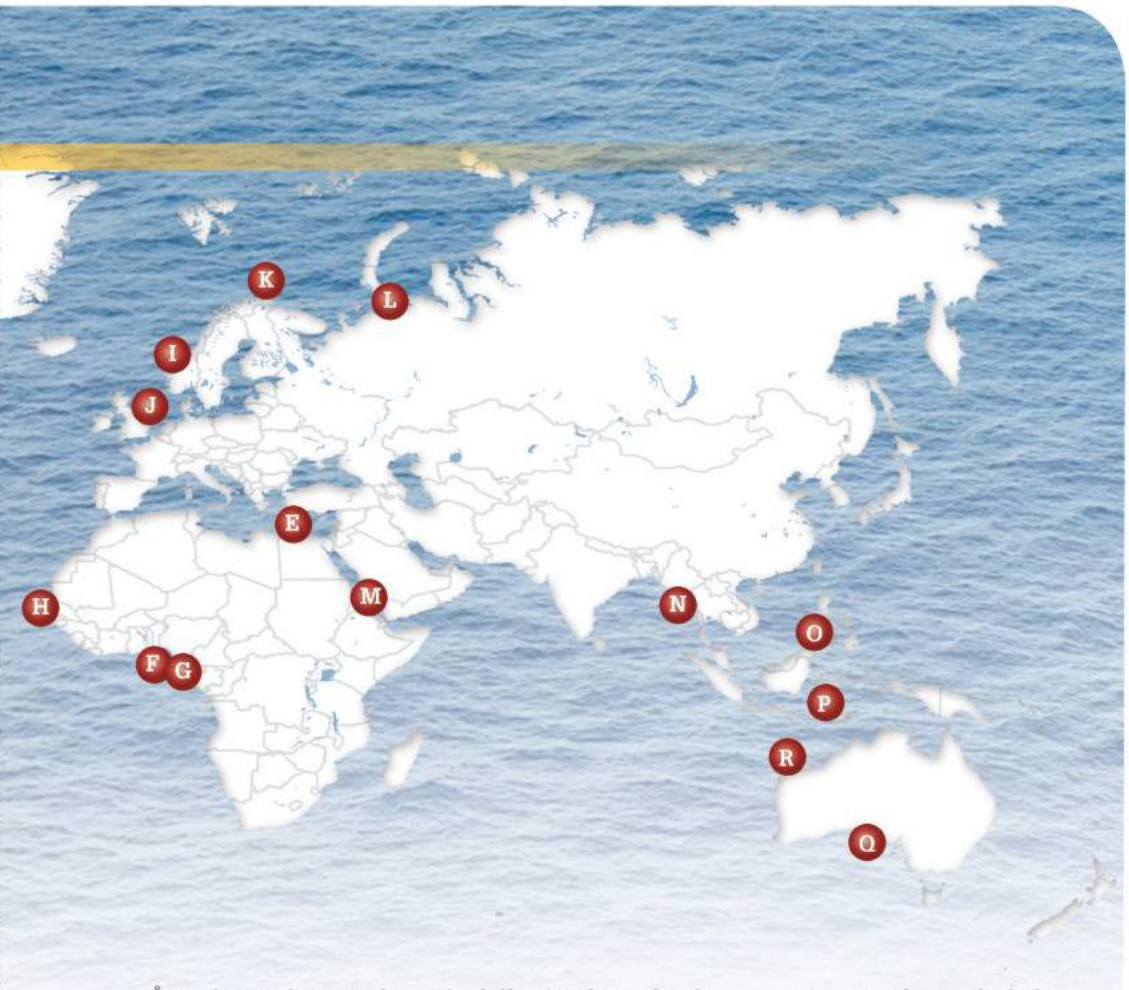
Erin Energy has completed acquisition of a new 3D seismic survey off Gambia.

Polarcus carried out the survey using the *Polarcus Alima*, and covered approximately 1613sq km on Erin Energy's A2 and A5 blocks some 28mi (45km) offshore Gambia.

Results are expected to be available during 2Q 2016. Erin Energy is operator of the A2 and A5 blocks with 100% interest.

I Statoil brings Asgard online

At 300m below the surface of the Norwegian Sea, the world's first subsea gas compression facility has come on stream, Statoil announced.



At Åsgard, introducing subsea compression will add some 306 MMboe to total output over the subsea Midgard and Mikkel reservoirs' lives, which will be extended out to 2032.

The project involves two 10MW gas compressors, a scrubber, pump and coolers, electrically powered from the Åsgard A floating oil production vessel. The compressor station measures 75m x 45m x 20m and weighs 4800-tonne with a 21MMcm/d (gas) capacity.

The $2.34 billion (NOK 19 billion) Åsgard subsea gas compression project is seen as a major step towards Statoil's subsea factory vision, which would enable a complete suite of processing technologies on the seafloor.

J Culzean gets green light

The green light has been given to Maersk Oil's US$4.5 billion (£3 billion) Culzean development in the UK North Sea.

It is being developed using a complex of bridge linked platforms, comprising a 12-slot well head platform, central processing facilities and utilities/living quarters for about 100 people, in about 88m water depth about 145mi east of Aberdeen.

Production is expected to start in 2019 and continue for at least 13 years, with plateau production of 60,000- 90,000 boe/d.

K 43 vie for APA 2015

Norway's Ministry of Petroleum and Energy received applications from 43 companies for its latest Awards in Predefined Areas (APA) 2015 Norwegian continental shelf licensing round.

APA areas have increased by 35 blocks in the Norwegian Sea and 11 blocks in the Barents Sea, with a total acreage of 127,608sq km up for bids.

Technical assessment of the applications are underway, and the NPD is also evaluation the applicants' geological concepts and exploration strategy for the areas.

The 23rd round application deadline is 2 December 2015. The Norwegian government aims to award new production licenses in 1H 2016.

L Second Prirazlomnoye well onstream

After nearly two years, Gazprom Neft has brought its second well into production at the Prirazlomnoye field in the Russian Arctic.

The second well is currently producing a total of 1800 tonne/d of oil, with production expected to increase at Prirazlomnoye more than two-fold in comparison with production levels in its first year in 2014, which stood at 300,000 tonne of oil.

According to Gazprom, the project will see 36 wells being brought into production, including 19 production wells, 16 re-injection wells, and one absorption well.

Prirazlomnoye is in the Pechora Sea, about 60km offshore Russia at 4500m water depth. It has recoverable reserves of approximately 70 million tonne of oil.

M South Pars 15 and 16 near startup

Phases 15 and 16 of the South Pars gas field, offshore Iran, are close to starting production, according to the project's manager. Production from Phases 15 and 16 of the offshore South Pars, jointly operated by Iran and Qatar, is forecast to reach 1.7 Bcf/d.

Phases 15 and 16 development of South Pars are aimed at producing 56.6 MMcm/d of natural gas, 75,000 b/d of gas condensate, 400-ton/d of sulfur, 1.05 MM-ton/yr of liquefied petroleum gas (LPG) and 1 MM-ton of ethane for feeding petrochemical plants.

Reza Forouzesh said the phases are expected to come online by mid-October. All 29 phases are expected to be developed in three years.

N Shell targets deepwater Myanmar

Shell is planning to start 3D seismic acquisition offshore Myanmar following its return to becoming an operator in the country.

The firm has issued a letter of award to Oslo-listed geoscience firm Polarcus for a 3D marine seismic project, which is currently expected to start in 4Q 2015.

Following the signing of three exploration and production sharing contracts with partner Mitsui Oil Exploration (MOECO) and Myanma Oil and Gas Enterprise, Shell has access to deep-water blocks AD-9 and AD-11 (Rakhine basin) and MD-5 (Thanintharyi basin), together

covering 21,000sq km, about 300km offshore in 1800-2700m water depth.

Malampaya DCP installation completed

Arup has completed the installation of the Malampaya depletion compression platform (DCP), a new offshore natural gas platform installed in the West Philippine Sea off the coast of Palawan, Philippines.

Arup oversaw the modularization and integration of the substructure in the drydock, provided technical supervision throughout the offshore works, and actively participated in the installation planning and execution for the 13,000 ton self-installing platform.

The platform was successfully installed within the installation tolerance of 1m from the set-out point, ensuring the interconnecting bridges to the existing platform could be installed without any modification.

Inpex submits new Abadi FLNG plan

Japan's Inpex has submitted a revised development plan for the Abadi LNG project offshore Indonesia.

Inpex had initially proposed an FLNG plant with 2.5 MTPA processing capacity, however, has been increased to 7.5 MTPA due to confirmation of greater volumes of gas.

The company says it will now undertake the required procedures in a timely manner to obtain the Indonesian government's approval for the Revised POD, and propel the project forward in partnership with Shell Upstream Overseas Services with the aim of launching FEED work for the development of the Abadi gas field.

Chevron to jointly explore Australian Bight

Chevron announced a partnership with the Commonwealth Scientific and Industrial Research Organisation (CSIRO) to investigate unexplored deepwater regions in the Great Australian Bight, in the first commercial partnership to operate the marine research vessel *RV Investigator*.

The multimillion dollar Great Australian Bight Deepwater Marine Program, funded by Chevron, aims to answer questions about the geology and ecology of this unique region.

The program will provide a better understanding of the Basin's geology and petroleum prospectivity to reduce exploration risks and costs. It will also improve understanding of the ecology and provide baseline data to inform environmental assessments.

"The Great Australian Bight remains relatively unknown, but it also represents one of Australia's most prospective exploration regions for oil and gas," said Ian Macfarlane, Minister for Industry and Science.

Quadrant to drill Roc-1 off WA

Quadrant Energy will spud the Roc-1 well located in the North West Shelf off Western Australia using the Tom Prosser jackup rig.

The best estimate for the commencement of the Roc-1 well is early to mid-November and the well is estimated to take around 50-60 days to complete. The current cost estimate to drill the Roc-1 well is around $45 million.

The Roc prospect is interpreted to contain at an estimate of 42 MMbbl of recoverable oil.

Quadrant is the operator of the WA-437-P permit with 40% stake Partners Finder Exploration, Carnarvon and JX Nippon each have 20% stake.

Contract Briefs

FMC secures Johan Sverdrup gig

Statoil awarded FMC Technologies a US$172 million engineering, procurement, and construction (EPC) contract for Phase 1 of the Johan Sverdrup field. The contract worth $172 million includes subsea trees, subsea wellheads, manifolds, and control systems integration. A frame agreement for add-on systems and a frame agreement for subsea service offerings have also been signed.

Oceaneering wins GoM work

Oceaneering will supply umbilicals for Shell's deepwater Appomattox development in the Mississippi Canyon area of the US Gulf of Mexico. The order is for electro-hydraulic steel tube control umbilicals, some 60 km (37 mi) in length. Product manufacturing will be performed at Oceaneering's umbilical facility in Panama City, Florida, Work is expected to commence in 4Q 2015 and be completed in 3Q 2017.

Ocean Installer awarded Moho Nord work

Total E&P Congo awarded Ocean Installer a contract for deepwater umbilicals, flowlines, and risers installation work at the Moho Nord field, off the coast of the Republic of Congo. Ocean Installer will install and precommission an umbilical, multiphase pump, flying leads and spools in water depths of around 1000m. The scope includes project management, engineering and logistics, in addition to offshore work. The project will be managed from Ocean Installer's Stavanger head office, while the high capacity DP3 construction support vessel *Normand Vision* will be utilized for the offshore execution.

Shell picks OneSubsea for Stones

OneSubsea will supply subsea services for Shell's ultra deepwater Stones development project in the Gulf of Mexico. The contract calls for the supply of subsea processing systems, which includes a dual pump station with two 3 MW single-phase pumps and two subsea control modules, a topside power and control module, a barrier-fluid hydraulic power unit with associated spares as well as installation and maintenance tools. Manufacturing and testing will take place at OneSubsea's processing center facility in Horsøy, Norway, with an expected delivery from Horsøy in early 2018.

Culzean activity increases

Maersk Oil North Sea UK has awarded several Culzean project contracts. Tata Steel and Subsea 7 have won separate contracts for the 22in, 53km-long gas export pipeline which will tie into the existing Central Area Transmission System (CATS). Subsea7 was awarded a subsea, umbilical, riser and flowline (SURF) contract, which includes providing project management, engineering, procurement, construction and installation of the pipeline, as well as a 3.6km pipe-in-pipe (10in outer pipe and 6in inner pipe) providing insulation for the transportation of the condensate to the in-field floating, storage and offloading facility (FSO). Subsea 7 will also provide subsea structures, tie-ins to the Culzean platform facilities and pre-commissioning expertise.

For the Culzean FSO, Japan's MODEC will design and supply the internal turret mooring system. Lastly, Heerema Fabrication Group will perform the engineering, procurement and construction for the Culzean jackets, for both the central processing facilities platform and the utility and living quarter platform. Six pile sleeve clusters will be fabricated at Heerema's Hartlepool facility in the UK. ■

Fig. 1: **Topside.** Images from Repsol.

Bringing Perla online

Shreeram Lom, Aaron Rampersad, and Juan Martínez, of Repsol, discuss the Perla field development, which came online offshore Venezuela in July.

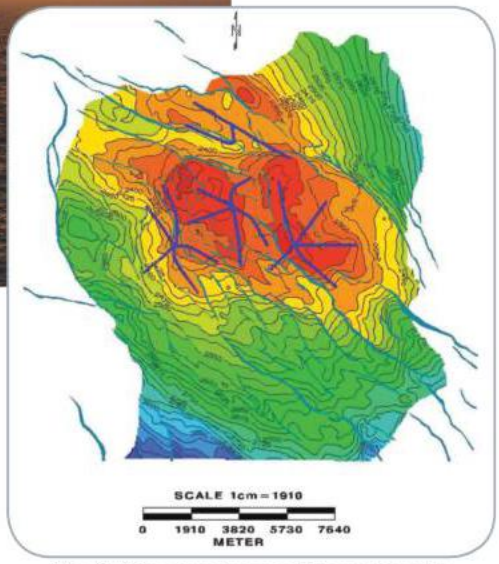


Fig. 2: Structural map of top reservoir.

The Perla field, which is part of the Cardon IV block, is the largest offshore gas discovery to date in Venezuela. The project forms part of the larger Rafael Urdaneta development project, approximately 50km west of the Peninsula de Paraguana (Gulf of Venezuela) in the Cardon IV West concession at roughly 200ft water depth. The field is operated by a company called Cardon IV whose shareholders are Repsol (50%) and Eni (50%). The participation of PDVSA to hold a 35% stake is currently under consideration.

Perla was discovered in 2009 through the exploration well Perla-1X that reached the reservoir at 8780ft true vertical depth subsea (TVDSS). The total original gas in place (OGIP) is 16.73 trillion cubic feet (TCF) and the proven reserves are 9.5 TCF. The production from the field is tied to PDVSA's pipeline network. The gas sales agreement was signed on 23 December 2012, and the development plan was approved on 20 August 2012.

First gas production started 25 July 2015 with the Perla 7 well producing approximately 135 MMscf/d and 3000 b/d of associated condensate. The full field development will occur in four phases with total estimated investment of US$6.620 million over the life cycle of the project.

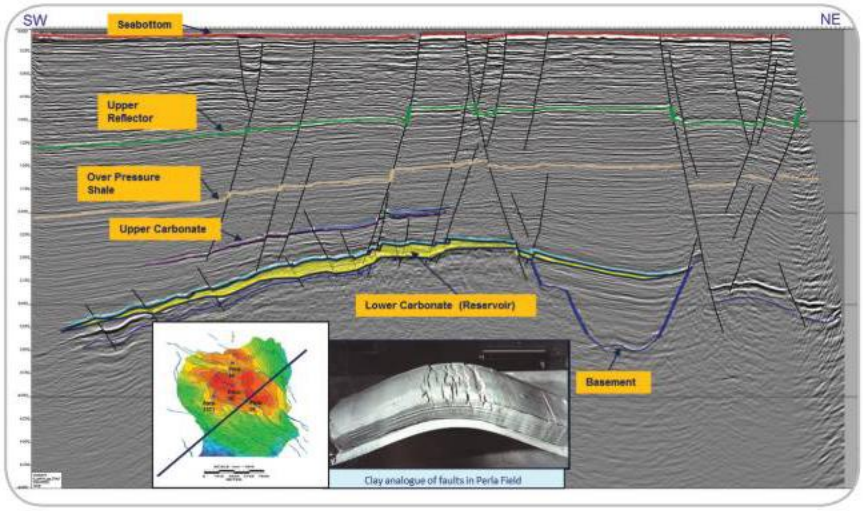


Fig. 3: SW-NE seismic line across the Perla Field.

Geology and geophysics

The Perla field consists of Upper Oligocene to early Miocene carbonates lying on a laterally discontinuous sequence of (Oligocene) siliciclastics, in turn deposited on a basement high. The field is characterized by northeast-southwest trending extensional faults, which are mainly

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due to the reactivation of the basement faults and also the subsidence caused by the Aruba and Urumaco Troughs. The carbonate is mainly composed by rhodoliths, branching red algae and larger benthic foraminifers with a minor contribution of green algae and corals. In terms of petrophysical properties both core and log data show a general increasing upward reservoir quality trend, with the uppermost unit characterized mainly by primary porosity, whereas the mid-lower units show mainly secondary porosity strongly affected by digenesis.

A 3D seismic acquisition was performed in 2006, which covered approximately 700sq km with a recording depth of eight seconds. The 3D volume is of very good quality showing excellent definition of faults and top carbonate (Fig. 3).

Reservoir and production

The Perla 1 reservoir has good petrophysical properties: porosity (15-25%) and permeability (10-80milidarcy (mD) in the upper section) generally degrading downward. The fluid is lean gas condensate (28 stock tank barrels (stb)/MMscf) with a vertical (gravitational) and lateral (origin) variation. The reservoir seems not to be hydraulically compartmentalized.

The development strategy is designed for 21 development horizontal wells, which would be drilled from four offshore platforms. The field development consists of four phases with increasing productions rates of 150 MMscf/d, 450 MMscf/d, 800 MMscf/d and 1200 MMscf/d.

Wells and drilling

Perla development wells are dry surface wells drilled using conventional jackup rigs. The field development strategy also included use of exploration wells as producing wells through tieback. Therefore, the exploration wells were abandoned temporarily using mud line suspensions for future tieback from the installed platforms (Fig 5 and 6). The exploration well campaign commenced in 2009 and lasted until 2011.

The casing design for the Perla field wells in the exploration and development phase consists of the following arrangement:

- 30in conductor casing in a 36in hole
- 20in surface casing in a 26in hole
- 13-3/8in intermediate casing in a 16in hole
- 9-5/8in production casing in a 12-1/4in hole
- 7in production liner in a 8-1/2in hole

In late 2014, a new pre-drill development campaign was started from the same subsea template as two of the previous exploration and appraisal wells. During this stage, two more wells were drilled with large horizontal sections and the wells were again suspended by the use of mudline suspension. After the successful installation of a hub platform, a rig was jacked up and skid placed above the production platform for tieback operations.

Production facilities

The development consists of four conventional four-leg wellhead platforms (Fig 7) operated as normally unmanned installations (NUIs). The platforms are arranged in hub-satellite configuration with three satellite platforms connected to one central hub platform via 14in submarine intra-field flowlines. The production from all four platforms is comingled on the central hub platform and then exported through a 30in, 67 km long submarine export pipeline to an onshore processing plant. At the onshore plant, the production is separated, conditioned and metered. The gas is finally sold through a tie-in to PDVSA's pipeline network at the connection point called Km 217.

The platform topsides facilities consist mainly of production facilities, utilities and materials handling equipment. No processing is performed on the platforms. As NUIs, the facilities are provided with redundant fiber optic cable (primary) and microwave (secondary) communications. The NUIs are monitored and controlled remotely from an onshore processing plant. To mitigate internal corrosion, the intra-field flowline and platform topsides piping is clad internally with stainless steel.

The development concept was selected and matured through a detailed front-end loading process involving internal and external engineering resources. The first step was a concept screening process, which yielded a broad spectrum of development concepts, which were matured through a pre-front-end engineering design (FEED) process. At the end of the pre-FEED process, the final development concept was selected which was further matured through a FEED process.

The work was executed through an engineering, procurement and construction (EPC) contract

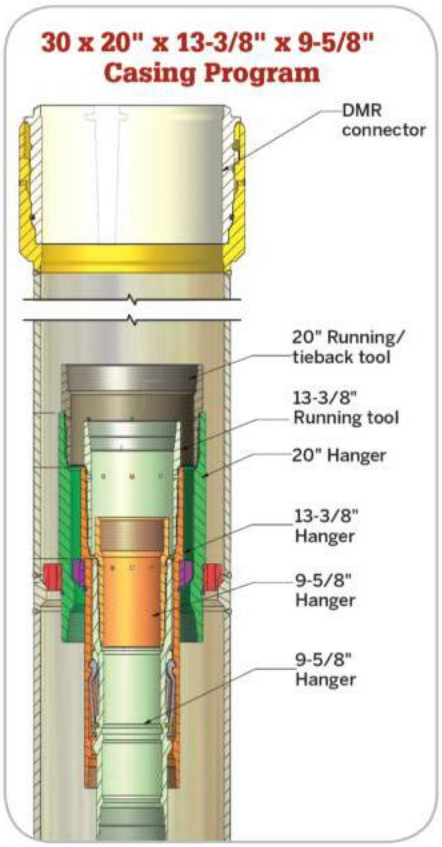

Fig. 5: Mudline suspension system assembly diagram.

Fig 6: Seadrill's West Freedom jackup at Perla.

through a consortium of contractors. The scope of work for the EPC contractor included detailed design, engineering, procurement, fabrication, transportation and pre-commissioning. A few long lead items were free-issued by Cardon IV. Installation of the platforms was performed through a separate installation contractor. The jackets and topsides were fabricated at an onshore facility in Mexico, transported to the field, and installed using heavy lift vessels. Upon successful completion of the platform installation, the rig was jacked up over the platform to tieback the pre-drilled wells as well as drill the development wells. The final hook-up of the platforms risers with the sub-sea pipelines/flowlines was performed using sub-sea and surface hook-spools. Cardon IV managed commissioning of the offshore facilities and onshore terminal facilities through a commissioning subcontractor. OE

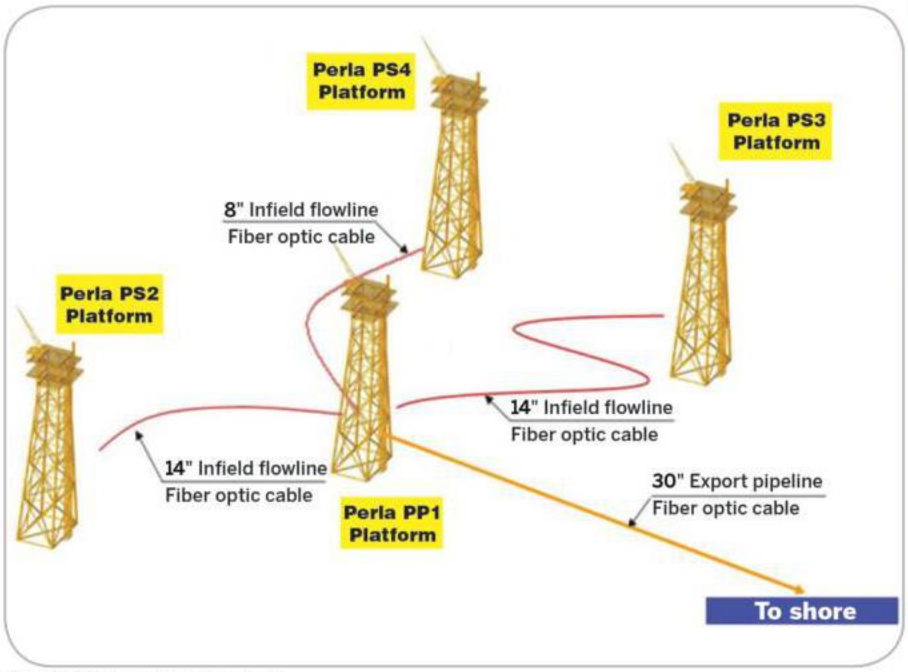

Fig 7: Offshore field layout.

Shreeram Lom *is offshore facilities engineer with 25 years' experience in offshore oil and gas development projects in several international locations. His current position is offshore engineering manager for Cardon IV Perla project for Repsol.*

Aaron Rampersad *is a reservoir geophysicist with 10 years' experience. He worked six years at the TSP asset in Trinidad generating prospects for infill drilling. Currently, he is the development Geophysicist at Cardon IV field for Repsol.*

Juan Martínez *is a well completion engineer with nine years' experience, six of them with Repsol assigned to Cardon IV since Perla Field exploration campaign in January 2010.*

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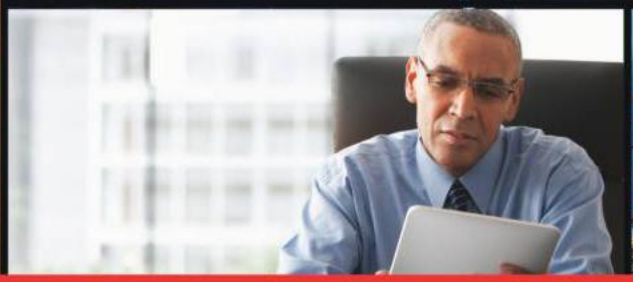


Supply and demand

When the oil price drops, people want to know how long the decline will last and when it will go back to "normal." Audrey Leon reports on how market watchers and researchers tried to make sense of the downturn at this year's SPE Offshore Europe conference.

Comparing the current downturn to oil price drops of decades past, one thing seems certain from the data: when supply outweighs demand, the oil price plummets, leading not only to a reduction in production but decline in investment, which in the long-term leads to future production shortages, and the cycle will continue, said Manouchehr Takin, a London-based international oil and energy consultant who spoke at this year's SPE Offshore Europe.

For the industry, it's obviously not great news. Takin noted that there are serious budgetary constraints and economic/social crises for all exporting countries – OPEC and Non-OPEC. The fall in price has also meant a fall in investment and massive staff reductions in world oil industry, not least in the North Sea.

In the UK oil and gas sector alone 5500 jobs have been cut. And with those cuts comes the bleak news that in 2014, the UK Continental Shelf (UKCS) spent more on operations than it earned from production, despite the fact that around the globe oil was trading near US$100/bbl. "The situation has been exacerbated due to the sharp fall in commodity prices," said Oil & Gas UK chief executive Deirde Michie. "We are all too well-aware that this is unsustainable and that investors are unwilling to commit to fresh activity. That is a deeply worrying place to be in."

Deidre Michie Photo from Reed Exhibition.

Adam Davey, economics and market intelligence manager, Oil & Gas UK, noted that volatility in oil prices is nothing new, but declared that the difference between the oil price drop in 2010 and now is that no one expects a quick recovery this time. "We will be in the $40s per barrel for the foreseeable future and we need to readjust the business to make sure it copes," he said.

But ultimately, Takin said that lack of investment, means that when demand returns, there could be supply shortage. "If investments are falling by 30-50%," Takin said, "less investment means there might not be enough oil." However, for the world economy, the news is less bleak. The low price could lead to global growth being boosted by 0.3-0.8%.

Clair Ridge installation. Photo from BP.

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	2012	2013	2014	2015
Shallow (<500m)	71	73	73	30
Deep (500-1500m)	23	19	27	13
Ultradeep (>1500m)	37	35	13	8
Total	**131**	**127**	**113**	**51**
Start of 2015 date comparison	135	125	90	-
	-4	2	23	51

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 2015-19

Water depth	Field numbers	Liquid reserves (mmbbl)	Gas reserves (bcf)
Brazil			
Shallow	9	57.75	333.28
Deep	12	941.00	2195.00
Ultradeep	40	10,923.75	12,450.00
United States			
Shallow	14	86.30	234
Deep	18	1004.27	1000.48
Ultradeep	24	2746.50	3380.00
West Africa			
Shallow	110	3732.20	15,898.22
Deep	37	4622.50	5540.00
Ultradeep	13	1635.00	2160.00
Total	**277**	**25,749.27**	**43,190.98**
(last month)	(273)	(25,701.77)	(42,908.70)

Greenfield reserves

2015-19

Water depth	Field numbers	Liquid reserves (mmbbl)	Gas reserves (bcf)
Shallow	892	38,248.29	513,122.34
(last month)	(909)	38,925.88)	(561,960.78)
Deep	120	7,555.58	71,735.91
(last month)	(120)	(7635.58)	(71,715.91)
Ultradeep	81	15,333.25	30,957.00
(last month)	(81)	(15,333.25)	(30,957.00)
Total	**1093**	**61,137.12**	**615,815.25**

Pipelines

(operational and 2015 onwards)

	(km)	(last month)
<8in.		
Operational/ installed	41,973	(41,385)
Planned/ possible	24,542	(24,891)
	66,515	(66,276)
8-16in.		
Operational/ installed	82,709	(81,917)
Planned/ possible	49,411	(50,024)
	132,120	(131,941)
>16in.		
Operational/ installed	93,622	(92,612)
Planned/ possible	43,131	(44,140)
	136,753	(136,752)

Production systems worldwide

(operational and 2015 onwards)

Floaters		(last month)
Operational	273	(273)
Under development	49	(47)
Planned/possible	312	(320)
	634	(640)
Fixed platforms		
Operational	9,529	(9241)
Under development	85	(92)
Planned/possible	1,380	(1378)
	10,994	(10,711)
Subsea wells		
Operational	4,813	(4744)
Under development	436	(467)
Planned/possible	6,442	(6471)
	11,691	(11,682)

Global offshore reserves (mmboe) onstream by water depth

	2013	2014	2015	2016	2017	2018	2019
Shallow	22,856.00	14,528.45	38,972.67	23,670.89	20,214.31	20,345.01	25,506.62
(last month)	(42,232.00)	(14,492.13)	(39,896.31)	(28,928.21)	(17,910.82)	(25,877.08)	(25,385.13)
Deep	481.00	4469.26	4340.71	2291.58	2230.92	4921.92	6417.57
(last month)	(480.55)	(4469.26)	(4340.71)	(2371.84)	(2150.66)	(4921.92)	(6484.04)
Ultradeep	2928.00	2342.81	1929.58	3034.17	3287.44	5221.54	7318.54
(last month)	(2928.40)	(2342.81)	(1929.58)	(3034.17)	(3287.44)	(5221.54)	(8519.54)
Total	**26,265.02**	**21,340.52**	**45,242.96**	**28,996.64**	**25,732.67**	**30,488.47**	**39,242.73**

17 September 2015

Adam Davey Photos from Reed Exhibition.

Takin, an Iranian native who worked for the OPEC Secretariat in Vienna for nine years, presented many factors that come into play with oil price fluctuations. For example, not only is the price affected by supply and demand tensions, but also financial players who can accentuate the price.

"For two to three decades the price of oil was $20/bbl," Takin said. "You forget about those times when it's been $100, but we had it for decades."

One day the market woke up. In 2008, oil reached a high of $147/bbl when only five years previous in 2003, it was $25/bbl. How did this happen? Well, the simple answer was that the market conditions were ripe for a price hike.

Looking at the late 1990s downturn, OPEC had made a decision to ramp up production in 1997, despite a recession in the Middle East. That decision caused the price of oil to fall under $10/bbl in 1998. Takin noted that it took two years for the price to go back up. But because of the lowered oil price, oil companies cut investments, due to a lack of confidence in the market.

"So, there was five years of underinvestment by companies," Takin said. "Based on the oil price collapse, companies didn't have confidence prices would go up. When they were doing project evaluations, their cut off was $14-15/bbl up until 2002-2003."

Takin said that when investment began 2004 onwards, and the global economy began to recover, there wasn't enough oil supply. "Demand was increasing, but supply could not catch up, the imbalance kept pushing up the price of oil."

The shortage of supply gave way to numerous stories in the media discussing peak oil and the end of oil as we know it. Takin said that this perception of peak oil and running out of oil accentuated the climb to $147 by July 2008. However, just as quickly as the price rose, it soon fell, plummeting to $30/bbl by yearend 2008.

By 2009, the US shale revolution had started, due to new technology and increased investment, reversing a trend in declining US crude production, where peak production of 10,000 b/d was achieved in the 1970s, and quickly fell through the next three decades.

But, by 2014, conditions were once again ripe for the cyclical market downturn. OPEC met in Vienna and decided not to reduce supply and thereby reduce their market share, Takin said.

Figures from the OPEC Monthly Oil Market Report from February 2015, show that in 2013-2014 the world's oil demand sat at 1 MMb/d, while the world's oil supply (excluding OPEC) sat at 2.2 MMb/d, Takin said. The need for OPEC crude sat at -1.2 MMb/d. Takin said that the oversupply would be worse had production from Iran and Libya been a factor.

For 2016, Takin notes that non-OPEC production will increase by 0.3 MMb/d, but excess supply will still persist, which means a continued downward pressure on price. In order to balance market, excess oil supply has to reduce 2-3 MMb/d, he said.

John Pearson

But, with the Iranian nuclear deal hanging overhead, where does Iranian oil fit into the scheme of things? Takin said we won't suddenly see 1 MMbbl flood the market. "I think it will be gradual, not quickly," he said. "But, by next summer, probably." And already, just due to the news of Iranian oil, Takin says we have seen downward pressure on the market.

Industry challenges

The overall theme of this year's Offshore Europe conference was boosting efficiency and remaining positive in the face of challenging times. Michie told the crowd at the Oil & Gas 2015 Economic Report breakfast that the market is adapting. "Companies like Halliburton and Baker Hughes, Shell and BG Group, Schlumberger and Cameron are merging, and infrastructure needed for the future is being acquired by firms focused on providing that service," she said. "A new business model is emerging on the UK Continental Shelf, one that can tackle the challenges a mature basin like ours."

However, Oil & Gas UK's data proved Takin's point that downturns lead to a loss of confidence and investment, especially on the UKCS.

"There's very little new fresh investment," said Adam Davey, economics and market intelligence manager, Oil & Gas UK. "Without more investment, investment could go down to £4 billion per annum by 2017. The average is around £8 billion per annum."

For the UK sector, Oil & Gas UK's data showed a dramatic rise in investment from £6 billion in 2010 to its peak of £14.8 billion in 2014. Davey says this investment is expected to fall at a rate of £3-4 billion over the next few years. He attributed the rise in spend due to recent projects such as Clair Ridge, Schiehallion/Quad 204, Laggan-Tormore, Mariner, Golden Eagle.

"Many of those projects are not yet complete," he said. "The capital investment, some sanctioned 2-3 years ago, is still being spent in 2015, 2016 and 2017."

Another issue in need of fixing is rising costs. Davey said Oil & Gas UK's data showed that while operating costs have been fairly controlled, there was a dramatic spike in 2010 and since then costs have grown 10% per annum.

"The increase is stark, and while some of this is good spend, the increase is so stark that some must be inefficiency," he said. "It's not all bad. Some of this investment has gone to improve production. Asset reliability is increasing. There's a tradeoff between spending now and enjoying benefits later.

"However, no matter how you look at it, such increases must be exceptional, we cannot continue to see cost grow at 10% per annum on the UKCS," he said.

John Pearson, Group President, Northern Europe and CIS, Amec Foster Wheeler agreed. Pearson, who was also presenting at the breakfast event said: "We can't change the oil price, but we can do something about cost. In terms of unit capital expenses, we have seen 20% CAGR over the decade. No other industry can sustain that." **OE**

Rig stats

Worldwide

Rig Type	Total Rigs	Contracted	Available	Utilization
Drillship	111	90	21	81%
Jackup	404	298	106	73%
Semisub	156	115	41	73%
Tenders	30	19	11	63%
Total	701	522	179	74%

Gulf of Mexico

Rig Type	Total Rigs	Contracted	Available	Utilization
Drillship	37	33	4	89%
Jackup	68	43	25	63%
Semisub	19	14	5	73%
Tenders	N/A	N/A	N/A	N/A
Total	124	90	34	72%

Asia Pacific

Rig Type	Total Rigs	Contracted	Available	Utilization
Drillship	14	8	6	57%
Jackup	116	77	39	66%
Semisub	33	17	16	51%
Tenders	19	12	7	63%
Total	182	114	68	62%

Latin America

Rig Type	Total Rigs	Contracted	Available	Utilization
Drillship	29	24	5	82%
Jackup	10	5	5	50%
Semisub	27	25	2	92%
Tenders	2	1	1	50%
Total	68	55	13	80%

Northwest European Continental Shelf

Rig Type	Total Rigs	Contracted	Available	Utilization
Drillship	N/A	N/A	N/A	N/A
Jackup	47	39	8	82%
Semisub	43	35	8	81%
Tenders	N/A	N/A	N/A	N/A
Total	90	74	16	82%

Middle East & Caspian Sea

Rig Type	Total Rigs	Contracted	Available	Utilization
Drillship	1	0	1	0%
Jackup	108	95	13	87%
Semisub	4	3	1	75%
Tenders	N/A	N/A	N/A	N/A
Total	113	98	15	86%

Sub-Saharan Africa

Rig Type	Total Rigs	Contracted	Available	Utilization
Drillship	24	22	2	91%
Jackup	22	18	4	81%
Semisub	14	10	4	71%
Tenders	9	6	3	66%
Total	69	56	13	81%

Rest of the World

Rig Type	Total Rigs	Contracted	Available	Utilization
Drillship	4	2	2	50%
Jackup	25	15	10	60%
Semisub	15	10	5	66%
Tenders	N/A	N/A	N/A	N/A
Total	44	27	17	61%

Source: InfieldRigs

21 September 2015

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

Nanotechnology: an industry perspective

Audrey Leon spoke to Rustom Mody, Vice President and Chief Engineer, Baker Hughes Enterprise Technology, to learn more about the company's research and development of nanotechnologies.

The uses for nanomaterials within oil and gas is endless from strengthening metals, and cements, to increasing energy storage and improving battery technologies.

According to the Interagency Working Group on Nanotechnology's 1999 report listing potential benefits of nanotechnology for the chemical and energy industries, it wrote: "The use of nanoscale materials for energy generation and storage may allow for higher capacities, higher rates of charge and discharge, and far greater control over the absorption and charge transfer processes… Similarly, removal of H_2S, H_2O, CO, and/or CO_2 from natural gas near well heads would enable more efficient transport of natural gas from the well head to the end user."

But that was over 15 years ago. It's safe to say that both research and the market for nanotechnology has advanced considerably since then. A new report by Research and Markets shows an industry with enormous growth prospects and expectations that the global nanotechnology industry will grow to US$75.8 billion by 2020.

With all that in mind, OE looked to industry leading service company Baker Hughes to see how the company has advanced their research and deployment of nanotechnologies within the oil and gas field.

Rustom Mody, Vice President and Chief Engineer – Enterprise Technology for Baker Hughes, oversees product and service research and development as well as engineering talent development across the company. He also heads industry and university collaboration for the company. Mody holds Bachelor of Science and Master of Science degrees in mechanical engineering and a Master of Business Administration in finance, as well as 16 patents. He is an active member of SPE, IADC and AADE and serves on various sub-committees of all three organizations. He also serves on the Boards of Advisors for the University of Oklahoma Engineering Department and University of Oklahoma Mewbourne School of Petroleum and Geologic Engineering, and Pumps & Pipes, a Houston research initiative that fosters collaboration and technology transfer among the energy and medical communities and NASA.

Rustom Mody

Inside the Baker Hughes nanotechnology lab, at the Center for Technology Innovation in Houston.
Photos from Baker Hughes.

OE: Are you currently using nanotechnology with your products?

Mody: Yes we are using nano-engineered products quite successfully.

OE: What factors led you to research and test nanotechnologies?

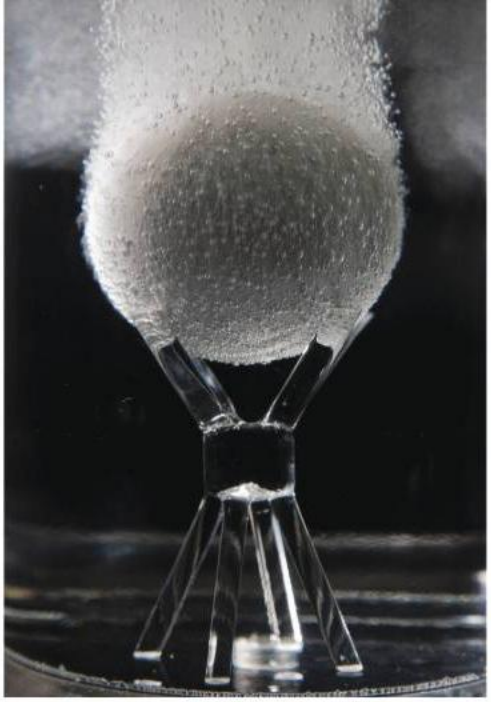
Mody: We work closely within the Pumps & Pipes community in Houston. Pumps & Pipes is a collaboration between the Methodist Research Institute (The Methodist

Hospital) and the energy industry. In the last couple of years, NASA has also joined the community. Through our observation of what was being accomplished with nanotechnology in medicine, the potential for nanotechology development and application within the energy industry became quite obvious.

OE: Please tell us of a recent project where it was successfully deployed.

Mody: Since first discovering nanostructured materials that would disintegrate downhole, Baker Hughes materials scientists have developed three important technologies that significantly reduce time and cost in hydraulic fracturing operations.

SPECTRE, the industry's first completely disintegrating frac plug, is made from CEM nano-engineered material developed and patented by Baker Hughes.



The IN-Tallic frac ball, also made from CEM nano-engineered material, that illustrates how this material completely disintegrates in wellbore fluids.

We developed and patented a technology called controlled electrolytic metallic (CEM) with a combination of high strength and in-situ disintegration characteristics that, as far as anyone knows, did not previously exist in other metal composite materials. The first application of CEM material was in our IN-Tallic disintegrating frac balls for use with multistage fracturing systems. We then used CEM technology in the industry's first intervention-less frac plug, SHADOW.

Last month at SPE ATCE, we introduced SPECTRE, the first frac plug that completely disintegrates downhole in the presence of wellbore fluids. The SPECTRE plug leaves no whole or partial plug components downhole—ensuring an unobstructed production ID for maximum flow area, reduced risk, and easy wellbore access. Now operators can increase completion efficiency and have the added benefit of a full-bore ID – without intervention.

In addition to our CEM technology, we are exploring the potential of nano-engineerd elastomers for high-temperature applications, nano-engineered lubricants for improved lubricity and heat transfer properties, and nano-engineered materials to increase wear resistance and enhance cutting properties.

OE: How does nanotechnology rank in terms of cost over other technologies?

Mody: It provides a unique ability to make dramatic improvements in material behavior properties, which improves both capex and opex for operators.

OE: How do you see this technology evolving for offshore use?

Mody: Because of their light weight and excellent conductivity, I see nano-carbon fiber cables being used to transmit electricity downhole. And, nano-engineered surfactants for enhanced oil recovery applications. **OE**

Voices

OE asked:

Are you using nanotechnology in your operations?

3M has developed internal research and development and manufacturing capabilities to create nanomaterials that have been used to enhance and extend 3M product lines, as well as to create new products for our many markets. 3M is looking to apply these capabilities and learnings to create novel material solutions for applications in the petroleum industry. One such technology development receiving much interest is in the use of nanomaterials in downhole foam stabilization for water conformance applications.

Kenneth J. Hanley,
Global Technical Director,
3M Advanced Materials Division

Nanotechnology offers new opportunities to steel pipe manufacturers dedicated to the oil and gas industry. The challenge for nanotechnology in this industry is huge since the requirements for robustness and durability in harsh environments are serious limitations for nano-engineered solutions that in other industries have found a relatively smooth implementation. Tenaris is addressing these challenges by adopting nanotechnology strategies with a focus on coatings and metallurgy, developing nano-enabled products and processes, with new or enhanced properties and functionalities and improving manufacturing efficiency.

Pablo A. Castro,
R&D Surfaces and Coatings department manager,
Tenaris

Living in a **material world**

Nanotechnology is a wide and growing field being researched and developed by both academia and industry alike. Elia Barnett spoke with researchers at University of Houston, Rice University, and Halliburton to see how far the technology has come.

Nanotechnology refers to a wide and growing area of scientific research with numerous applications in many disciplines. It involves controlling material properties by size and then designing around these materials. When materials are shrunk down to a scale of 1.5-300 nm in length, unique properties can emerge that are different from the larger bulk material.

Lee Hall, program manager, Nanotech Advanced Materials at Halliburton explains the reason why materials behave differently on the nanoscale: "When we shrink materials down to the nanoscale, the ratios of their surface area to their volume increase exponentially. And defects of the materials becomes fewer and less important. So when dimensions are less than or equal to let's say wavelengths of light, the quantum properties of materials that can't be observed in the bulk begin to dominate."

Quantum properties that otherwise would be absorbed in the volume of the larger material come out with the increasing surface area and tiny dimensions of nanomaterials. Imagine all the materials in the world and depending on size, double each material's potential uses. It's like taking the periodic table and being told there's a parallel universe for each element. Science fiction has come to life in nanotechnology.

Scientific research has gone into understanding these different properties and to explore the future applications. The potential of nanotechnology crosses over into almost every industry. Slowly the oil and gas industry has been gaining interest in tapping into nanotechnology's prospects. In the energy capital of the world, universities are pouring resources into the nanotechnology research specifically for offshore oil and gas applications.

Academia

One area of major focus for the University of Houston (UH) is studying advancements for the oil and gas industry. Dr. C. Vipulanandan, professor and UH director of Center for Innovative Grouting Materials and Technology (CIGMAT), researches how to work with "smart cement"

Top: A bubble is split before entering a constriction. Bottom: Neighboring bubbles pinch a third into two before it enters a constriction like those found in oil-bearing reservoirs.
Images from Biswal Lab/Rice University.

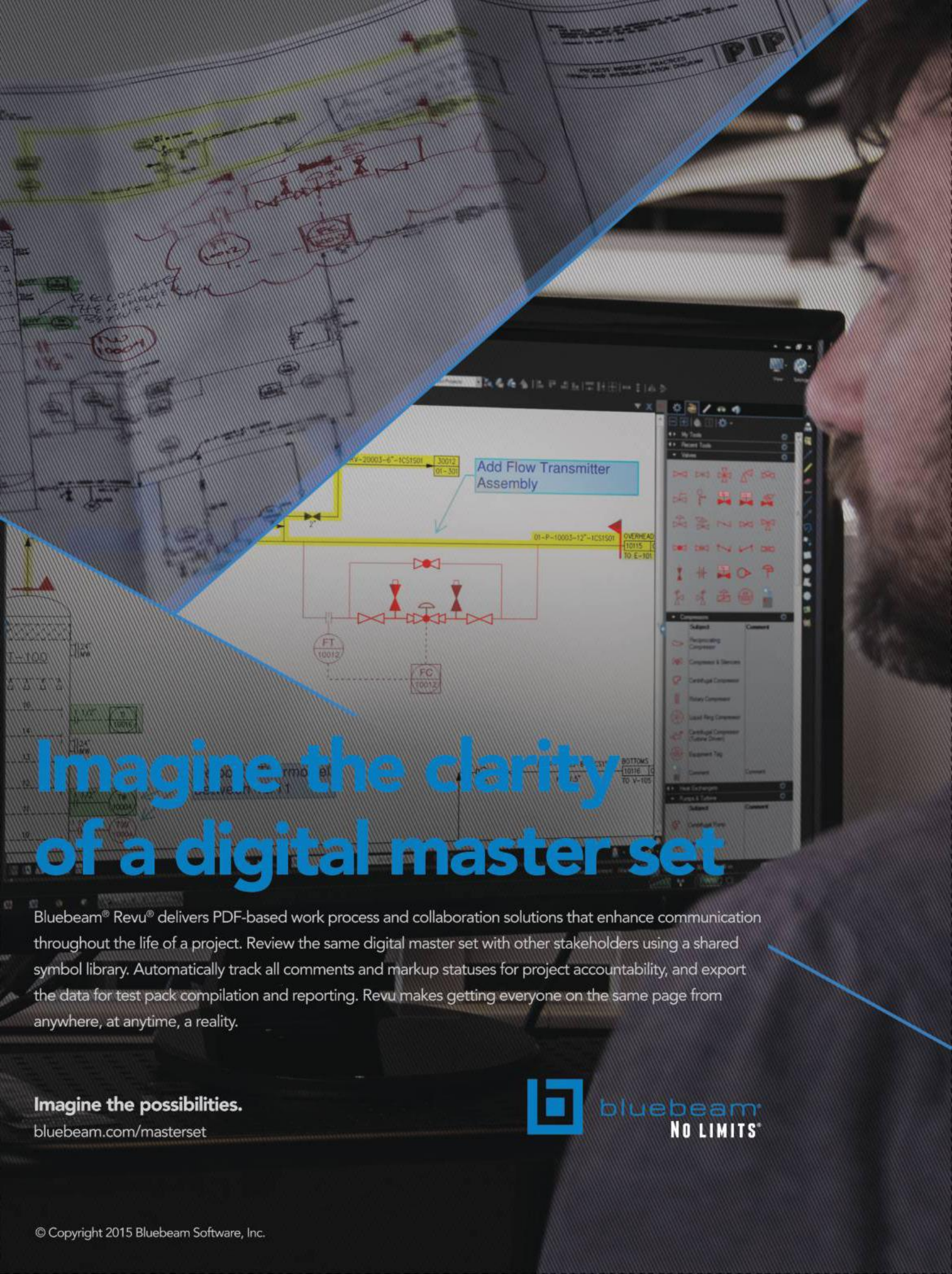
in downhole conditions.

The smart cement is designed as a sensor that uses electrical resistivity to monitor the strength and hardening of the cement. This is especially useful when cementing a well casing in subsea, high-pressure high-temperature (HPHT) conditions. According to Vipulanandan, contamination of the cement due to various factors such as seawater and oil-based drilling mud are common, major issues affecting offshore cementing. One of the purposes of his research addresses oil-based drilling mud (OBM) contaminated cement problems and looks at "how to detect contamination and how to minimize the contamination."

Recently, Vipulanandan presented a paper at the OTC showing how adding nanoparticles of calcium carbonate (NCC) to the smart cement modified its behavior to protect against contamination, thus increasing its strength, decreasing its curing time and increasing the ability to monitor the cement. His research shows that the addition of 1% NCC to oil-based drilling mud (OBM) contaminated cement increased the rheological properties of the cement slurry due to its higher surface energy as a nano particle. The smart cement formula uses electrical resistivity to read the cement's strength, curing time, and to monitor for weak points. OBM is a major concern because the contamination weakens the casing's dry time and compromises the strength. With the addition of 1% NCC to both 3% and 1% OBM contaminated smart cement, the electrical resistivity increased allowing for more accurate readings. In fact the higher the contamination, the higher the resistivity. The results of the research found that the NCC modification resulted in considerable improvement of compressive strength and piezoresistivity of OBM contaminated smart cement both after one and 28 days of curing under water.

Rice University, located in Houston, is historically well-known for major breakthroughs in nanotechnology and its applications. Sibani Lisa Biswal and George Jiro Hirasaki, faculty in the Department of Biomolecular and Chemical Engineering both study the use of foam for enhanced oil recovery from mature oil reservoirs.

Hirasaki says that traditional oil recovery processes use the injection of water or gas to displace oil. A



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High-pressure high-temperature testing facilities with resistance measurements. Image from Dr. C. Vipulanandan.

number of gases are used for enhanced oil recovery, including natural gas, enriched natural gas, nitrogen, carbon dioxide, and steam.

"A common feature of gas is that it has a low viscosity and density," Hirasaki says. "This tends to result in the injected gas overriding and bypassing the more viscous oil phase."

Application of nanotechnology helps stabilize the nanometers thick foam lamella that makes the flow of foam through porous rock act as if a viscous fluid was being injected, he says. This results in the preferential flow of oil instead of the injected gas and, thus, improves oil recovery.

In the foam state, the gas has the ability to get into the tighter pores and extract more oil from the reservoir. Biswal compared the foam's oil recovery abilities to shampoo in which the bubbles forming have both a hydrophobic and hydrophilic side. One part of the foam attracts the oil; the other part displaces it to the surface, she says. The purpose of the understanding the behavior of films or bubbles in the foam is to find better methods to recover oil in hard to reach reservoirs.

Industry

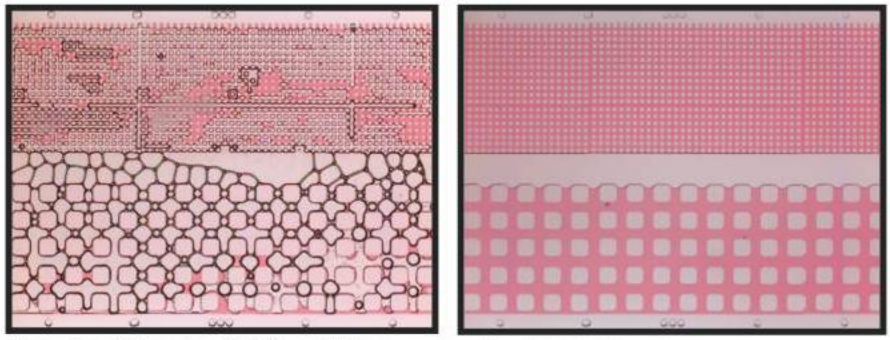
All these areas of research create new possibilities for the oil and gas industry. Many of the applications are already standard downstream. What ways can nanotechnology improve conditions upstream? Halliburton is one company looking to apply the technology to its operations.

"Nanomaterials and nanostructured materials are really great candidates as fluid additives," Hall says. "We currently have some programs that are looking at improving things like rheology control and fluid loss properties in drilling and cement, shale inhibition in drilling fluids, controlling reactivity and water transport during cement curing while improving strength.

"A little further out," he continues. "We're looking at delivering chemistry to targeted areas of the reservoir, tailoring all those nanomaterial surfaces to interact with specific reservoir rocks. There's some involvement with interaction of fluids with logging tools whether they're resistive or NMR or acoustic logging. Those are all great applications of nanotech that I think Halliburton will

be looking to take advantage of in the future."

Hall also says, for offshore conditions, nanotechnology can improve the thermal properties of drilling fluids and cements. These standard building tools for well construction are made more complicated in an offshore environment, he says. Drilling fluids and cements undergo huge temperature and pressure changes from cold sea floor to hot reservoir environments. "In similar environments, nanomaterials can retain their solid mechanical properties better than bulk materials while avoiding the thermal breakdown or side reactions normally associated with free polymer or molecular materials," he says.



Foam floods in microfluidic models. Images from Biswal Lab/Rice University.

Conclusion

Most nanomaterial research is geared toward human body conditions, but HPHT environments present an exciting new opportunity in which nanomaterials can be studied. "Academia, if they are not incentivized to look at some their nanotechnologies in those environments, there's no reason we should expect them to. If oil and gas does not reach out with challenge statements, and commensurate support and collaboration, we shouldn't really expect that their new research and discoveries will be portable to our industry," Lee says.

There's an obvious gap between nanotechnology applications for oil and gas industry and the nanomaterial research. Proposing new methods is risky and requires extensive research. Lee emphasized that industry's role is to communicate to researchers the specific conditions that need to be met in order for researchers to produce inventions that can be applied in in offshore environments.

There is a lot of potential for nanotechnology in the offshore oil and gas industry. The harsh conditions of offshore environments, coupled with the high temperatures and pressures invite new technological breakthroughs in nanomaterial research. Additionally, the cost of the nanotechnology is created around the fact that smaller doses of the material are needed in order to get the job done. Less material can lead to lower costs and higher efficiency rates. The technological advances can create a safer, high efficiency work environment. As the communication gap is bridged between academia and industry, more nanotechnology advancements and applications in the oil and gas industry will inevitably surface. OE

Gregory Hale explains how avoidable downtime costs producers billions of dollars every year, with equipment failures being the most common culprit.

Gearing up for asset integrity

Engineers remotely monitor all aspects of oil production, and work across locations to make quick adjustments in Shell's Smart Fields control centers.
Photo from Shell.

When a team of NDT inspectors witnessed a block of ice falling to the rig deck from a pipe two levels above this past summer, they knew they had a potential asset integrity – and safety – issue on their hands.

The ice had formed when rig workers partially shut down the pipe for maintenance work and the halt in usage caused the temperature of the pipe to drop considerably, despite it being summer. Ice then formed and fell when the pipe was brought live again. No one suffered an injury and it turned out the pipe remained intact, but that is not always the case.

Analyzing asset integrity can go two different ways, where one would be the high tech digital perspective focused on software working with hardware to understand how devices and components are functioning and how long before they need replacement to ensure continued uptime. Automation technology in the 21st century.

Then there is the other direction like the incident this past summer where a level of maintenance needs to occur on the low tech side where workers roll up their sleeves to ensure deteriorating assets continue operating, while processes remain up and running. After all, time is money.

It has been estimated that, globally, mostly avoidable corrosion-related leaks and equipment failures cost the oil and gas and chemicals industries US$220 billion, according to a report from Shell. On top of that industry averages suggest 5% of production capacity is lost each year due to unplanned downtime and in a down market those numbers can add up to big losses. More than any other reason, equipment failures are the most common culprit. When you combine this with fewer resources (money and people) keeping the operation running is a challenging task.

"Reliability is more important than anything else," said Robert DiStefano, vice president and general manager for reliability consulting at Emerson Process Management. "As much as 5% of production capacity worldwide suffers from reliability issues and 43% of that 5% includes unplanned downtime because of equipment problems."

Companies that have solid reliability programs reap benefits, including:

- Reduced downtime and increased profitability
- Spending less money for maintenance
- Increased safety – incidents go down when reliability goes up

"People are starting to use reliability as

Workers perform inspection on an offshore installation. Photo from Oceaneering.

a business strategy," DiStefano said. "If a CEO is not asking direct reports about downtime and what money they are spending on maintenance, then they are derelict of duty. You have to change the practices."

Tough times call for tough measures and the operation needs to stay on top of maintenance or out of condition assets could cause an unscheduled stoppage.

With unplanned downtime and maintenance issues solved as they come up during the day, it typically results in poor reliability and safety. World-class operators frequently review maintenance policies and nurture a culture of continuous elimination of all sources of loss, according to a report from industry consultants McKinsey & Co. They optimize preventive and condition-based maintenance for critical equipment, while minimizing additional maintenance for less-critical systems. Key requirements are a full understanding of the criticality of equipment, a complete maintenance log, and a readiness to draw on all available expertise in optimizing maintenance policies.

When regular maintenance policies fail to eliminate losses, the best operators propose modification projects with clear business cases and rank them according to return on investment, according to the report.

No unplanned downtime

"(Oil companies) are spending for efficiencies. They are looking at asset integrity. You can't afford unplanned downtime," said Luis Gamboa, global business development manager for oil and gas at Rockwell Automation.

There is no doubt companies are trying to achieve more with less. So the focus in these down times is on extending the life of existing assets. But if operators don't do that properly, then there will be a greater loss of process containment and reliability. The solution is to be as smart as possible and monitoring processes are key.

Asset integrity ranges from technical meetings involving experts advancing state-of-the art equipment design, inspection, testing, or reliability, to a plant operator on routine rounds spotting leaks, unusual noises or odors, or detecting other abnormal conditions.

However, this element primarily involves inspections, tests, preventive maintenance, predictive maintenance, and repair activities performed by maintenance and contractor personnel at operating facilities and quality assurance processes, including procedures and training, which underpin these activities. Asset integrity extends throughout the life of the facility.

Taking a quick look at successful offshore energy companies, it is quick to see a strong commitment to a maintenance and safety hierarchy that ranges from the field level all the way up to the corner office will always pay off. Strong safety and maintenance cultures go hand-in-hand because poorly maintained assets invariably end up the root cause of accidents to assets and cause injuries – or worse – to employees.

Beginning at the platform deck level, a company's skilled workers may perform complete end-to-end maintenance, or management may outsource operations and maintenance (O&M) activities to technical services providers.

Learning from others

Along the Gulf Coast, asset owners/operators routinely outsource advanced operational maintenance and repairs to technical service providers who specialize in one or more aspects of the maintenance "ladder" that extends from construction, hookup and commissioning to operations to shutdowns and turnaround.

One key finding in a research study was the desirability of an unbroken chain of accountability from the work scope and project goals outlined by the asset owner to the supervisors and crews of contractors doing the work.

It was clear from the study the classic cliché of too many cooks spoil the broth really comes into play offshore. By reducing the number of maintenance service providers to less than a handful makes managing the chain of accountability much easier. Working with fewer players ensures safer, more efficient and easier-to-manage operations. When significant risk reduction, reduced personnel on board and lower O&M costs are the end game, having fewer services suppliers helps ensure a productive asset integrity environment.

Dividing O&M among multiple suppliers can be more challenging and costly because each supplier has a limited work scope and lacks an understanding of the big picture. From a safety and efficiency standpoint, using fewer technical service providers gives better results, the study said.

That is why Gulf of Mexico operators can benefit from lessons learned from other offshore regions where operators have used the "fewer supplier/higher

chain of accountability" philosophy for years, said Martha Sandia, vice president of North America and the Caribbean for Stork. The best results come from partnering relationships where O&M functions go out to a single provider who takes responsibility – and ends up held accountable – for improving safety, reducing downtime and lowering operating costs.

Photo from Stork Technical Services/Maarten de Groot Photography.

Asset Integrity 101

An effective asset integrity program depends on:

- **Equipment and systems end up properly designed, fabricated, and installed.**
- **The unit operates within the design limits of the equipment.**
- **Inspection, test, and preventive maintenance tasks end up conducted by trained and qualified individuals using approved procedures and completed as scheduled.**
- **Repair work conforms to design codes, engineering standards, and manufacturer's recommendations.**
- **Asset owner takes appropriate actions to address deficiencies, regardless of who and how they ended up discovered.**

Communication means success

Partnering relationships also facilitate flexible commercial models based on key performance indicators (KPIs). These performance models can successfully apply in turnkey projects provided quality communication skills prevail between an asset owner/operator's staff and the technical service provider.

Information and communication are keys and some asset owners/operators normally do not give contractors access to the information they need to design and implement an effective O&M program, but achieving effective O&M coordination starts early in the planning stages when technical advisors from the technical service provider can analyze and integrate all tasks into a coordinated plan that incorporates contingencies, Sandia said.

To help overcome owner/operator reluctance, there are programs to allow asset owners/operators and service provider project managers to jointly set project objectives and KPIs, Sandia said. "Part of the program is to create a workshop led by a neutral facilitator whose agenda is focusing on opportunities to streamline O&M processes as well as safety compliance, hazard awareness and risk mitigation."

The workshop brings together four key stakeholders from each side – asset manager, O&M, HSE and procurement. From the service provider there is the area manager, O&M project manager, HSE and supply chain representatives.

"During the workshop, participants identify specific risk-reducing and cost-saving activities and both sides create a specific value proposition that can cut costs and increase efficiency and safety," Sandia said.

At a basic level, asset integrity is the systematic implementation of activities, such as inspections and tests necessary to ensure important equipment remains suitable for its intended application throughout its life. Specifically, work activities related to this element focus on preventing a catastrophic release of a hazardous material or a sudden release of energy and ensuring high availability (or dependability) of critical safety or utility systems that prevent or mitigate the effects of these types of events.

Designing and maintaining equipment fit for its purpose and functions when needed is paramount. Maintaining containment of hazardous materials and ensuring safety systems work when needed are two of the primary responsibilities of any platform.

Whether it is a high tech solution or using a low technology approach, rigs need to stay up and running and assets need to stay in top shape because the downturn will not last forever and there will come a point to where revenue generation will take off. **OE**

Asset Integrity: A bird's eye view

Gregory Hale shows how web-based software utilizes high definition photos and video to extend the life of aging assets.

One offshore producer was looking at conducting a typical turn-around (TAR) out on the Gulf of Mexico, but the catch was time was important as was cutting costs while remaining safe.

There is no doubt TARs are expensive and time consuming, but also much needed. When you really look at it, you not only have the cost of the TAR itself, but the lost production. Even in the current down market, an offshore asset still produces US$2-3 million a day.

Under a normal scenario, the producer's TAR scheduling was standard for the industry, scheduled eight months in advance. Then six months out, teams would deploy to the asset for a three-day tour, digital cameras, notepads, measuring wheels and tapes in hand.

"During the deployment six engineers took photos, notes, and measurements of all major systems and equipment scheduled for replacement, repair or servicing. In reality, the three-day tour was really five days, as the first day was traveling to the heliport at the Gulf of Mexico, and the fifth day the engineers traveled back from the asset," said Rob Smith, Head of Americas for AIMS Global Consulting.

"After a weekend, the engineers met in the office to decipher their notes, pictures, sketches and measurements. Of all the information gathered, just about 80% of the documentation made sense," Smith said. "The remaining 20% remained unusable due to bad photos, photos taken out

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Corrosion caused by insulation which led to leaking pipes was not only an asset issue, it was also a safety problem.
Images from AIMS Global Consulting.

Extending life of assets

Asset life and extension issues for areas such as platform jackets, subsea structures and well assets are critical. But those solutions generally end up related to equipment. This, however, is not always the case topside where the impact of other issues can be equally important as traditional equipment deterioration based approaches.

This list, compiled from a paper written by Brian G. Hudson of ABB Global Consulting, illustrates typical issues culled from asset life extension studies delivered for North Sea installations ranging in age from over 30 to less than 10 years:

- Removal of redundant equipment simplification, loadings or new berths
- Increased congestion of equipment from operational strategy changes (e.g. production platform to hub)
- Replacement of obsolete equipment
- Operation outside a defined equipment operating envelope
- Turn down capacity of key equipment as process requirements change
- Reducing equipment reliability, particularly machines and rotating equipment
- Newly emerging corrosion/deterioration mechanisms, i.e. changes in process fluids, e.g. sand, H_2S
- Integrity of minor structures (handrails, walkways, ladders)
- Neglect of utility systems (air, nitrogen, HVAC, cooling water)
- High cost, usually due to age related unreliability of key systems, such as fire mains and pumps
- Electrical power limitations affecting current and future operations
- Compliance with current and future environmental legislation
- Upgrading safety and escape equipment and active/passive fire protection to meet latest standards
- Competencies against aging workforce; need to substitute technology for skills and loss of corporate knowledge
- Changed or reduced manning regimes and leaner organizations with increased reliance on subcontractors
- Lack of clarity for ownership of knowledge between operator and subcontractors
- Loss of "corporate knowledge" and "unfriendly" documentation systems

of context, indecipherable hand-writing, and abbreviated field notes."

"The next step was assembling work packages and bid packages. In this case the work packs and bid packages uploaded to an internal SharePoint site, which was better than storage on an individual's laptop, but not optimal from a best practice and sustainability point of view," Smith said. "Personnel turnover was another problem that affected the project. No one on the current TAR had participated on the previous TAR, and no one knew what went well and what did not last time – a key step in developing best practices for your asset."

The bid packages then went out to qualified contractors to bid on the various pieces of work, such as painting and labeling, equipment replacement/modification, and heavy maintenance.

Tried and true ways of conducting business works in heady times, but in a $40/bbl world, things have to change for companies to stay efficient and competitive. That is where an automation-centered application comes into play, where it can help boost productivity and profitability while cutting down on unplanned downtime.

Critical assets

The elements offshore can wreak havoc on installations as wind and water can corrode materials over time, while heat can distort structures. Minimizing maintenance costs and extending service life is essential. Asset integrity is therefore critical for offshore oil and gas producers.

Proper asset management is a prerequisite for any operation.

Ensuring asset integrity will provide a solid understanding of the condition of a platform's critical equipment and an understanding of its repair and replacement needs. The importance of effective asset integrity management increases as the industry infrastructure continues to age.

Along those lines, from high definition photos and video to remotely operated aerial vehicles, there are different more high tech ways to ensure a more effective and least costly TAR.

In the Gulf of Mexico TAR case, primary and secondary engineering resources were able to meet on shore, in their office conference rooms and even sit at their desk and actually view the asset without being there. A total team emersion of subject matter experts was able to advantage of a web-based software solution that can utilize high definition, 360° spherical photo and video technologies, Smith said. That high tech jump start could boost the turn-around capabilities.

Rather than just looking at P&IDs, planning resources were able to view the actual asset in 360° high definition images. They could view the actual systems, associated P&IDs, related maintenance documentation and procedures all from the work computers, share the information on a big screen in the conference room and collaborate in real-time, take measurements, screen shots, and create bookmarks for important work areas.

On top of that, the entire engineering team ended up directly involved in the process and provided their input without transporting them offshore, saving 24 personnel on board (pob) days and six helicopter trips.

Introducing the OE Asset Integrity Webinar Series – Proving the Industrial Internet of Things

Asset integrity is all about continuously monitoring equipment and process health, which allows for greater data analysis and visibility in preventing failures and poor operational performance. Analytics gathered through this Industrial Internet of Things (IIoT) technology can change work flows from reactive to proactive, head off problems before they become big issues, help eliminate unplanned downtime and improve asset performance and safety.

Dan O'Brien,
Product Director,
Digital Suites for Oil and Gas,
Honeywell Process Solutions

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Check your issue of OE and at OEdigital.com regularly for upcoming webinars outlining the strategies, tactics and tricks needed to maximize performance of your offshore assets while favorably impacting the bottom line.

Screen capture of a web-based software solution that utilizes high definition photo and video technologies.

These work plans could also end up saved in the web-based system, referenced in context of where the work was going to happen, or stored as a listing on the screen. These same work packs and pictures ended up shared with contractors, who could view the relevant areas of work without needing to physically visit the offshore platform.

The contractors saved time and money bidding on the project, and the client saved 72 pob days in the planning process, and 15% in the work bids, as contractors could develop tighter scopes of work.

Safety an issue

Another visual application came into play when an offshore operator was suffering from corrosion caused by insulation that led to leaking pipes. "The platform ended up built with insulation blankets, which are conducive to corrosion. On top of that, the problem grew because more blankets ended up installed than required," Smith said. The project scope was to identify the location and total blanket count, determine which blankets they needed for personal protective equipment (PPE) and which for the process, eliminate those not required, and convert as many as possible to other insulation methods.

Another complication was that no offshore access to the asset was available for over two weeks, based on other critical projects.

By using a visual 360° spherical photo of the asset and blankets. Workers were able to identify blankets and tag them in the system, which then linked back to the isometric drawings.

"As a result, the team was able to review the images in a conference room at 7 am and by 2 pm that same day, a six-person team was already working on a solution," Smith said. That project accomplished in two weeks what 12 man-weeks of work could not. They also saved time, labor cost ($140,000) and 86 pob days and it also allowed for a better work scope for contractor at a 25% reduction in original costs.

Aging assets

With the volatile oil price and aging profile of existing offshore platforms, the ability for operators to keep their assets running efficiently beyond the original design life, whether for the short, medium or long term and still maintaining high standards of safety and integrity, is paramount for any business strategy.

A focus to make the most of mature assets is improving production by establishing the economic limit of what can end up achieved with today's technology and best practices, and using this to identify opportunities for increasing production and driving down operating costs.

"People are trying to achieve more with less," said Tim Wenman, senior consultant, asset integrity at Shell Global Solutions International BV, in a report on Shell's website. "When companies want to reduce costs (capex) they are often reluctant to invest in new equipment, so the focus has to be on extending the life of existing assets. But if you don't do that properly, then you can experience loss of process containment and reliability will also suffer."

Ensuring a reliable operation where assets are running in top shape and seeing where potential problems can crop up will not only help producers today in a down market, but will allow for greater margins when prices start rising. Automated solutions will allow producers to stay informed about their assets so they stay up and running. **OE**

Asset performance software

Gaining more visibility into what is happening in the process not only allows for greater asset usability and less unplanned downtime, but also a safer environment.

Along those lines, Honeywell Process Solutions (HPS) launched its Uniformance Asset Sentinel, which continuously monitors equipment and process health, allowing for greater visibility in preventing asset failures and poor operational performance.

The technology works by continuously accessing data from a various sources, including process parameters, vibration data and alarms. Using a real-time event processing engine, it continuously performs performance, health, efficiency and safety-related calculations and compares those results of the current actual performance to an expected performance model. Predicted or detected deviations from these models can generate notifications to facilitate investigation and intervention to minimize the cost and frequency of an event.

This line expands HPS' Uniformance software suite and supports the Industrial Internet of Things (IIoT), enabling companies to collect, organize and analyze data for a specific asset or "thing." These analytics can change work from being reactive to proactive and head off problems before they become big issues and help eliminate unplanned downtime and improve plant performance and safety.

In this market where cost cutting and savings is even more important than ever, the goal is to potentially help companies increase asset utilization by up to 10% by reducing unplanned downtime. It can potentially cut maintenance costs by up to 15% by better predicting and preventing catastrophic equipment failure and inefficient operations. ■

Gregory Hale *is the editor and founder of ISSSource.com and the contributing automaton editor at Offshore Engineer.*

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Scientific drilling

Photo from Joides Resolution Facebook page.

A new offshore play is emerging in the oil and gas exploration business – deepwater contourites. Elaine Maslin spoke to Professor Dorrik Stow about what and where they are and how they were found and how scientific deepwater drilling is helping to unlock their secrets.

For those of a certain age, the idea of deepwater scientific drilling might bring up memories of tales about adventures to the earth's core or deepwater extra-terrestrial life conjured up by John Wyndham in his 1950s science fiction.

They would be right, up to a point. Today's deepwater scientific drilling, stemming back to a tradition of drilling in deepwater to understand more about the earth's crust and formation, is helping to discover life in the most unlikely places – including microbial life deep beneath the seafloor – as well as helping to understand planetary dynamics, through subduction and earthquake mechanisms, and environmental changes.

But, it is also helping to unlock new subsurface paradigms of particular interest to the deepwater exploration industry, including deepwater sedimentation, specifically contourites. Thanks to research carried out through scientific drilling, more is being learned about this new paradigm for deepwater exploration. It's still a relatively new area scientifically, but, the oil and gas industry is starting to take note and fields are already being developed which fit the contourite description – offshore Norway and Brazil.

Scientific necessity

"Drilling is the only way to actually know what's in the subsurface, says Professor Dorrik Stow, Director of the Institute of Petroleum Engineering at Heriot-Watt University in Edinburgh, Scotland. Stow has taken part in scientific drilling programs offshore Angola (1980), leading to the discovery of Cretaceous black shales in the subsurface, paving the way for oil discoveries offshore west Africa, and the Gulf of Mexico (1983), and the Bengal Fan (1987), and documenting the Himalayan uplift history and tectonic influence on deepwater sedimentation, which helped to understand deepwater turbidites – one of the world's key reservoir systems.

More recently, he has been researching contourites. "Originally we thought the oceans were deep and quiet and nothing but slow pelagic run off. Early expeditions with research ships just recovered pelagic sediment. At the beginning of the 1950s, a new paradigm emerged, which showed sediment moved down stream to deepwater by turbidity currents."

Origin story

Scientific drilling dates back to 1968, when it was initiated to help prove the then new theory of plate tectonics. It has since moved on to look at the continental margins, looking at how sea levels affected sedimentation along continental margins and the build-up of continental margins – a key area for the offshore industry – as well as drilling into the ocean crust to discover of what it is made. More recently, the focus has shifted to climate change and environmental change and what ocean records can tell researchers about past environments.

Other research areas close to the petroleum industry's heart include exploring black shale source rock, to find out where they form when and why.

Scientific drilling is internationally funded through groups of nations and their science research councils. Currently, Europe, Japan and the US are running the Ecord program, or European Committee for Ocean Research Drilling, supported by a number of other nations. It has two drillships operating out of Japan and the US, with different elements of the program run out of different centres, with Heriot-Watt focusing on the facilities and equipment. ▪

***Joides Resolution* drillship out to sea.**
Photos from from Dorrik Stow.

Once formed and then buried, these form the deepwater reservoirs we see globally today. In the 1960s, "along slope" currents, which distribute sediment along slopes, were recognized as another mechanism. "In some cases, those currents are pretty strong and can move sand, etc. We call these contour currents and the deposits contourites."

In 2011-12, International Ocean Discovery Program (IODP) expedition 339 set out to drill in the Gulf of Cadiz, in the east North Atlantic Ocean, using the *Joides Resolution* drillship. The 470m-long, DP *Joides Resolution,* operated by a subsidiary of Norway's Siem Offshore, comes with non-riser drilling, coring, and wireline logging equipment as well as a fully equipped shipboard scientific laboratories (including sediments, physical properties, magnetics, geochemistry and micropaleontology). The vessel, currently working on the Bengal Fan, started life as the *Sedco 471* in 1978, but was converted for scientific research in 1985 and is now part of the IODP. It is able to drill in up to 7000m water depth and has cored holes to 2000m below the seafloor.

During its work in the Gulf of Cadiz, seven sites were drilled, five in the Gulf of Cadiz and two in the West Iberian Margin, with 19 holes, 681 cores recovered, 8km of sediment drilled, and 6.3km cored.

According to the expedition report, the Gulf of Cadiz, due to its contourite sands, is the "world's premier contourite laboratory," providing a testing ground for the contourite paradigm.

The expedition recovered more than 4.5km of contourite cores, found more than the expected quantity of contourite sands, extensively distributed and "clean and well sorted," representing "a completely new and important exploration target for potential oil and gas reservoirs," the report says. While the basin was known to be dominated by along slope currents, coming from the Strait of Gilbralter around the Iberian Peninsula, they also found thick, extensive amounts – more than expected – of sandy contourites.

"We managed to drill through 225m of it, although it was quite a struggle because the sands kept collapsing on us and we got stuck," Stow says, suggesting it could have been thicker at that point.

These are sediments the oil and gas exploration industry has already drilled though. Stow says Repsol had drilled a well in a similar area targeting a potential oil play below the contourite sequence. When they recovered data from the well, they found they had drilled through 800m of contourite, Stow says, over an area of about 4000sq km. "It could be the biggest sands we know of in modern oceans [as a play] and a significant rival to anything down slope and turbidite," he says. Furthermore, some of the contourite muds that were drilled through during the IODP expedition had a more than 2% organic carbon content, suggesting they could also be source rocks. "We hadn't realized that before," Stow says. "Anything with more than 1% organic carbon content is a potential source rock."

Which just shows the importance of scientific drilling. "Unless you drill through the rock and bring it back you don't really know what is there and that applies to science and industry drilling," Stow says.

"Scientific drilling is designed to ask the big scientific questions about the earth's history and the workings of the planet as a whole. The spinoff is that all the results are applicable to industry, including the petroleum industry."

The industry is getting more and more interested in contourites, Stow says. Offshore Brazil, Petrobras, has identified at least part of one of its deepwater fields, the Marlim field, as contourite sands. Statoil has also identified a field that is in a contourite sand sheet offshore Norway, Snorre.

Cairn Energy is also looking at some deepwater West Africa systems that could contain contourites.

"It is just getting known," Stow says. "We are trying to set up a joint industry research project looking at contourites. About 12-13 companies came to the first meeting to explore funding."

With the oil and gas industry becoming more accustomed to working in deepwater, as the easier to find resources dwindle, contourites could become a significant new target, Stow thinks, aided by scientific drilling.

"It is more and more difficult to make the big easy finds, so more and more you need to know your science to provide the most likely places hydrocarbons will be." **OE**

A core sample.

Drilling automation comes to life

Gregory Hale looks at how automation capabilities are removing guess work and allowing for real-time decision-making.

A down market can mean companies opt to batten down the hatches and patiently ride out the rough patches, choosing to get ready to hit the ground running when business eventually picks up; or they can innovate and find ways to take advantage of current opportunities through technology advances.

That is where offshore drilling automation can come into play.

Shell knows letting a machine handle the mechanical and hydraulic drudgery of drilling means people can stay away from hazardous areas. Instead, engineers can focus on perfecting and calibrating algorithms allowing for a consistently high level of performance, while not relying on a dwindling supply of Baby Boomer drilling experts getting ready to leave the industry. That is what drilling automation is all about.

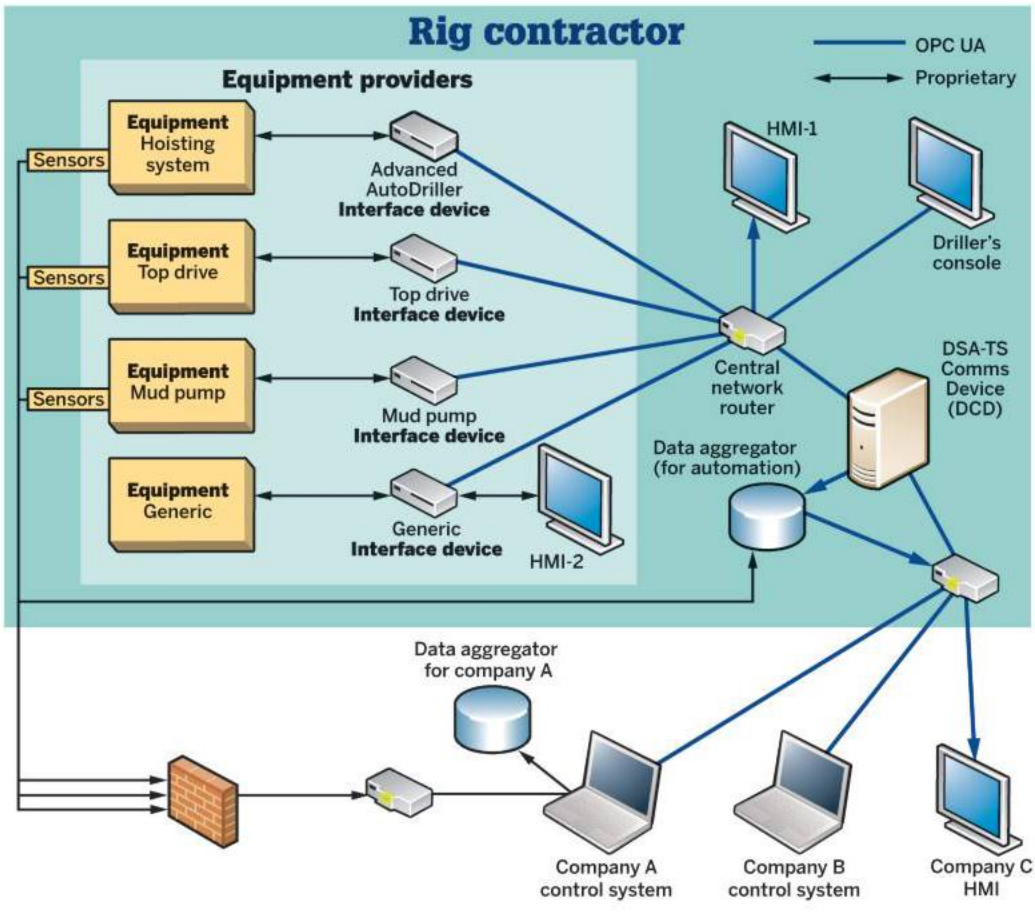
That is why it created the SCADAdrill control system, which provides autonomous drilling and trajectory control. The system is not a science fiction experiment. It uses common tools sourced from low-cost suppliers. It can connect to the existing instruments and controls of a drilling rig. It can operate the rig machinery and monitor all aspects of the drilling process. Although it is capable of working without human supervision, SCADAdrill allows well engineers to monitor the rig remotely. If necessary, control can end up taken over from the machine.

Shell is one industry giant working on and moving toward drilling automation. Joining Shell is supermajor ExxonMobil, Norway's Statoil, Brazil's Petrobras, and service companies Schlumberger, NOV and Baker Hughes. Each wants to find ways to program all or parts of the drilling process.

Real-time optimization

While automated drilling is currently seeing more action onshore than offshore, there are aspects being utilized that could lead to an automated drilling operation on the seas. The goal is to link surface and downhole data in an automated way to allow for real-time drilling optimization. This real-time automation allows visibility into the current drilling environment that could be several miles from the rig floor. This way it can be possible to know with more accuracy what is going on in the process.

"We are providing real-time high-speed telemetry and downhole sensors for enhanced rig control and real-time drilling decisions to be made," said Stephen Berkman, director of Global Business Development at NOV Dynamic Drilling Solutions. "The objective isn't solely focused on rate of penetration (RoP), it is a combination RoP improvement and borehole stability. Operators are making more



The architecture for an automated rig allows for portable, machine independent, OPC UA Clients to function as data-to-information converters and automation algorithms.

informed decisions based on the high-speed data, allowing monitoring of downhole conditions. Risk mitigation is the emphasis offshore to change the way we drill."

Drilling efficiency is one area that needs improvement, Halvor Kjørholt, manager for drilling and well research for Statoil said at the SPE Intelligent Energy International, held in Utrecht, Netherlands, this past April.

He talked about applying modern control technology used in other industries to run drilling process sequences in an automated mode, which would enable the industry to move away from the relatively manual process drilling is today.

"It's about moving drilling more in the direction of process control," he said.

Communication protocol

Communicating the information from the well to topside deterministically remains a vital concern so rigs can better monitor what is going on in all aspects of the drilling operation.

One communication protocol is emerging as the standard and that is OPC UA, which sees wide usage in industrial automation. The Drilling Systems Automation Technical Section (DSATS) committee of the Society of Petroleum Engineers (SPE) supports the use of OPC UA for device communications and control.

"OPC UA focuses on time critical deterministic information and reliability," said Thomas Burke, executive director of the OPC Foundation. "We started talking about DSATS in 2012 with the OPC Foundation, but things have really started to take off as of late."

OPC UA enables different devices to talk to each other. Each individual rig device communicates to a rig PLC. An automation PLC communicates with the rig PLC to control the devices through exposed set points. As the type, or supplier, of rig PLCs varies from rig to rig, portable automation control programs are not possible. Data access from the rig PLC is generally a passive, one-way data stream.

The use of OPC UA provides:

- A standard and secure bi-directional network protocol for device communications
- The ability to model each rig device as a structured object
- A standard, portable interface for data query and controlling devices
- Historian capabilities
- Device discovery, allowing for plug-and-play rig components

Through technology advances and use of accepted protocols, automated drilling in the offshore environment will allow for a cleaner, safer and more efficient operation.

"If you apply this correctly, you reduce your costs," Berkman said. "If the client is looking at applying technology to reduce costs and improve efficiency and lower break even costs or how many events I can avoid in non-productive time by utilizing high-speed downhole data either to drive the rig or drive the decisions, then it works." OE

Gregory Hale is the editor and founder of Industrial Safety and Security Source (ISSSource.com) and is the contributing automation editor at Offshore Engineer.

All subsea options

Most of the building blocks are in place for the all-subsea solution. But do they offer an attractive proposition? Elaine Maslin looks at DNV GL's current thinking.

Last month, a huge milestone in the history of subsea production was reached. Statoil, operator on the Norwegian Sea Åsgard development, brought the world's first subsea gas compression system online, a project that will help boost recovery from the Mikkel and Midgard fields by some 306 MMboe.

Statoil hails subsea compression as one of the key stepping stones towards the industry being able to create an all-subsea production system – i.e. one without topsides – enabling the industry to move into harsher, deeper and more remote environments while boosting recovery rates.

There are strong drivers to make this technology work. According to DNV GL, although over 50% of the giant oil discoveries in the last six years are in waters deeper than 2000m, only a handful have been brought onstream.

But, while Statoil has been boldly going where others have yet to tread, with its subsea factory concept, launched in 2010, is the technology for a full subsea system ready yet, how viable and economical is it and where does it offer the greatest benefits?

DNV GL decided to find out. Its study, All Subsea – Creating value from subsea processing, published during the Underwater Technology Conference earlier this year, compares a benchmark FPSO set-up with a hypothetical all-subsea pipeline to shore field development. However, instead of making a direct comparison between the two alternatives, it moves the various main processing components to the seabed in nine steps; multiphase boosting, heating of pipelines, subsea water injection, subsea separation, subsea compression, power transmission from shore, power distribution and control, and, finally, oil export by pipeline (eliminating the FPSO).

As a result of its work, DNV GL says subsea processing is now a real alternative to conventional solutions. But, it is brownfield projects that currently offer the best business cases for this technology, at least in the short-term.

Operations during the Åsgard subsea compression project installation campaign this year. Image from Statoil.

"For brownfield projects, the various technologies may be used alone or in combination with other technologies. In contrast, an all-subsea solution has more limited applicability," DNV GL says. "The most likely future all-subsea applications are oil and gas field developments in mature geographies, gas discoveries that only a few years ago were assumed to be developed with subsea compression to onshore LNG liquefaction are instead moving in the direction of floating liquefaction, FLNG."

DNV GL says that while some of the technology steps it looked at were clearly enhancing or enabling, other parts of the concept "severely limit its overall applicability." Subsea compression for gas export, for example, saves risers, however, the subsea equipment is expensive and availability is uncertain relative to topside solutions, the report says. Subsea power from shore, using HVAC, is limited to 200km step out and other options are immature, it says, and have limitations around equipment size and control. Subsea power equipment would move less reliable but critical components into a hostile environment and export by pipeline is expensive for long distances, unless volumes are large.

In theory, deepwater projects should favor the all-subsea solution, due to the sheer size and multi-decade revenue streams they offer creating some of the most cost-effective barrels available. But, deepwater capex, especially in today's low oil price environment, could make such projects prohibitive.

There could be ways to get around some of these issues, such as having stepped step outs from shore, say, placing the field center 100km from shore, with a 100km step out from it, to reduce weight, complexity and cost of separation and power equipment. Building projects on a hub basis, that facilitate future tie-ins would also bring flexibility to the development, the report suggests.

Principal researcher and lead author of the paper, Tore Kuhnle says brownfield applications offer the best short-term application for subsea processing technologies. "The technology is there within certain limits. Engineers have done their job. Now it is how you can capitalize them, i.e. coming to commercial agreements around putting different oil grades in to existing pipelines. In brownfield applications, you need to be able to make modifications on the vessel offshore to put on a power module, for example. It is not a technology risk anymore, it is building the case in this environment."

In the short-term, for greenfield projects, the best candidates are mature-area, midsize oilfields, rather extreme deep water, long-range fields, Kuhnle says.

DNV GL is planning to follow-up this report with a further study, which will address systems approaches to subsea processing. Despite the business case for all-subsea being limited, DNV GL thinks that all the pieces of the puzzle are there and that the industry needs to address the next step – setting out the final requirements for the all subsea case and how to qualify it as a system, not just at the component level. **OE**

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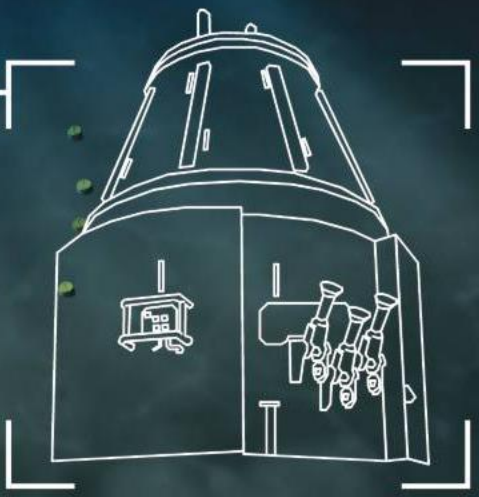

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Choice of pumps

Jerry Lee investigates the use of hydraulic submersible pumps as an alternative to the common ESP for artificial lift operations.

An ultra-high reliability hydraulic submersible pump.
Photos from ClydeUnion Pumps - an SPX brand.

Extracting hydrocarbons from a reservoir is an energy intensive process, and when the natural drive mechanisms become uneconomic for producing a well, artificial lift systems become necessary. Submersible pumping systems are commonly chosen because these tools boost production rates by adding energy into the system. The pump translates mechanical power into fluid dynamic producing pressure and "head," a measure of the distance that a pump can produce, to push the formation fluid to the surface, says Michael Davis, senior technical instructor at Halliburton.

Electric submersible pumps (ESPs) are widely used, however, they have been criticized for breaking down a few years after installation (see Panel). For those operators requiring artificial lift, an alternative already exists in the form of the hydraulic submersible pump (HSP).

"The HSP technology was initially developed to overcome several limitations associated with electrically powered ESPs," says William Harden, director, consulting engineer, Oil & Gas, ClydeUnion Pumps, an SPX brand.

Much like an ESP, the HSP is a downhole pump that provides pressure to boost formation fluids to the surface. Both use a mechanism to rotate a shaft, which powers the pump stages that pressurize the fluid to assist production.

An HSP consists of a power fluid flowline, multistage hydraulic turbine, shaft, and multistage pump impellers, and at the surface, separation and filtering facilities, and power fluid pressurizing pumps are required. An ESP, however, is modularly designed, and consists of at least one motor, at least one seal or protector, a shaft, an intake or gas separator, multistage pumps and electricity cable, and at the surface a transformer, junction box, switchboard or variable speed drive.

Operationally, the technologies are also very different. For HSPs, the flowline, which connects the surface equipment to the downhole pump set, is used to supply the pressurized power fluid to the multistaged axial flow turbine. The fluid (seawater or produced water) passes through the turbine stages, generating torque to drive the multistage pump impeller stack, and produce at an economic rate. The system can be either open or closed looped.

"In the 'open loop' configuration the produced fluid at pump discharge subsequently commingles with the exhausted turbine power fluid and flows up to the surface facilities where the power fluid is separated and recirculated back into the HSP power fluid supply," Harden says.

Formation fluid commingling and exhausted power fluids can have a positive impact on flow assurance by providing viscosity and emulsion management in heavy oil applications as well as reducing flow line friction losses. Additionally, if heated power fluids are used, the increased temperature and heat capacity of the commingled fluid can prevent gelling in hydrocarbon fluids and mitigate wax deposition.

"In 'closed loop,' the majority of the power fluid does not commingle with the formation fluids and, therefore, requires two dedicated flowlines and concentric annuli for the independent supply and return of power fluid. In this arrangement, power fluid returns to the surface separately where it is filtered and re-pressurized by the surface pump for re-use."

HSPs are controlled through a combination of regulating the power fluid in the flowline and managing the back pressure in the production tubing. Operational control is affected by variable speed pump drive motors on the power fluid supply pumps, which generate the pressurized drive fluid delivered to the turbine, and by fine tuning the local choke valve on the production tree to regulate flow and create back pressure.

"Optimal performance can be set through monitoring and adjustment of the volumetric ratios of the turbine and pump flows, and instrumentation systems are available for the downhole monitoring of speed, vibration and fluid pressure and temperatures, for additional visibility of well and pump performance," Harden says. In lieu of reliance on downhole sensors or electrics, HSPs would still be operational in the event of a downhole instrumentation failure. ESPs, however, use a downhole cable to supply electricity from the surface equipment to the motor, which rotates the shaft and transmits its mechanical power to

suspension. This ability to automatically react to rapid changes in fluid density greatly reduces the HSPs susceptibility to gas locking and enhances its ability to maintain continuous production, Harden says.

For ESPs, a gas separator module can be attached above the intake to deal with gassy fluids. Unlike conventional surface separators, this module actively separates gas from the fluid utilizing a centrifugal spinning force. "The formation fluid is spun within the system, pushing the oil and water against the wall of the separator and up through the tool. The gas comes together in the middle and is vented out into the wellbore," says Raj Naicker, technical sales advisor at Halliburton.

Reliability is an important consideration, particularly in offshore environments where daily rates greatly exceed those for onshore projects. In its design, the HSP eliminates the potential failure modes associated with electric motors, cabling, glanding, penetrators, and insulators. Furthermore, the power fluid that drive the turbines serves a dual purpose by providing a positive, outward clean flush to the pump end bearing system and obviates the need for complex thrust carrying seal protector systems. The combination of these factors have resulted in a system, which has achieved a mean-time-to-failure of over 11 years, which is about three times the industry average for conventional ESPs, Harden says.

Current HSP technology is limited to fluid temperatures up to 220°C. However, thermal production operations, such as steam assisted gravity drainage, would require a system designed for temperatures up to 300°C.

In defense of ESPs

As a modular system, ESPs can be individualized for each well. If the well requires multiple motors, seals, and pumps, the entire system does not need to be redesigned; the operator can simply request a system with those features. Additionally, if the reservoir begins to produce gas, the intake can be switched out for a gas separator. The system can operate in deep and deviated wells, and requires minimum maintenance. ESPs can be assembled, set downhole, turned on, and if left alone to run, it can actually run better, says Michael Davis, senior technical instructor at Halliburton. Also, for operations where there are visual and audio regulations from municipalities, the surface impact is very small, consisting of the wellhead, drive, and transformer.

However, the reliability of ESPs has been criticized. Though failures have been observed, the cause may not stem from the ESP itself. The ESP can only perform as it was designed to perform, if the criteria of the well changes, the design of the ESP must be adapted; if the ESP is forced to function in a way other than the way it was designed to, the ESP will develop problems as a result of misuse.

"If we are given all the information from the operator to size the equipment correctly and run it in the correct operating mode, the ESP can run for 10 years without any intervention," says Raj Naicker, technical sales advisor at Halliburton.

The system must also be serviced properly on the wellhead. If shortcuts are taken or if there is pressure to run the tool, then reliability is sacrificed for rig time. "Everything goes hand in hand. Doing everything right in the front will result in a longer run life," Naicker says.

The Captain field

The Chevron-operated Captain field is a heavy oil asset, 130km off Aberdeen in the UK North Sea, with some areas that are known to have a gas cap. ESPs are used at 36 platform wells at the field, while HSPs are used on 21 subsea wells.

The HSPs were selected due to the ability to handle high levels of gas reliably, which is facilitated by a multiphase helicon-axial pump stage design, enabling continued operations under slugging conditions and provides the headroom to increase production rates*.

Since installation in the early 2000s, HSPs have been operated at gas volume fractions of up to 70%, although usually in the 5-40% range. Designed using the open loop configuration, the HSPs have been producing from 1500-18,750 b/d.

With over 15 years in operation, the HSP units have achieved a mean-time-to-failure (MTTF) that is typically three times the current level for conventional electric motor driven systems; in 2010, MTTF was recorded at 11.76 years, with some units in operation for nearly 10 years. The key to maintaining uptime was the performance of the topside desanding and power water supply system.

Some failures have occurred, due to erosive wear by sand ingestion, or ingestion of debris from well completion or by tubing corrosion. However, these have subsequently been mitigated. **OE**

** Mali, G. A., Morrison, A. K., Green, A., Graham, R., & Harden, W. G. (2010, January 1). Hydraulic Submersible Pumps: 10 Years Experience on a Heavy-Oil Field in the North Sea. Society of Petroleum Engineers. doi:10.2118/135234-MS*

A hydraulic submersible pump.

Sea change

Despite rapid progress in the 1980s and 1990s, ROV technology development has ground to a halt, according to some. Are we on the brink of a new era? Elaine Maslin reports.

A UHD generation III during offshore deployment. Photo from FMC Technologies Schilling Robotics.

In the early 1970s, a new technology was brought to the offshore oil and gas industry – remotely operated vehicles (ROVs).

Initially unreliable, clumsy and of limited use, they were soon able to carry relatively complex tools, with more versatile manipulators and, by the late 1980s, they had gained industry acceptance – subsea systems were being developed specifically for ROV intervention.

Today, they carry an array of sensors, cameras and tools into the depths of the oceans in order to perform subsea exploration work and work on subsea infrastructure and production systems.

In August 2014, there were some 720 of them, with 561 of those being Class III, or work class, according to the International Marine Contractors Association.

Yet, for some, these subsea worker bees haven't quite developed technologically as fast they could, at least not since the late 1990s and they are due a technological growth spurt.

Tyler Schilling with an FMC Technologies Schilling Robotics employee and a UHD ROV.
Photo from FMC Technologies Schilling Robotics.

Clumsy

According to Tyler Schilling, a co-founder of what is now FMC Technologies Schilling Robotics, today's ROVs are clumsy. "I think, despite the fact I have been doing this for 30 years, dedicating my entire working adult life to this technology, ROVs are extremely clumsy in their current form and they are going to enter a new era," he says.

ROV engineer and consultant Doug Bathgate puts it another way: "There

ROVOP deploys a Schilling ROV. Photo from ROVOP.

were great expectations and high hopes for ROVs in the 1980s – when I first became involved – and some advances in the 90s, but progress has ground to a halt since the millennium. The ROV and ROV tool market is still at the Morris Minor stage [compared to automotive development] and has to progress."

To some extent, the technology is already out there, but it's not being fully utilized, Bathgate suggests. He says today's work class ROV typically has a five-function arm, a seven-function arm and an array of cameras. But, because 3D cameras are not routinely used they are effectively wearing an eyepatch, limiting depth of field vision, and the vehicle has limited movement in one of its arms.

"If you asked that ROV to change a light bulb it couldn't hold the unit to twist the bulb as one arm would have to be used to hold on while it was up the ladder," he says. What's more, the "modern" ROV seldom carries multiple tools and does not have a multi-tool hand, which limits its ability to multi-task.

Even smaller ROVs could have a better standard equipment package – instead of, as happened recently, as gas collector having to be duct tape and jubilee clipped to an inspection and observation class ROV during a gas leak inspection, Bathgate says.

Operators have also not had the drive to develop new tools, he says, because more money is to be made out of the day rates on the vessels deploying ROVs than specialized ROV tooling and with only a hand full of major players dominating the market, the competition is limited.

Brett (Gonzo) Eychner, head of ROV operator ROVOP's Houston operations, worked with Oceaneering for 32 years before spending time doing consultancy work with FMC Technologies Schilling Robotics.

Commercial impediments

Eychner says it's also how ROVs are valued that stops tooling being used or new technology being developed. "You can already put two, seven-degree manipulators on and as many 3D cameras as you want, it is just a matter of money, i.e. rates. But operators will specify lower specification units to lower rates, with their key metric focused on downtime.

Brett (Gonzo) Eychner, head of ROV operator ROVOP's Houston operations. Photo from ROVOP.

ROV downtime has been a key focus for the industry for the past 20 years and the resulting improvements have been substantial. ROVs, once seen as highly unreliable, are now more reliable and maintenance regimes like FMC Technologies Schilling Robotic's 60 minute philosophy for resolving issues on an operational ROV have also helped reduce downtime – when rig rates could be at stake.

But, focusing on downtime also means less focus on making sure the ROV can spend more time on task, by carrying multiple tooling, for example, Eychner says. "I want to see the industry change the way it views downtime. It is a definition the oil field has used and it can be manipulated and doesn't show time on task. If the industry could look at time on task and the ability to be able to do a job more quickly, we might see a change, then you can go down with a higher technology specification and do the job more efficiently and it would be recognized."

Schilling agrees. "The vast majority of the industry operates on a day rate commercial model, where you bid on how many dollars a day you are willing to provide the equipment and personnel and although almost all of the end customers say price isn't their first consideration, mysteriously it somehow ends up coming back to that. You can have all kinds of fancy technology on your ROV, but you won't get paid a dollar more a day because you have it. All that really exists is some penalty if the machine isn't functioning properly – if it is broken."

Schilling says he used to split customers into two categories – the break less and the work faster. "The break less were predominantly worried about never going on downtime, but they didn't really have any commercial incentive to get things done quicker." This camp stems from efforts to simplify what

Mark Bokenfohr, co-founder of pinless connector firm WiSub. Photo from WiSub.

is a complex contracting environment and an effort to simplify one small part of that environment. But, it results in an aversion to the risk posed by trying new technologies.

"The work faster were contractors who weren't based on day rate, but on completing the task, and of course if you want to work faster you also have to break less. But, the break less category has grown to become almost the entire market. So there is very little incentive for people to develop and deploy new technology in the market."

Cautious operators

Operators caution around trying new technology and going with what they know has also resulted in something of a one-company market for manipulators. Schilling Robotics' manipulator became such a success that now few are willing to try out anything else.

Schilling himself says this is understandable, as the consequences of failure can be significant – particular when a rig is on day rate – but that in many cases failure is the result of bad execution and that one firm having such a dominant position isn't that healthy for technology development in the market as a whole because competition is locked out.

Schilling Robotics' complex seven-function manipulator has beaten out competition from the likes of Kraft Robotics and Perry Slingsby, each of which have built complex manipulators, some with force feedback, says Mark Bokenfohr, from Bergen-based pinless connector firm WiSub, who has worked in the ROV business for some time.

Schilling hasn't always had such success. Its all-electric Quest and the "puck" user interface, for example, did not prove as successful as its manipulators and more recently the UHD ROV, which itself took Schilling Robotics' willingness to offer operators whatever they want on the unit, Bokenfohr says.

In such cases as the "puck," not considering the acceptance level of the user and not taking on too much in one go, were lessons learned.

On the up side

But it's far from doom and gloom. "There have no doubt been advances in the ROV industry, which 20 years ago tolerated figures like 10% downtime on the 'temperamental' and highly complex ROV system," Bokenfohr says. "The equipment has not become less complex, but the downtime due to equipment failure has been greatly reduced."

Improvements have been made around manipulators, maintenance and operability, and even systems integration, where the primary ROV intervention tool is incorporated into the whole field design and operations, he says. Machine vision systems are also being developed, which could see the ROV operator (who is also the manipulator operator) become more like a "bus driver," flying up to a panel, grabbing on and pressing the "go" button, then watching the arm take over and perform the intervention task by itself, Bokenfohr says. Firms like SeeByte have produced software systems that enable autotracking and auto-navigation, and intelligent positioning.

But there's still room for improvement. Bokenfohr says there could be improved standardization, particularly around interfaces, such as around subsea power and data interface. "There are already some reasonably well-defined standards for mechanical interfaces, such as defined in ISO 13628-8 and its equivalent API standard," he says. While some suggest standardization could stymie innovation and not be in the interest of equipment manufacturers, "there is no doubt that there is something to be gained from singing from the same song sheet," he says. For example, manufacturers including International Submarine Engineering (ISE), in Vancouver, and KystDesign, in Norway, have specified items that can be sourced from more than one supplier, such as common hydraulic pumps and electrical components, Bokenfohr says. "However, others argue their customized equipment is optimized for serviceability or ease of maintenance, product life and performance. Yet, lack of cross-compatibility of tooling or equipment drives up support costs for ROV systems. Who is right? I don't think that the market has yet decided."

Finally, to effectively deploy ROVs, training is also key – at least until the ROVs of the future, which can perform more functions automatically, are adopted by the market. ROV operators are currently trained to be flyers and fixers and manipulator training remains "on the job," Bathgate says, "at great expense to the client."

Internet based training, flying a virtual vehicle via a remote monitor, with a cheap but functional manipulator remote means they could train from anywhere in the world. Standardization in the training space would also be beneficial, Bokenfohr says.

In today's climate, the future development of ROVs, and how long it takes to adopt the new technologies, remains to be seen. The question is, Bokenfohr asks, will the next advances be driven by speculation or support from operators who can see the potential? **OE**

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Schilling Robotic's HD camera.
Photos from FMC Technologies Schilling Robotics.

Sparking a ROVolution

Subsea robotics firm FMC Technologies Schilling Robotics has a vision, which it thinks could overturn the way subsea equipment is designed. Elaine Maslin found out more from co-founder Tyler Schilling.

Coming from the figure head of the foremost remote operated vehicle (ROV) firm in the oil and gas industry, the statement that today's ROVs are clumsy is striking.

But, what's more striking is the vision Tyler Schilling has for future ROVs. Today, FMC Technologies Schilling Robotics is working on HD cameras as sensors to enable positioning, as well as store embedded information, and shared control and tool dynamic positioning. But, in the future, Schilling has a more revolutionary goal – reversing the trend for subsea equipment to become ever more complex and designed to minimize ROV use. Having a new family of subsea robotics, not all free-flying, could enable subsea production systems to be more like simpler surface production systems.

There are a few more near-term goals he has first, however – including making ROVs, which are notoriously difficult to operate, less "preposterous" to pilot. "We still live in a phase of the industry that I refer to as the age of the exceptional individuals," he says. "That means the largest determinant in the performance of one ROV crew over another is the guy behind the joy stick. It is ludicrously difficult to pilot an ROV."

Tyler Schilling in the Schilling Robotics assembly shop, Davis, California.

"The thing that makes it even more preposterous, even in today's depressed environment, is that there are operations out there costing more than $600,000/day being held up by people fiddling around with a machine like this. I think they can be made 4-6 times more productive then they are now."

Schilling Robotics is working on a number of areas to make that happen. "One of the main technology threads we are pursuing is one we call shared control," Schilling says. This is a term long-used in the robotics industry to denote technology where you share duties between the machine and the human, playing to each's strengths. This has been illustrated by so-called "peg in hole" tasks – where a robot needs to align an object to a hole and mate it. To perform such a task with an ROV, some 10 degrees of freedom need to be aligned – which is why ROV work is so hard. If a computer was used to perform the alignment, with the human supplying the intent, the operation would be easier.

This is what Schilling Robotics calls tool dynamic positioning. "We are just about ready to try our Beta release of tool dynamic positioning to the market place and do some offshore tasks with it," Schilling says. "We realized it would be profoundly beneficial if, rather than the body of the ROV being positioned relative to the sea floor, the ROV could be positioned relative to the well or the work space. That's really what the user wants. All we have done is make his or her job incrementally easier by positioning the body of the ROV. That's a big area we have been working on."

Another area Schilling thinks great strides can be made in the sector is by using video cameras as sensors, "going beyond just letting people look at stuff, but using it as a sensor to control the motion of both the ROV and its tool," he says, turning the camera into a multi-functional instrument.

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What he is describing is the technology that allows car drivers to sit back while their car parks itself, or skiers to set off a drone, which follows and films them as they go down the mountain side. It is charge coupled device (CCD) technology, which uses an integrated circuit etched onto a silicon surface, forming light sensitive elements, which record light by electronically reading the charge created by photons which land on its surface, turning this into a digital image – and data. CCD has given rise to SLAM, or simultaneous localization and mapping, which, using fast processing algorithms can extract fiducial points from each frame of a video and compute the motion of those fiducials from frame to frame, allowing the user to create a 3D map of the object and plot the position of the camera relative to it at the same time.

"We think we are at the very beginning of a large advance for the industry," Schilling says. "Bring this technology together with the ROV and its tool and dynamic positioning and you have a machine able to continuously understand where it is and have an ever improving 3D model of the work space. This will see productivity and ease of use take off."

The realization around the role video cameras can play in improving ROV productivity led Schilling Robotics to invest in video camera technology. The firm's camera sends data back along the same Ethernet as the data and communications for the ROV uses, filling the video frames with meta-data, which can then be searched, such as depth, heading, etc. This information, instead of just being live on a screen, is now machine readable and searchable.

Schilling says the firm is also considering the implications of 3D printing and the potential to design in the option to have parts both able to be mass produced and 3D printed on site. "We have been discussing why don't we build in

A UHD Gen III.

to the development process a rule that says think of ways to design parts so they can both be produced by 3D printing and normal manufacturing processes, so we can make parts economically but they can also be printed on the spot," Schilling says.

But, by far the biggest innovation is yet to come.

"One of the most exciting threads we are focused on is actually a long-term horizon one," Schilling says. "Right now we are investing in shared control with video as a sensor and a whole host of technology in that vein. But, it occurred to us a couple of years ago that the people who design equipment that produces oil on the sea floor have typically been designing equipment that uses the ROV as little as possible.

"As an example for flowline connectors, the task has been reduced to simply require the ROV to pump fluid into the connector or the tool in order for it to latch. This certainly asks for very little from the ROV; however, the ROV intervention makes for a large and expensive connector. We believe and have started a program to turn that model on its head. We're asking what new family of robots would enable sea floor equipment designers to make substantially less expensive equipment."

"The poster child in the surface industry is to hook up a flowline using an API flange. There's a flange on both sides, a gasket then a plurality of nuts and bolts. It is less than 1% the cost of an ROV mateable sea floor connector, largely because the robot cannot deal with all those parts. That, in my opinion, is a challenge.

"I think it will take five years for the first 'thing' to hit the water and maybe 10 years for it to really pick up and take off. I visualize it as a whole new family of robotic devices, of which only a subset would be free-flying ROVs. It is very conceptual at the moment and what we are trying to do right now is envision what the fundamental principles would be that would drive the eventual design."

But, will the industry be receptive? "I have spent the last 30 years with people telling me 'Tyler, that stuff is too fancy, all we need is agricultural technology, and you keep pushing stuff on us that's too fancy.' But I'm pleased to report, as of two years ago, I now agree with those people because the agricultural industry has surpassed us in the use of 'fancy technology'. The level of automation in the agriculture industry is remarkable." **OE**

Neat intervention

Applying university research to an industry challenge has helped create new solutions for Aberdeen's Hydrasun. Elaine Maslin reports.

When Hydrasun set out to take well intervention hose technology to a new level, its aim was to develop a product that provided operational efficiencies and cost savings over currently available flexible conduit systems.

Hydrasun thinks it has not only done that, but, thanks to help from researchers at the University of Strathclyde, the hose will be able to support both its own weight and that of other equipment, such as a distribution manifold.

The new 5000 psi-rated 2in hose, named "Interventor," is virtually neutrally buoyant, light weight, and has a small minimum bend radius compared to other fluid transfer technologies used in well maintenance activities. The hose is un-bonded in structure with aramid reinforcement. It has been designed to be used for fluid injection, such as methanol or acid, on subsea well intervention campaigns, or for dispersant, in the case of a subsea blowout, and most commonly from light well intervention vessels.

Interventor characterization testing at University of Strathclyde. Photo from Hydrasun.

"The main driver from operators is for economic well intervention technologies," says Ben Coutts, director, engineering and research and development, Hydrasun. One example of how Interventor can deliver benefits over current surface to subsea fluid transfer methods, is instead of having to deploy a hose on a cable or wire rope, in order to provide the required level of tensile strength, which means manually clamping it to the cable or wire as its deployed, the hose is itself load-bearing – up to 1.5-tonne with 3:1 safety factor, Coutts says.

Because a separate support cable is no longer needed, less equipment is required onboard and deployment/retrieval of the hose is both safer and quicker.

Interventor comprises a nylon inner liner, aramid reinforcement layers, and an outer polyurethane protective sheath. An empty section weighs 3.2kg/m in air and 5.38kg/m in air filled with seawater. Submerged, and filled with seawater, it reduces to 0.2kg/m.

Because Hydrasun uses aramid for strengthening, the hose itself has no metallic parts, Coutts says, just high fatigue resistance without corrosion.

The materials used means the hose has a small minimal bend radius, which means it can be loaded onto small drums, and is able to operate at temperatures from -40° C to 72°C. To maintain the small bend radius between sections, Hydrasun had a flexible, high pressure articulated joint developed by a supplier to connect the up to 700m-long hose sections. But, it was the hose's load bearing strength, confirmed during testing at the University of Strathclyde that has given it additional functionality.

Hydrasun was introduced to the university by the Oil & Gas Innovation Centre (OGIC), a new UK body to match industry with academia, which the firm helped set up. "When the requirement for materials characterization was needed Hydrasun came to us," says Ian Phillips, OGIC's CEO.

Five universities provided proposals and Strathclyde was selected. "What's significant is that it is not a traditional oil and gas industry related university," Phillips says. "Strathclyde has been one of the most responsive of the universities taking part. The principal wants Strathclyde to be the MIT of the UK and they do have a very industrially focused approach to the world."

By working with a university through OGIC, Hydrasun secured 50% funding for the research. The university, through the project, also gains material for its research projects.

Initially, testing to destruction was performed at Lloyds British in Scotland, with 3.5-tonne load followed by successful hydrostatic tests. Then, at Strathclyde, more complex characterization tests were performed, including static and dynamic load testing, load elongation, cyclic testing, loading under pressure, bending with compression, bending with tension and combinations of the two, etc.

"Minimal failure loads were established, at 5.7-tonne, on a worst case scenario with the hose unpressurised," Coutts says.

An initial 110,000 cyclic fatigue test (equivalent to 19 days continuous service offshore Africa) was performed, cycling between 1-2-tonnes with no degradation of the hose, followed by a successful hydrostatic test at 7500psi.

"This was a key piece of work," Coutts says. The end result has been operators that now have shown interest in running long-term tests. Hydrasun plans to continue development and testing of Interventor in preparation for commercialization by December 2015. OE

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A 2.0 silver lining?

A packed plenary session during SPE Offshore Europe 2015.
Photo from Reed Exhibitions.

Low oil prices, falling investment and the need to transform the UK exploration and production sector were high on the agenda at SPE Offshore Europe. Elaine Maslin reflects.

Cost cutting and efficiency measures were supplanted by a new rhetoric at SPE Offshore Europe 2015 – the need for a complete transformation.

The statistics are certainly bleak, at least for the short-term. While numbers held up at this year's show – some 55,947 attended, the second highest attendance rate for the event, according to the organizers – there are clear signs of stress in the industry.

Oil & Gas UK's 2015 Economic Report, revealed on the second day of the conference, outlined a 15% reduction in jobs, or 5500 posts, in the industry since the end of 2014.

The report anticipates the UK North Sea industry will make a 22% reduction in costs by the end of 2016. It says operating costs are expected to fall from £17.8/boe in 2014 to £17/boe in 2015 and then by a further £2-3/boe by the end of 2016. But will this be enough? Take out the costs saved by the 15% reduction in staff and the numbers do not seem that great. Next, compare the reduction in costs to the reduction expected new investment, i.e. the source of new work. Capital investment is expected to drop from a record £14.8 billion in 2014 to £10-11 billion this year, then by £2-4 billion in each of the next three years. That's a 29% drop this year alone.

Even with better results in terms of efficiency and cost cutting measures, there's still the stark issue of exploration rates. "The three-year average of around 55 MMboe of recoverable reserves discovered per year is the lowest since exploration activity began on the UK Continental Shelf," states the report. Without exploration, there will be no new barrels to produce.

But, few believe the situation is irretrievable. The lower-for-longer oil price environment is now accepted and many actually believe this will be healthy for the industry, with at least two conference speakers chanting the mantra – "don't waste a good crisis." The fat, built up amid high oil prices and easier profits, will be cut, new technologies will be adopted – and the signs are there already that small-tech companies dealing in data-based analytics are already being welcomed by operators, according to PwC's Jon Shelley. This is an opportunity for the industry to embrace that long talked about E&P2.0 espoused by 2015 SPE President Helge Hove Haldorsen – smart technologies, condition-based monitoring, real-time analytics, automation, and new business models.

Hydrocarbons, it is accepted, will still be needed for decades to come – the fundamentals are there. But, "we can't just cost cut our way to greatness; new technology, new business models and collaboration2.0 are necessary to achieve the desired 'Extreme Makeover E&P Edition'," Haldorsen says.

Embracing different business models, such as unbundling access to infrastructure from asset ownership, could in itself provide new investment, according to a presentation in a technical session by experts at the University of Aberdeen. They modeled the effect of unbundling access to infrastructure from asset ownership and worked out that doing so could increase the net present value of North Sea fields by up to £10.93 billion and see up to 34 new fields developed.

It's also not all about exploration and production. A new business stream is finally starting to open up on the UKCS. In a report commissioned for SPE Offshore Europe, Wood Mackenzie said the low oil price is halting the high oil price-fueled investment in mature fields seen in the past few years, leading to ramp up in decommissioning activity and spend over the next five years. Some 140 fields could cease production over the next

five years, suggests Wood Mackenzie, even if oil prices return to US$85/bbl. They also put the cost of decommissioning the UK North Sea's assets at an eye watering £54 billion.

Either way, new entrants to the industry will still be needed for decades to come. Fields are still being developed, not least Clair Ridge, Mariner, Culzean and maybe even Rosebank. Which means the industry still needs to give a positive message, to "inspire the next generation" – the theme of this year's event.

Both event chairmen, Charles Woodburn, CEO of Expro Group, and Michael Engell-Jensen, executive director of the International Association of Oil & Gas Producers (IOGP) agree that more needs to be done to both inspire the next generation and help those newly qualified graduates who have been caught out by the current economic difficulties.

How well the industry has embraced all these themes will no doubt be topics at the next SPE Offshore Europe, due to be held in Aberdeen 5-8 September 2017, complete with at least one new feature to reflect the current environment – a Decommissioning Zone. **OE**

The ISIS threat

While much of SPE Offshore Europe focused on the North Sea, there was also a strong global focus, via UK Trade and Industry's country briefings, as well as keynote sessions looking at global security issues. John Bradbury sat in on the "Security of staff and assets" keynote.

Oil and gas assets in the Middle East and Africa are facing an increase threat from ISIS a security expert has warned, as the group grows and seeks to acquire new territory.

Al-Qaida and jihadist expert Aymen Ali Dean told delegates on day two of SPE Offshore Europe during one of the keynote sessions how Al-Qaida has become more dangerous since 2004-6 when its ideology prompted a change in strategy.

"If you took 10 Al-Qaida leaders in 2004-5 and asked what they wanted, you would get 20 different answers," Dean told show delegates. Today, he said, the organization has featured a lack of discipline and commitment from recruits.

But its approach has been refined, and today the Islamic State group (ISIS) and jihadists pose a threat to the security of the energy industry, delegates heard.

But the organization's logic has dictated that no jihad – holy war – can exist without an Imam, and an Imam cannot exist without a state, and that therefore a state and an Imam have to exist first, before a jihad – directed against the West – can be pursued, explaining why ISIS is now seeking to establish a Caliphate or Islamic state, within Syria and Iraq.

Dean said there has been a shift from a global to a regional jihad, he said in countries like Yemen today, where there is an ample supply of weapons – typically four pieces of equipment to every individual, as well as energy resources.

"There are implications for every industrialized nation as they have an obsession and desire to control energy resources in both old and new territories," Dean said. "ISIS doesn't only seek to acquire resources, they also destroy them," he said, citing the example of the Baiji complex, Iraq's largest refinery north of Baghdad. Pipelines and refineries are also susceptible to attack, he said.

ISIS also poses a further threat to the energy industry delegates heard: "ISIS also seeks to recruit from inside the industry, to establish connections and to gather intelligence," Dean disclosed. And why? Dean said it was because between US$200-600 million of revenue was at stake, from captured and producing energy assets.

"As long as there is oil in the market that is half the price or even a third of the price, someone will buy it," Dean said.

One of the largest buyers of crude oil produced from energy assets already controlled by ISIS is the regime in Damascus, Dean revealed, where it is used for power generation, and for lighting.

ISIS will seek to gain more territory, gain more control, Dean said. "... resulting in more people going over to them. Territory is the most important end-game."

And just to underline the preoccupation with security, bags were checked on entry to this particular conference session and a police presence was in evidence prior to the start.

Dean himself is a jihadist expert, who has studied the rise of Al-Qaida, the rise of the Taliban in Afghanistan, and Pakistan, and he has also worked as a counter-terrorism adviser and the author of a study on terrorist financing. **OE**

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Doing it for the kids

The theme of this year's SPE Offshore Europe is inspiring the next generation, and the event's opening plenary showed how a few notable figures set foot on their STEM career paths. Audrey Leon reports.

While most of this year's SPE Offshore Europe conference dealt with how to deal with the uncertainty of low oil prices and thousands of job losses, the opening plenary on day one sought to remind the audience why they entered the industry in the first place, and share that love of career choice with the next generation.

English physicist and BBC presenter Brian Cox, looking quite magical standing in front of a star-filled nighttime display, discussed how Carl Sagan's romantic view of space led him on a path to physics research. Cox's own path was begun with his fascination around the Orion constellation. He made the argument that studying what you love doesn't ruin it. "The more detail you understand, the more interesting it gets," Cox said.

Matt Corbin of Aker Solutions said his entry into the industry came via the construction industry with contest to design a pedestrian bridge with John Laing. Eventually, he ended up at a small subsea engineering firm when no other opportunities with John Laing were available.

Corbin rallied for the UK industry to continue working with schools to help expose pre-college aged children to various jobs within the industry. Of the new generations of millennials looking to enter the workforce, Corbin said: "14% of young people would take a pay cut to work for a company that lines up with their core values. I'm not sure I would have done that."

Continuing, Corbin said: "[They] want flexibility in the work environment. They are truly intellectually agile in a way we haven't seen before. This millennial generation – they're the most social."

Making the connection between space and energy exploration, Cox said the industry needed to be aware of important space-related developments. Particularly, the discovery of large deposits of methane gas on Saturn's moon Titan, which in theory could be a future source of LPG, Cox said.

One issue noted repeatedly during the session was that the oil and gas industry does a fairly terrible job of telling its story to not just young people but the public at large.

"The idea that energy use is bad is nonsensical," Cox said. "Your industry is the industry that makes life better."

Matt Corbin concluded: "It's a complex industry, thousands coming up with solutions every day. There are so many myths, but it's our responsibly to bust some of that."

Cox expressed a similar sentiment: "Inspiring is the easy part. We work in interesting areas, but the follow up is the key."

Charles Woodburn introduced the panel discussion by stating, "We will only thrive if we have the very best minds on our side. We need to do a better job engaging the youth. For someone who is ambitious, looking to make a difference, you have a lot to offer (the industry)." OE

Top image: Opening plenary on "How to Inspire the Next Generation," featured speakers such as Professor Brian Cox; Keisuke Sadamori, IEA; Liz Rogers, Head of Environment and Social Responsibility, BP; Simon Bittleston, Vice President Research, Schlumberger; Matt Corbin, UK Managing Director, Aker Solutions.

Above: Physicist and BBC presenter Brian Cox speaking at SPE Offshore Europe's opening plenary about how he fell in love with science. Photos from Audrey Leon/OE.

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Revised promises

Brazil will need to drill around 300 development wells in deepwater in order to sustain and reach its production target. Douglas Westwood's Mark Adeosun takes a look at what is at stake.

Petrobras has long been a pioneer in the adoption and deployment of deepwater technology. This has enabled the firm to build huge reserves of some 16 billion bbl of oil.

Converting these reserves to production, a bigger issue is that Petrobras has a history of setting ambitious targets with a poor record of meeting them.

The first oil output from Brazil's giant Libra offshore area is now scheduled to flow in 1Q 2017, later than 2H 2016 as announced by Petrobras in June 2015. This delayed start-up date is one of the first signs that Petrobras will continue struggling to meet its own scaled-back targets as announced in its "2015-2019 Business and Management Plan." Nevertheless, in July 2015, Petrobras set a new daily oil production record in its pre-salt basin of 865,000 b/d. It is pertinent to state that this production does not include natural gas extraction.

The Petrobras corruption scandal, unearthed in 2014, involving the exchange of bribes for inflated contracts with suppliers, will continue to impact the exploration and production sector [Read more – see page 70]. Blacklisted companies will be banned from the tendering process hereby losing significant industry experience achieved over the years. However, a more open tender process will improve Petrobras' reputation and investors' confidence in the long-term.

The long delayed "2015-2019 Business and Management Plan" released in June is a reflection of the new reality for Petrobras. With collapsed oil prices and unfavorable exchange rates, Petrobras has slashed their expenditure plans by 40% from the plans announced more than a year ago.

Recognizing the upstream challenges, the company is now allocating 84% of its budget to exploration and production compared to 70% in the previous plan. The biggest cut goes to their refining and supply sector, which has seen its budget reduced by 67% compared to last year's plan.

Petrobras recorded a steep decline in revenue in 2Q 2015, with a net profit of US$150.8 million from April to June, down 89% from the same period a year ago, which was prominently due to impairment of upstream assets. Over the last quarter, Petrobras' net debt increased to $104.4 billion.

Domestic production decline rate from matured fields is a huge challenge with around 200,000 b/d of capacity eroded each year. Brazil's huge deepwater potential remains constrained with Petrobras having to revise their production target for 2020, which now forecasts domestic oil output to increase to 2.8 MMb/d – 40% lower than its projection 12 months ago.

The scale and importance of Brazil in the overall offshore sector means that the impact of the latest spending revisions will be felt throughout the oilfield service industry supply-chain. Douglas Westwood (DW) expects offshore oilfield services (OFS) expenditure to amount to a total of $10 billion over the next five years, with rig and crew accounting for 75%.

As the state-owned company continues with its divestment plan, major international oil companies such as ExxonMobil, Total, BP, and Shell continue to show interest in Petrobras' producing oilfields as well as operating rights in Brazil's coveted offshore pre-salt basin.

Shell is considering investing billions in Brazil. This is set to be a focal point after its planned acquisition of BG Group, even as it plans to sell huge chunks of its business to pay for the $70 billion deal, which will make Shell the largest foreign oil producer in Brazil's deepwater oil and gas fields. Despite a comprehensive drive to cut expenditure in the face of persistently low oil prices, the acquisition of BG Group will transform Shell into the world's biggest liquefied natural gas (LNG) supplier. The company has announced plans to sell around $30 billion in assets from 2016-2018, to improve its balance sheet and focus on its core deepwater oil and LNG business. Shell and BG's combined oil production in Brazil is expected to attain 550,000 b/d by the end of the decade, from approximately 200,000 b/d at present.

Brazil's huge deepwater oil reserves are set to become key sources for meeting growing global demand over the next few decades. As the industry continues to respond to the oil price environment, exploration activity is being curtailed. Operators' cutbacks in exploration spending have resulted in cancellations/amendments of drilling rig contracts.

This appears to be the primary strategic response to low oil prices. However, DW expects drilling activity to recover in 2016 as many explorers seize the opportunity to drill at lower costs. DW predicts that over the forecast period, Brazil will need to drill around 300 development wells in deepwater in order to sustain and reach its production target. Furthermore, of the 29 new rigs being

built by the company, many are under threat from either funding problems or yards withdrawing from the contracts.

DW will continue to take a conservative position on Brazil and the cut in production target now brings in line Petrobras' expectations and our own "DW D&P" forecast. **OE**

Mark Adeosun joined Douglas Westwood in 2013, and has since conducted has conducted high-level research into various oil and gas projects, with a focus on offshore drilling and deepwater activity. He has undertaken market modeling and analysis, focusing on offshore markets and exploration and production activities. Adeosun has a BSc degree in geology and a Master's degree from the University of South Wales in Geographic Information Systems.

The *Cidade de Paraty* is a third generation FPSO vessel capable of processing 120,000 b/d of oil, associated gas treatment for 5 MMscm/d with compression and carbon dioxide removal and a water injection facility for 150,000 b/d. It is currently developing Lula NE, Santos Basin, offshore Brazil.

Photos from BG Group

The *Cidade de São Paulo*, which started production in January 2013, is the second of 15 FPSO's that will ultimately produce from BG Group's big five discoveries in the Santos Basin.

The FPSO *Cidade de Angra dos Reis*, on location in the Santos Basin.

Taking on Papa Terra

The safe installation of the first tension-leg wellhead platform offshore Brazil could pave the way for future similar developments, says DNV GL's Mike Roberts and David Ryan.

First production from Papa Terra this March signaled the successful completion of a landmark development: the first tension leg wellhead platform (TLWP), P-61, for South America and inaugural application of dry tree technology off Brazil.

DNV GL's global teams played an important role in identifying, mitigating and eliminating risk during what was a particularly high-profile and complex project – P-61's safe construction, transportation, installation and operation 110km off the South American coast.

The project may mean TLPs are increasingly considered as viable future development options to tap the region's significant deepwater reserves.

The TLWP

The Petrobras-operated Papa Terra heavy oilfield is in Campos Basin block BC-20, at 1190m water depth. The field is estimated to contain from 700 million to 1 billion boe. P-61 was installed in April 2014 connected to a tender assist drilling rig moored nearby, transferring hydrocarbons through flexible lines to the *P-63* FPSO, about 350m away.

The TLWP has dry trees connected to top tensioned risers, with the tender assist drilling rig supporting all the well drilling and workover activities.

A total 13 production wells are being connected to P-61, with the first well, PPT-16, having started production in March.

As with many TLPs, construction took place in multiple locations.

The topsides were constructed at the Keppel FELS' yard in Singapore; the tendons and piles in the US, and the hull by Keppel FELS Brazil, at its BrasFELS yard. The topsides were transported to Brazil in late 2012, for mating with the hull using floatover methodology. The TLWP installation was completed in March 2014.

Global scope and expertise

FloaTEC, the US-based joint venture between McDermott and Keppel FELS, responsible for engineering, procurement, construction and installation of the TLWP, called on DNV GL's marine assurance and technical advisory team in 2010 to provide marine warranty services (MWS).

As an MWS provider, DNV GL has supported the safe construction, transportation and installation of approximately 80% of the world's TLPs, starting in the 1980s when the-then Noble Denton was involved in the installation of the first platform of this kind: Hutton, in the North Sea.

For P-61, DNV GL worked closely with FloaTEC, acting as third party verifier on behalf of the underwriters to identify, minimize and, where possible, eliminate project risk during specific activities in line with its own internationally-recognized guidelines.

The project involved reviewing hundreds of design and installation documents and drawings for the various components, including heavy lift procedures for site fabrication and procedures for the transportation of tendons and tendon buoyancy modules from the Gulf of Mexico to Brazil.

The team also reviewed the procedures for the floatover of the topsides onto the hull, as well as the asset's subsequent tow and installation offshore, including the installation of the piles and tendons.

Benefits and challenges

Generally, TLPs are a widely adopted and trusted solution for deepwater developments, particularly where there is an infrastructure already in place. They have a smaller footprint on the seabed and are particularly stable as they are not subject to swell and roll motions.

Yet, TLPs do present specific challenges that need to be addressed in advance through the creation and agreement of appropriate procedures, which require independent MWS verification.

Subsea challenges

For P-61, like many TLPs, the real complexity is below the surface, particularly considering the intricate infrastructure that comprises tendon systems, subsea risers and umbilicals.

In this case, the design of the various mooring systems, specifically between the FPSO, the TLP and the tender assist rig needed to be carefully planned using 3D assessments to avoid infrastructure clashes such as the crossing of mooring lines throughout the entire installation process, not just the final integration.

Chevron's Papa Terra facility offshore Brazil. Photo from DNV GL.

Weather challenges

The Campos Basin is an exposed deepwater environment. Specific issues included swell conditions, affecting the installation vessel and the TLP's hull, which could have caused considerable project delays.

Vertical motion caused by swell, or vertical surge, becomes an issue during the integration phase, when the tendons are being connected to the hull. Here, maximum environmental criteria were developed, to ensure the optimum environmental conditions and required weather window was established using historical environmental data for the location.

Meteorological and oceanographic information is a key requirement for location approvals, transportation and structure design, and weather-limited operations. Procedures were also put in place to mitigate the impact of adverse weather and, though installation was halted at times because of extreme conditions, this was an orderly procedure with only minor delays in order to maintain the safety of the operation and personnel.

The Papa Terra facility. Photo from Programa de Aceleração do Crescimento, from Flickr under creative commons license.

Logistical and design approach

Various elements of a TLP are typically constructed in multiple locations and need to be transported safely to the final destination for assembly and installation. P-61 was no exception.

At Keppel FELS yard in Singapore, the designers took the innovative approach of constructing the topsides on a purpose-built barge, specifically to suit the floatover operation. The barge and topsides were floated on to a heavy lift vessel for transport to Brazil with the transportation route round Cape of Good Hope, which is notorious for extreme weather conditions.

Hull construction was also unusual. Normally, the hull portion is built as one unit with four columns; however, the Brasfels dry dock in Brazil was not wide enough to support this method and, as such, the lower part of the hull and starter columns were built as two C-shaped sections. Both were floated out jointly before being welded together. The fabrication was continued with the completion of the four columns.

This floatout was subject to incredibly tight parameters, with small clearances between the keel of the hull, the temporary supports in the dry dock and the dry dock sill. Everything had been considered to ensure the operation's feasibility: the floatout not only had to be timed with high tide in order to have the maximum depth at the exit point, but there had to be careful weight management of the hull to ensure it was not sitting too low in the water.

Opportunities

Despite current oil and gas price challenges, there remains huge potential offshore Brazil, a region home to more than 7.5 million sq km of on- and offshore reserves. International investment is increasingly likely due to the ongoing 13th licensing round, covering some 266 blocks across 10 geological basins, together with current proposals to reform the pre-salt production-sharing regime.

The design of the various spread mooring systems required for the FPSO and the tender assist rig meant that if a spread mooring system was used for P-61, the offshore location would have had a very complex system of mooring lines, subsea risers and umbilicals. This would have been difficult to install and maintain adequate clearances between any mooring lines, subsea risers and umbilicals. By using a TLP, the number of mooring lines was significantly reduced thus alleviating this problem.

Added to that, now the industry in Brazil has seen its first TLP installation, it is possible the technology will be increasingly considered as a viable and effective development option to exploit these reserves. **OE**

***Mike Roberts** has more than 31 years' engineering and management experience, including 25 years in the design and installation of offshore structures. Roberts is also the Global Technical Authority for three of the Noble Denton Marine Assurance and Advisory Guidelines and is presently re-writing these guidelines following the merger of DNV and GL Noble Denton.*

***Captain David Ryan** is a master Mariner with more than 35 years' experience at sea and onshore in the marine industry, with the last 14 years specializing in marine warranty, marine casualty investigation, and marine risk management. Ryan is the Marine Manager in the Houston hub and a member of Noble Denton Marine Assurance and Advisory Technical Standards Committee on the subjects of Marine Warranty/Marine Assurance and Marine Transportations.*

Tackling the deep

Brazil's deepwater offers huge opportunities, but also big technology challenges. The Industry Technology Facilitator's Paddy O'Brien and Arthur Braqa explain.

Offshore activity in Brazil raises particular technical challenges in tandem with the global drive to cut costs, improve efficiency and integrity and develop better safety practices.

Brazil's pre-salt oil and gas discoveries in the Santos and Campos Basins play a key role in the country's plans for economic growth and prosperity, and continue to set new production records.

The pre-salt play is also a potentially lucrative draw for international oil companies looking to take advantage of new exploration and production opportunities in the 13th licensing round in October.

Recent reports from Brazil's regulator, Agência Nacional do Petróleo (ANP), suggest that despite the low oil price and recent political controversy, the number of companies subscribed to participate in the forthcoming bidding process had already exceeded the number registered in 2013.

ANP received interest from about 17 companies from eight countries and pre-approved 12 of them late August. This new exploration frontier, only discovered in 2006, poses huge technical hurdles in seismic and visualization technology to properly map the pre-salt targets. High-pressure, high-temperature (HPHT) innovation is also advancing. A decade ago the physical technology did not exist to drill to such deep and ultra-deepwater depths and special equipment such as managed pressure drilling is now needed alongside heavier riser systems and drill strings.

An advance in reservoir characteristics, fluid behavior and data collection from wells requires more technical traction to give the industry better understanding and reduce uncertainties around pre-salt productivity. This will allow operators and decision makers to evaluate the number, location and best placement of production wells. Improvements have already been made in terms of reducing well count and costs, increasing the recovery of oil and gas and improving operating efficiency. Work is underway to develop technology to improve acquisition, processing and interpretation of seismic data, which will advance the exploration efforts in the country.

Offshore exploration in Brazil has taken place since the 1970s, and, like the North Sea, is undergoing increased activity to decommission many of its fields and subsea wells. Petrobras is currently looking to leverage learning and global best practice worldwide through the use of existing technologies and capabilities for well-plugging and abandonment (P&A), which demands its own complex technical solutions. One of the challenges for P&A is the availability of technologies for appropriate inspection of the well, from the inner side, to assure the appropriated integrity of the well and make sure there are no risks of accident or leakage.

Collaboration drives innovation

ITF is bringing together local academia and international operators, such as BG, Chevron, Shell, Total and Repsol Sinopec Brasil to instigate a number of joint industry projects to complement operators' own R&D activities.

Following the organization's recent call for proposals on "Water Production Challenges – Flow Assurance," two projects have been proposed with the Universidade Federal da Paraíba (UFPB) – Departamento de Engenharia Química and the Universidade Tecnológica Federal do Paraná (UTFPR).

The first with UFPB is on produced water treatment by adsorption for reinjection and disposal purposes. This project aims to reduce the concentration of oils, greases and other contaminants from produced water effluents generated in petroleum producing units. This will address the challenge of improving the quality of water for reinjection, disposal and release into the sea in accordance with regulatory requirements.

The second project with UTFPR is the development of an integrated multiphase flow metering system. In this proposal, optical, electrical and ultrasound measuring techniques coupled to intelligent algorithms will be integrated and evaluated, with the aim of developing a phase fraction meter without the use of ionizing radiation. In addition to the above project, ITF is working with the same University

on the development of a downhole phase fraction meter. A multidisciplinary team of experienced researchers and graduate students from both Electrical and Mechanical Engineering Departments at UTFPR will be set up to execute this project.

Unlocking potential

New technologies deployed now and in the future will be essential to unlock the country's potential. These include: novel riser systems; new flexible riser technologies and integrity management including life extension; qualification of new materials such as linepipe clad and corrosion resistant alloys; and CO_2 separation and injection equipment with a large footprint at the process plant.

It is anticipated that the cyclical nature of the oil and gas industry and the imminent and much anticipated 13th licensing round, will pave the way for a new wave of investment to meet technology demands. This creates an ideal setting for developers and operators to come together to deliver solutions which will benefit the entire oil and gas sector in Brazil. OE

Photos from ITF.

Dr Patrick O'Brien *is CEO of the Industry Technology Facilitator, ITF.*

Arthur Braga*, is Country Manager, Brazil, ITF.*

William J. Craig

What's in the car wash?

Operation Car Wash is the exposure of widespread corruption in Brazil following a federal police investigation into money laundering through a petrol station chain. The core element of this is how collaboration agreements between the accused and the state are being used to obtain information in exchange for judicial pardons or reduced sentences. Petroleo Brasileiro SA (Petrobras) Chief Executive Officer Maria das Graças Silva Foster and five of her top managers resigned in late 2014 amid a corruption probe that's wiped out billions of dollars of the oil producer's value and threatens Brazil's economic revival.

Petrobras is mired in allegations that former executives were bribed to award construction contracts, some of which were related to the 2014 football world cup.

The resignation of Foster — a 61-year-old engineer who rose through the ranks to become the first female CEO of Latin America's largest publicly traded oil company in 2012 — comes after the stock sank as much as 70% from a September peak as she grappled to gauge the losses from the alleged scheme. Foster, herself, isn't under investigation.

Operação Lava Jato– literally, 'Operation Car Wash' – started more than a year ago as a fairly typical Brazilian federal police investigation into money laundering through a chain of petrol stations. Since then it has blossomed into an almost soap-opera style parade of handcuffed executives, police raids and filmed depositions, with an added spicing of top rated defence lawyers and indignant politicians.

With investigations on-going throughout 2015 so far, details still emerging and no convictions handed down, the broad outlines of Car Wash were clear. More than a dozen major Brazilian construction companies, involved in the 2014 FIFA World Cup, and the 2016 Olympic Games, stand accused of paying bribes via middlemen to secure million- and billion-dollar contracts with Petrobras, a publicly quoted oil company in which the Brazilian government holds a controlling stake. It has also been alleged pro-government parties controlled Petrobras appointments to key positions that handle procurement. Most bribes were split between the middlemen, Petrobras executives and parties that support the government, investigators say, with much channelled via offshore shell companies into campaign slush funds.

Photo from OE staff.

Witnesses have said that the construction companies formed a multi-year cartel around the two major international events in 2014 and 2016 to share out contracts and pad prices, extending beyond petroleum to highway, stadium construction, transport and hydropower contracts.

With the exception of those who have agreed to cooperate, all companies, executives, middlemen, politicians and parties mentioned have denied any wrongdoing. Petrobras says it was a victim, while construction companies and some foreign suppliers to Petrobras say they faced de facto extortion – a situation of 'pay to play'.

How much was syphoned off? No final figure has yet emerged, but certainly hundreds of millions of dollars. Witnesses have mentioned skims of up to 3% on contracts worth tens of billions of dollars between 2003-2014.

Te lesson appears to be the existence of a well established system of endemic corruption within state-owned enterprises that are responsible for awarding very large contracts that should be for the public benefit.

Opening a can of worms

Brazil is no stranger to corruption. However, several attempts to bring major cases to trial have failed to achieve convictions, sometimes because of police work, sometimes because Brazil's anti-corruption laws offer innumerable possibilities for technical challenges, particularly when evidence comes from wiretaps, and frequently because the convoluted judicial system allows cases to drag out until they prescribe, particularly when elected officials are involved. In Car Wash, police and prosecutors are bending over backwards to avoid previous errors.

The snag with corruption cases is often a multi-player version of the prisoner's dilemma: as long as everyone denies everything, the hard evidence may be inconclusive. In Car Wash, the secret has been persuading some suspects to provide detailed confessions in exchange for reduced penalties. In Portuguese it's called colaboração premiada, which translates literally, as 'rewarded collaboration.' Journalists and even lawyers frequently call it delação premiada (rewarded accusation). The Organisation for Economic Co-operation and Development (OECD) Working Group on Bribery, in its latest (Phase 3) report on implementing the OECD Anti-Bribery Convention in Brazil, published October 2014, calls it "cooperation agreements and judicial pardon."

Whatever the name, collaboration has made all the difference in Car Wash. Federal police have used the collaboration agreements like a can opener, to pry the case apart.

So far, prosecutors say they have negotiated 12 collaboration agreements with individuals including currency dealers, former Petrobras executives, middlemen and businessmen. Charges were filed against 87 individuals for crimes including corruption, participating in a criminal organization, and money laundering, however, for a variety of reasons none of those initially charged were politicians.

What lies beneath the surface?

As with an iceberg, it is not what is immediately visible which is most devastating, but what is below the surface, so the Car Wash case has grown and grown.

Senior executives, more accustomed to private jets and five-star hotels, were held four to a Spartan cell, 12sq m with an open squat toilet. Defense lawyers claimed they were being pressured into collaboration, but the supreme court rejected several habeas corpus pleas.

In the latest developments, amid rioting in the streets of major cities São Paulo and Rio, and demands for the federal president to resign, the heads of two of Brazil's largest conglomerates were detained by police as part of an ever widening corruption investigation at Petrobras.

Marcelo Odebrecht and Otavio Azevedo – presidents of the Odebrecht and Andrade Gutierrez holding companies – were arrested in July as part of a federal operation that has now involved 220 police in four states. The Odebrecht and Andrade Gutierrez conglomerates include two of Latin America's largest building companies.

The arrests are the most senior-level detainment of corporate executives since the Petrobras scandal broke last year. It would appear that the Car Wash will continue to run for some time and may bring down the Brazilian government. **OE**

William J. Craig *is a lecturer in the department of Law, a course leader for the LLM/MSc Oil and Gas Law course at Robert Gordon University, and is a member of the European Corporate Governance Institute.*

FURTHER READING

Brazilian scandal creates business opportunities
http://www.oedigital.com/component/k2/item/10070-brazilian-scandal-creates-business-opportunities

Solutions

Plexus unveils Python

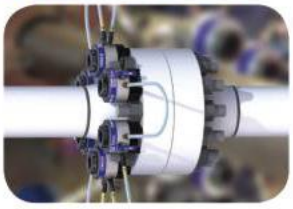
Wellhead systems engineering firm Plexus Ocean Systems launched its "game-changing" Python subsea wellhead SPE Offshore Europe. Aberdeen-based Plexus' HPHT POS-GRIP wellhead systems have already become an industry norm on jackup operations for high pressure wells. Python was created, using Plexus' proprietary POS-GRIP friction grip technology, out of the HGSS JIP, launched in 2011, when, following the Macondo disaster in the US Gulf of Mexico, a number of operators tasked Plexus to provide a better solution for locking down casing hangers in the subsea wellhead.

Ben van Bilderbeek with the Python subsea wellhead. Photo from Plexus.

CEO Ben Van Bilderbeek says, as well as solving the locking problem, the JIP has gone on to also make casing hangers readily releasable, for re-entry during sidetrack operations, annular seals have been developed with properties that match the integrity those in the rest of the well system, and the number of components in the system has been reduced, also reducing the number of trips required for installation.

Python is an 18 ¾in full bore subsea wellhead system, rated to 15,000psi at 350°F, which can be readily be upgraded to 20,000psi at 450°F. The system provides for 4,000,000lb "instant" casing hanger lockdown capacity, exceeding compliance with API 17D/ISO 13628-4, having recently met additional operator requirements for "life cycle" testing. Python is currently going through final cycle testing and will be ready for offshore deployment in a trial well during 2016. www.plexusplc.com

Force 10 for bolts



Atlas Copco Tentec bolt tightening solutions launched a new range of topside bolt tensioning tools – Force 10 during SPE Offshore Europe.

The Force10 tools consist of 10 base tools covering bolt sizes from 3/4in to 4in (M20 to M100) and has been designed to fit on to most ANSI B16.5, ANSI B16.47 Series 1, MSS-SP44, API-6A and API-17D standard flanges.

The range offers multiple tool variations per bolt size, with just five tools are required to suit bolt sizes from 3/4in to 4in (M20 to M100). Force10 tensioners from models F10-04 to F10-10 feature heavy duty integrated springs that assist in resetting the tensioners in between pressure cycles, speeding up bolt tensioning and reducing the effort needed by the user.

Models F10-01 to F10-03 feature a mechanism which directs oil flow away from the operator in the instance the ram is over-stroked and exhausts oil harmlessly into the internals of the tensioner.

Force 10 models F10-04 to F10-10 have internal hydraulic check valves that can sense the position of the tensioners hydraulic ram and again safely releases oil flow internal to the tool. www.tentec.net

Harben powered pump

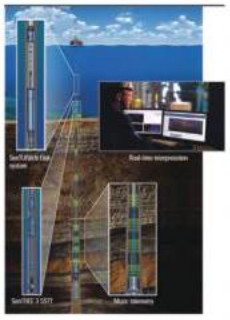
Flowplant showcased its latest pump, a multi-purpose high pressure pump unit for water based hydraulic control fluids, chemical cleaning and subsea applications, powered by Harben.

Flowplant's Harben radial piston pump has been designed so that all moving parts, with the exception of the inlet and outlet valves, are separated from the pump media by a tubular nitrile rubber diaphragm suited to handling high pressures up to 700 bar. The inert characteristics of nitrile means that many different chemicals can be pumped without detriment to service life.

The design means all Harben pumps can run dry without fear of damaging any components because the pump design does not rely on the pump media to cool or lubricate the moving parts.

Powered by a Harben P type 420 bar pump with heavy duty bearings and a variable speed motor, Flowplant's latest rig can operate as an umbilical and valve high pressure flushing unit, a hydrostatic test rig, a mobile HPU with the addition of a suitable accumulator and for hot chemical cleaning. www.flowplant.com

SenTURIAN E&A on show



Schlumberger showcased its new SenTURIAN E&A well test subsea landing string electrohydraulic operating system, which enables operators to safely access, shut in, and disconnect from a well at seabed in less than 15 seconds in water depths up to 12,000ft (3660m) on stand 3D140. This is the latest addition to the SenTURIAN family subsea systems, designed for reservoir testing during exploration and appraisal operations.

Schlumberger says SenTURIAN E&A is the world's first subsea landing string electrohydraulic operating system that complies with International Electrotechnical Commission IEC 61508 SIL 2 certification. Designed to run with Muzic wireless telemetry, the system allows equipment functionality checks and enables full operation of the surface flow head, lubricator valves and SenTREE subsea test tree, as well as the monitoring of downhole pressure and temperature. www.slb.com

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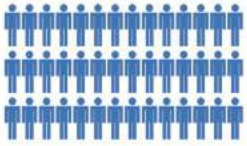

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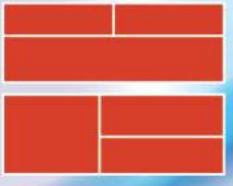

10
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Activity

Tracerco aids verification

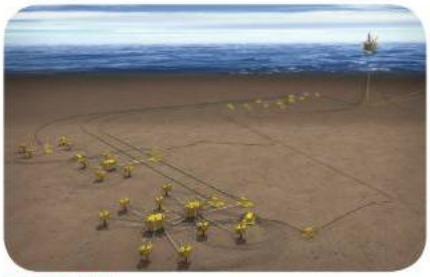
Johnson Matthey company Tracerco was due to have a five-strong fleet of its deep-water CT pipeline scanners out and in the market by the end of September, the firm's managing director Andy Hurst told *OE* during SPE Offshore Europe.

The first commercial use of the Discovery CT scanner, which can scan through coated pipelines, without having the remove the coating, was earlier this year, in deep water US Gulf of Mexico, with Shell *(OE: July 2015)*.

Since then, one of the firm's units has also been working in the North Sea and Tracerco is mobilizing two, fast response, 20ft containerized units, containing everything needed to deploy and support the deployment of the Discovery scanners to be based out of Perth, Australia, and West Africa. The Discovery units themselves would just need to be air shipped to location.

Discovery. Photo from Tracerco.

Hurst said that while the market was subdued, there was still strength in the market for life extension work, specifically around verification work, as well as flow assurance projects. "Undoubtedly, there are strong head winds in subsea inspection, as there are in any part of the industry, but we are seeing very strong interest for life extension verification and flow assurance is strong, too."



SURF JIP

An industry forum that addresses challenges in subsea integrity management is being extended for a further three years with backing from global oil and gas operators.

Phase II of the The SURF IM Network is led by Wood Group Kenny with support from the Industry Technology Facilitator (ITF). Phase 1 was launched last year, supported by an industry wide group of 14 operators and has been extended to run on an annual subscription basis through to 2018 with an expected project value of around £300,000.

In Phase I, progress was made in understanding the issue of control system module reliability and the outcomes of a comprehensive participant survey was presented to subsea suppliers to highlight integrity challenges and find ways to enhance reliability for the future.

SPE celebrates

The Society of Petroleum Engineers (SPE) Aberdeen Section kick-started its 2015/2016 session during SPE Offshore Europe with a celebration of the achievements of the previous year's session.

2015 SPE International President, Helge Hove Haldorsen delivered a keynote address and presented the North Sea Regional and SPE Aberdeen Section awards to members who have shown dedication to the Aberdeen Section over the past 12 months. The winners were:

Haldorsen

North Sea Regional Awards:

SPE North Sea Service Award – Anthony Onukwu, former 2012-2014 Section Chairman and SPE Aberdeen Section Director

SPE North Sea Young Professional Outstanding Service Award - Nikhil Shindgikar, former SPE Aberdeen Chair of the Young Professionals Committee

SPE Aberdeen Section Awards:

SPE Aberdeen Section Service Awards - Brenda Wyllie, DEVEX 2016 chair, and Mark Brinsden, co-chair of the SPE Aberdeen Energy Information Committee, and an SPE Technical Editor and Distinguished Lecturer

Young Professional Service Award - Ritika Pawar, Chair of the SPE Aberdeen Student Development Committee

Best Student Chapter Award - Dundee University

The section has won the SPE International Award for Section Excellence for six years in a row.

2016 OAA launched

The 2016 Offshore Achievement Awards, supported by ***OE*** (Offshore Engineer), were launched during SPE Offshore Europe, with new categories revealed.

2016 will mark the 30th anniversary of the awards. New categories include Environmental Innovation, focusing on technologies or systems that have reduced the industry's environmental impact, and Collaboration, recognizing multiple companies or inter-company teams effectively working together on a project, or those collaborating closely with the community on CSR initiatives.

The Outstanding Skills Development Programme Award will recognize companies bringing new talent to the industry. The Above and Beyond award has been introduced and is open to any individual who goes beyond their daily role to contribute to their company or the industry in general. This year's Significant Contribution award is also open to companies, projects or individuals this year.

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Spotlight

The ROV Renaissance man

This year has been a year of anniversaries for many, not least OE, which celebrates its 40th anniversary this year, alongside first oil from the North Sea. Another firm marking a milestone is Schilling Robotics, now FMC Technologies Schilling Robotics, which is 30 years old this year. Elaine Maslin profiles co-founder Tyler Schilling.

Tyler Schilling has been credited with being something of a renaissance man. The head of what has become a, if not *the*, leading business in the ROV industry, he is involved in every part of the firm, from the boardroom to the machine shop and the electronics lab.

So, it may be a surprise that his break into subsea robotics was the result of working as a fabricator in the crew of a motorsports team, which was the result of a summer job working on vintage race cars for a neighbor at his father's ranch.

These were all a series of chances that set Schilling on a path to co-found Schilling Robotics, with Wes Gerriets, 30 years ago this year.

However, it's perhaps not so surprising, given his background, and a continued love of the automotive sector – he says seeing what the auto industry is doing (think automated parallel parking) is a bell-weather for where subsea robotics should be going, although he's not so keen to work on today's cars.

"I was very fortunate to grow up at a time when anything seemed possible," says Schilling, from Davis, California. "That was the whole atmosphere, not only in the world, but also living near Silicon Valley, where all the breakthrough things were happening in semiconductor industries."

He also lived in a household "where you made things." His father, originally a machinist at a firm that made turret lathes, trained to become a physician, but the house retained its metal lathe, woodworking tools, printing set and more.

Tyler Schilling

When his father retired and bought a ranch in California's coastal mountain range, Schilling and his three brothers went to help out in the summer. "As luck would have it, the next door neighbor restored historic race cars for a living, so I got a summer job working with him, as a metal fabricator and painter of these things," Schilling says. When the racing reason came along, he joined a Can Am team and, in 1982, at one of the races, at Road Atlanta, he met Andrew Bazely, a former mink farmer. "He was a true renaissance man," Schilling says. "He had a remarkable race car that had incredible innovations from the front to the rear and not only did he design all of it, he also built it."

Bazely also had an underwater products firm, Hydroscan, in San Diego and asked Schilling to join. "The first project was designing and manufacturing robotic arms to go on a newfangled thing called an ROV," Schilling says. "That's how I got my exposure to ROVs. In addition, what I learned from him was fearlessness about what problems to attack. While he didn't express it this way, it was clear to me his attitude was 'someone in the world makes everything, so why not me.' It's a fairly liberating concept."

Schilling had found his niche; robotic manipulator arms and, in 1985, he co-founded Schilling Robotics, along with Gerriets. The rest, as they say, is history. Schilling Robotics was sold to Alstom in 1992, under whose ownership the company moved into ROVs, while its manipulators went on to be adopted by competitors such as Oceaneering. The firm has been owned by FMC Technologies since 2012.

But, Schilling has never lost an interest in and for both mechanical engineering and for the latest advances in technology, such as the use of video sensors and complex positioning systems based on algorithms developed by the global "app" developer community.

He has a passion for mechanical wrist watches and when the iPhone 6 came out he bought two, one to use and the other to pull apart. "We all marvel at Apple's software, but their mechanical engineering is some of the best on the planet," he says. "It is a wildly complicated machine but you can just turn it on and start exploring." Schilling lives, works and breathes subsea robotics, while also taking a healthy interest in corporate culture and behaviors. And, despite having developed Schilling Robotics into the market leading position it maintains today, Schilling has never let go of a drive for continuous technology development. In fact, he describes today's ROVs as "clumsy," and subsea technology as lagging behind advances seen in the agricultural industry – once seen as a source of more simple and basic engineering. **OE**

FURTHER **READING**

Read more about Schilling on page 54.

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Numerology

30 Tcf The amount of gas estimated at Eni's Zohr discovery offshore Egypt ▶ See page 16.

46% The decline in offshore rigs operating in the US Gulf of Mexico as of August 2015. *(Source: US Energy Information Administration)*

£14.8 billion

The peak level of investment on the UK Continental Shelf in 2014. ▶ See page 25.

11.76 years The mean-time-to-failure of some HSP units at the UK Captain Field ▶ See page 48.

The number of UKCS fields that could cease production in the next five years. *(Source: Wood Mackenzie)*

140

16 billion bbl

The huge amount of oil reserves Petrobras has built up ▶ See page 64.

5 Companies submitted bids in Lease Sale 246 in western Gulf of Mexico. ▶ See page 16.

100 The number of Chinese-built cranes Huisman has delivered from Zhangzhou, China. *(Source: Huisman)*

The year the Perla field was discovered off Venezuela.

▶ See page 20.

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- ☐ 03 Operations Management
- ☐ 04 Geology, Geophysics, Exploration
- ☐ 05 Operations *(All other operations personnel, Dept. Heads, Supv., Coord. and Mgrs.)*
- ☐ 99 Other *(please specify)*

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- ☐ 24 Drilling/Drilling Contractor
- ☐ 25 EPC *(Engineering, Procurement, Construction)*, Main Contractor
- ☐ 26 Subcontractor
- ☐ 27 Engineering Company
- ☐ 28 Consultant
- ☐ 29 Seismic Company
- ☐ 30 Pipeline/Installation Contractor
- ☐ 31 Ship/Fabrication Yard
- ☐ 32 Marine Support Services
- ☐ 33 Service, Supply, Equipment Manufacturing
- ☐ 34 Finance, Insurance
- ☐ 35 Government, Research, Education, Industry Association
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- ☐ 102 Drilling
- ☐ 103 Subsea Production, Construction *(Including Pipelines)*
- ☐ 104 Topsides, Jacket Design, Fabrication, Hook-up And Commissioning
- ☐ 105 Inspection, Repair, Maintenance
- ☐ 106 Production, Process Control, Instrumentation, Power Generation, etc.
- ☐ 107 Support Services, Supply Boats, Transport, Support Ships, etc.
- ☐ 108 Equipment Supply
- ☐ 109 Safety Prevention & Protection
- ☐ 110 Production
- ☐ 111 Reservoir
- ☐ 99 Other *(please specify)*

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The Monster bit

Varel produced what it believes to be the largest drill bit in the world – it was nicknamed Monster by the drilling engineer who used it on its first outing this year. Elaine Maslin reports.

While the average size of a drill bit can vary quite significantly in the North Sea offshore industry, from about 6in to 26in, or about the size of a melon, few might be prepared for a 45in bit.

Photo from Varel.

But, a 45in drill bit is exactly what Texas-based Varel Oil & Gas was tasked with producing after being approached by Hess Corp. with a particular challenge.

US-based Hess has been operating the South Arne field offshore Denmark since 1999 and it has been spending some US$1 billion to extend the production life of the field and optimize production from the tight chalk reservoir.

Hess wanted to replace some large hole openers offshore with a one-bit solution, to save handling. The result was a 45in milled tooth roller cone bit to help drill a series of splitter wells where a 40in casing was required to be run through 46in guides.

Weighing in at 5100lb, the drill bit was nicknamed Monster by the drilling engineer who used it on its first outing earlier this year.

Varel believes it to be the largest in the world and the first with an interchangeable inner polycrystalline diamond compact bit, allowing a full 45in hole at total depth (TD) without rathole to help align the following casing.

Its first outing was in the Danish sector of the North Sea, in April this year, where it was run on a 12¾in precontoured mud motor and had two Varel supplied 44in stabilizers above this. The 45in L111 was successfully run to TD, with both slide and rotary drilling. The bit drilled a total of 290ft at an average rate of penetration of 35ft/hr to drill the section to TD. Varel says Hess plans to use the bit on a second surface location this year.

The Monster travelled some distance for its Danish debut. The Monster was made by Varel at its plant in Matamoros, Mexico, close to the border with Texas.

It was then trucked to Brownsville, Texas, before being transported by sea from Galveston to the Port of London. The final leg of the journey took it by road up through the England and Scotland to Aberdeen before it was deployed offshore. OE

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- ☐ 105 Inspection, repair, maintenance
- ☐ 106 Production, process control instrumentation, power generation, etc.
- ☐ 107 Support services, supply boats, transport, support ships, etc
- ☐ 108 Equipment supply
- ☐ 109 Safety prevention and protection
- ☐ 110 Production
- ☐ 111 Reservoir
- ☐ 99 Other (*please specify*)

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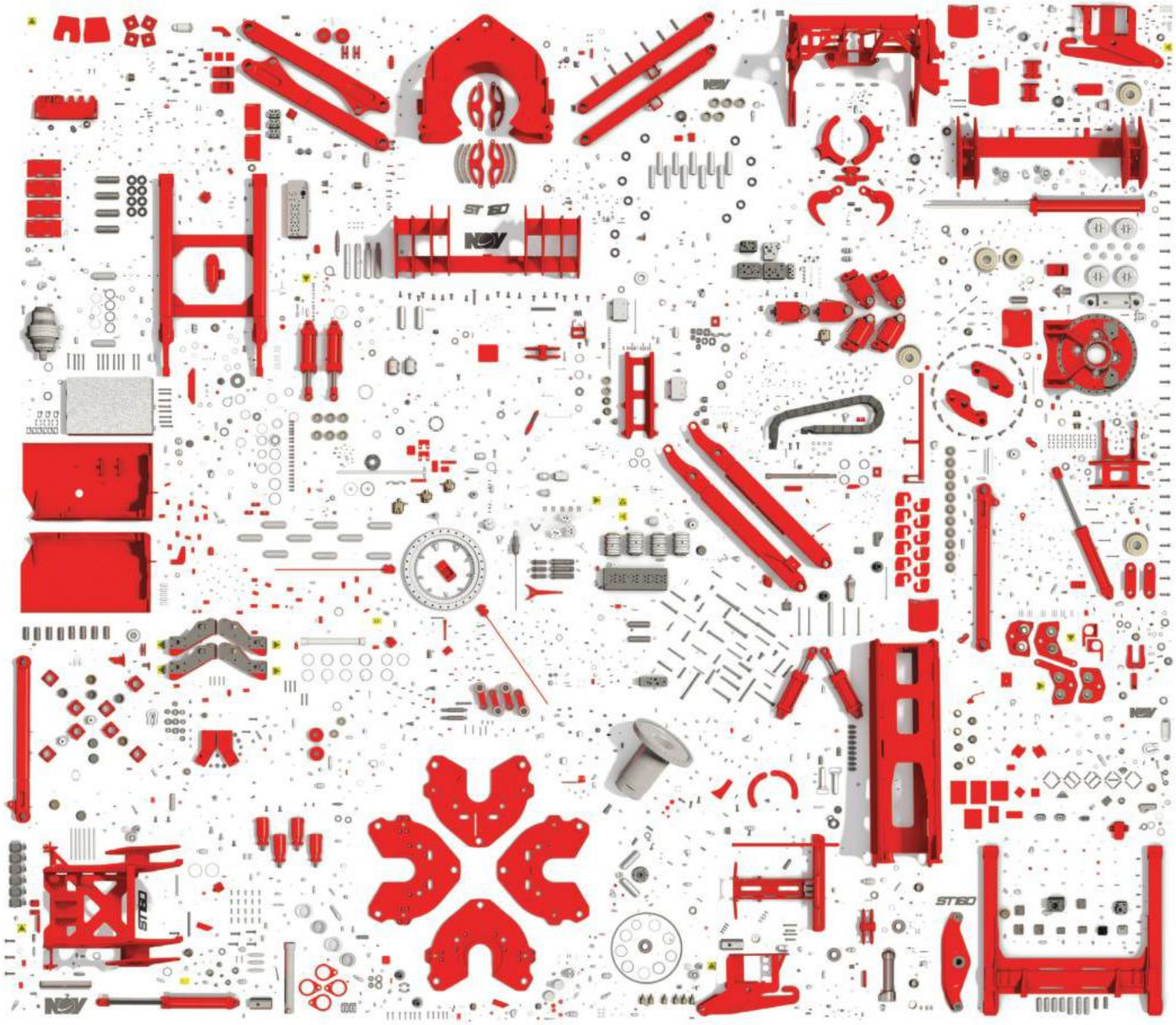

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