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DRILLING MARKET REVIEW

Offshore drilling market faces an uncertain year 32

As a slew of newbuild drilling rigs hit the market in 2015 coupled with oil companies slashing budgets due to surging costs, it is speculated that the industry will witness an acceleration in the rate of marginalization of legacy assets.

BRAZIL

Brazil remains center stage in rig market..... 42

Brazil has ambitions to become one of the largest oil exporters in the world over the next decade or two, but the country's ability to reach that goal is the pressing question. In September 2014, Brazilian federal energy planning company Empresa de Pesquisa Energetica laid out its 10-year plan for energy expansion, which foresees that the country will be able to produce 5 MMb/d of oil by 2023.

EXECUTIVE INTERVIEWS

New venture offers step change in reservoir recovery..... 46

In May 2013, Cameron and Schlumberger announced the creation of OneSubsea, a joint venture to manufacture and develop products, systems, and services for the subsea oil and gas market. Recently, *Offshore* met with OneSubsea CEO Mike Garding to discuss the company's achievements to date, the challenges he sees for the industry going forward, and the ways in which the new venture can help the offshore oil and gas industry address those challenges.

Industry addressing challenges of deepwater, data management 54

For 30 years, INTECSEA has provided frontier technology leadership for the energy industry's most challenging offshore field development and pipeline projects. Recently, Neil Mackintosh, president of INTECSEA, met with *Offshore* to discuss the latest trends in offshore oil and gas development, subsea engineering, data management, and the outlook for the industry in the next five to 10 years, and beyond.

GEOLOGY & GEOPHYSICS

Unstructured data management shifts industry to unified IT infrastructure 58

Managing the associated unstructured data generated by seismic images is a major investment of money, resources, and equipment. Moreover, as increased resolution continues to come online, survey technologies in field and processing techniques stretch decade-old computing constructs. Raw data sizes are also growing exponentially. The advances made in seismic data acquisition technology factor in this growth; however, post-processing, compression, high-fidelity master archiving, and data redundancy schemes all serve as multiplier effects on the raw data ingest rate.

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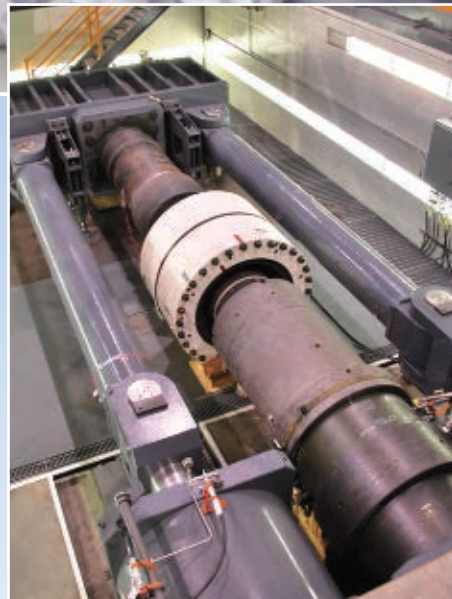
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Validation testing of a subsea wellhead system in DRIL-QUIP's horizontal test machine.

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GEOLOGY & GEOPHYSICS

Ice data management system improves Arctic operations..... 62

In the past, even with radar, satellite images and ice charts, it was very time consuming for ice observers to integrate or update reams of ice, weather, and ocean information. ION's Concept Systems has developed Narwhal, a fully-integrated ice management system where information is loaded automatically, time-stamped, and geo-referenced in a single database. As a result, ice observers, captains, and management can make more informed decisions, reduce downtime and costs under extreme conditions, and maximize the effectiveness of every operating season in icy waters.

ENGINEERING, CONSTRUCTION, & INSTALLATION

Integrated approach enhances conductor removal efficiency 66

Abandonment is the final and inevitable stage of every well. Safe and efficient P&A programs, including conductor removal, are increasingly becoming a priority for production companies to ensure they are in regulatory compliance, maintain high environmental standards, and can move forward with new exploration and production initiatives. An integrated portfolio that provides the necessary fit-for-purpose and latest technologies and expertise, as well as flexibility, is critical in carrying out complex conductor removal operations efficiently, while avoiding risk, and NPT remediation costs.

New prototype device advances decommissioning technology..... 70

As mandated by the federal government, so-called "idle iron" – wells, platforms, and pipelines that are no longer producing or serving exploration or support functions related to the company's lease – are being removed from the Gulf of Mexico. Versabar and Chevron teamed up with the intent of producing a safer, more efficient, and environmentally-friendly method of severing subsea structures. Their goal was to find a way to cleanly sever jackets and conductors 15 ft below the mudline with a minimum of direct personnel exposure and at the same time remove the accompanying structures following completion of the cutting operation.

Multiple platforms facing removal after cessation at North Sea gas complex..... 74

The end of production from the Thames gas field and its satellites in the UK southern basin could trigger the most extensive decommissioning program yet performed in the North Sea. Perenco and Tullow Oil are the two operators responsible for the campaign. Altogether 12 fields are involved, comprising six in the Thames Complex and six more in the greater Thames area. They are spread out over 13 blocks and five quadrants. Cessation of production was officially declared for all the fields on May 14, 2014, ending more than 25 years of gas supply to the UK mainland via the Thames offshore infrastructure.

62



66



70



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International Edition
Volume 75, Number 2
February 2015



COVER: The offshore drilling market faces a year of uncertainty in 2015, confronted with a slew of newbuild drilling rigs, reduced budgets, surging costs, and falling oil prices. Nevertheless, a number of drilling rigs remain active in offshore oil-producing regions. One of those that remains on duty is Transocean's ultra-deepwater drillship *Discoverer Clear Leader* (cover). The dual-activity, high-specification drillship will continue its work for Chevron in the US GoM through August 2018. (Photo by Ken Childress, courtesy Transocean)

PRODUCTION OPERATIONS

Smart valve system provides interventionless completions 78

The artificial lift method of gas lift is an increasingly popular means of boosting production from wells with lagging reservoir pressure. The method injects a compressed gas into well annulus between the production tubing and casing. The industry need for lower risk, interventionless alternatives to gas lift valve changeouts prompted Baker Hughes to develop a smart gas lift valve that could function as a dummy valve during completion operations and then convert to a live valve, without the need for a well intervention. This is achieved through the use of a disintegrable barrier or plug made of nanostructured composite material.

PIPELINES & FLOWLINES

Pipe-in-pipe technology adapts to changing needs in deep and shallow water..... 82

Over the past two decades, the pipe-in-pipe (PiP) product has become an essential part of the subsea field development engineer's "tool box." Due to its high insulation performance, it minimizes heat losses from the transported fluid to the environment that more traditional subsea coatings cannot provide. In 2014, Technip installed its 50th PiP via the reel-lay method; the first project was in Australia in 1989. Along the way, the company has advanced the technology at various points.

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<http://www.offshore-mag.com/webcasts/offshore/2014/12/frac-smarter-with-hydrocarbon-tracers.html>

Offshore Top 5 Projects – 2014

The editors of *Offshore* have made their choices for winners of the Five Star Award – the top five offshore field development projects for 2014 – and the winners were announced in a webcast on Dec. 16, and in the December issue. Learn how the industry is applying the latest technologies for production and development in deepwater and other challenging offshore environments; addressing key environmental and safety issues; and using lessons to make remote and associated offshore fields economically viable and accessible to the market.

<http://www.offshore-mag.com/webcasts/offshore/2014/12/offshore-top-5-2014.html>

New videos

Jack/St. Malo

Chevron presents three videos describing the development of the deepwater Jack/St. Malo project in the Gulf of Mexico. The Jack and St. Malo fields are within 25 mi (40 km) of each other in about 7,000 ft (2,100 m) of water in the Walker Ridge area, approximately 280 mi (450 km) south of New Orleans. The fields were co-developed with subsea completions flowing back to a single host, semisubmersible floating production unit located between the fields. Production began in December 2014.

<http://www.offshore-mag.com/topics/video-index>

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COMMENT



David Paganie • Houston

Drilling contractors feel effects of current oilfield economics

The current churn in oil and gas operations caused by adjustments to the new per barrel prices is reaching into all areas of the business. *Offshore* continues its examination of what 2015 promises that started with January's issue by looking at drilling contractors and the issues of fluctuation in rig demand, types of rigs in use, and the rates they can charge for a given rig. That makes *Offshore's* annual survey of drilling contractors more important than ever.

The effects of falling oil prices, and their impact on spending, are showing in the drilling contractor industry, though perhaps not as fully as on operator spending. But, the two are not without direct connection, and operator spending is headed downward in 2015, according to budget reports. A number of newbuild rigs are expected to be available this year, but the day rates on those and on existing equipment are dropping.

It is the older and lower capacity rigs that are expected to be hit first, and as many as 140 rigs may be taken out of service in the next few years. Another immediate concern is the number of existing and expected newbuild rigs currently without contracts.

The strongest sector for drilling contractors in 2014 was the jackup rig demand, and jackups account for the majority of new rigs that will become available in the next couple of years. Day rates for jackups have declined, but not as much as the rates for deepwater rigs.

In the midst of all this, *Offshore's* annual Top 10 Drilling Contractors survey shows quite a few changes during 2014. Senior Technology Editor Robin Dupre takes a deeper look into the drilling market and its future starting on **page 32**, and the results of the survey, supplied by IHS Petrodata, can be found there too.

One area of the world that has drawn attention for its drilling activity is Brazil, but circumstances there have confused the rig market as well. Petrobras, while not the only operator, is certainly the biggest. It has taken to the newbuild rig market in halting steps, starting and stopping a number of deepwater rig commitment plans. The good news is that Petrobras will have to drill a number of deepwater wells if it is to reach its targeted production increase for 2023. Justin Smith of IHS Petrodata provides a look at the current and future prospects offshore Brazil starting on **page 42**.

Meanwhile, oilfield technology development continues to carry on in the face of general market flux. *Offshore* has talked with two of the most noteworthy sources of expertise to see what has their attention. Bruce Beaubouef, *Offshore's* managing editor, talked to Mike Garding, CEO of OneSubsea, the creation of Cameron and Schlumberger, that targets the development and manufacture of subsea systems. That Q&A session is presented starting on **page 46**. Among a range of topics, Garding talks about the creation of OneSubsea and discusses what the venture brings to the market. He also talks at length about high-pressure/high-temperature development and multi-phase subsea compression.

Offshore's discussion with Neil Mackintosh, INTECSEA's new president, covered such topics as the latest trends in R&D, subsea engineering, data management, and the long-term prospects for technological advances. Mackintosh also addresses the challenges of doing business in the international arena; discusses the possibilities for improving recovery; and offers his thoughts on powering subsea equipment. His views are presented starting on **page 54**.

INTECSEA's Mackintosh also brings up the topic of big data and its management, and Manuel Terranova of Peaxy delves even further into that discussion starting on **page 58**. Terranova discusses the issues surrounding analytical tools for massive, and increasing, amounts of unstructured data. One big issue is simply "losing" data in the disconnect between how data is accessed and how it is stored. Terranova defines the principle parts of the big data dilemma and the business values of dealing with those issues.

David Paganie

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2014 May	\$151,000	\$499,934	\$735,000
2014 June	\$151,000	\$497,554	\$735,000
2014 July	\$151,000	\$501,231	\$735,000
2014 Aug	\$151,000	\$503,924	\$735,000
2014 Sept	\$151,000	\$499,614	\$735,000
2014 Oct	\$151,000	\$503,030	\$735,000
2014 Nov	\$151,000	\$507,601	\$735,000
2014 Dec	\$151,000	\$507,944	\$735,000
Jackup			
2014 Jan	\$30,000	\$130,352	\$361,000
2014 Feb	\$30,000	\$129,948	\$361,000
2014 Mar	\$30,000	\$130,592	\$361,000
2014 Apr	\$30,000	\$131,360	\$361,000
2014 May	\$30,000	\$132,688	\$365,000
2014 June	\$30,000	\$135,746	\$365,000
2014 July	\$30,000	\$135,922	\$365,000
2014 Aug	\$30,000	\$138,650	\$389,000
2014 Sept	\$30,000	\$141,812	\$389,000
2014 Oct	\$30,000	\$143,689	\$389,000
2014 Nov	\$30,000	\$144,288	\$389,000
2014 Dec	\$30,000	\$145,537	\$389,000
Semi			
2014 Jan	\$145,000	\$391,246	\$659,098
2014 Feb	\$145,000	\$389,970	\$659,098
2014 Mar	\$145,000	\$384,203	\$659,098
2014 Apr	\$145,000	\$389,871	\$659,098
2014 May	\$145,000	\$393,029	\$659,098
2014 June	\$145,000	\$396,024	\$659,098
2014 July	\$145,000	\$397,427	\$659,098
2014 Aug	\$145,000	\$395,136	\$659,098
2014 Sept	\$145,000	\$390,181	\$659,098
2014 Oct	\$145,000	\$392,117	\$659,098
2014 Nov	\$145,000	\$394,554	\$659,098
2014 Dec	\$145,000	\$393,000	\$659,098

Source: Rigzone.com

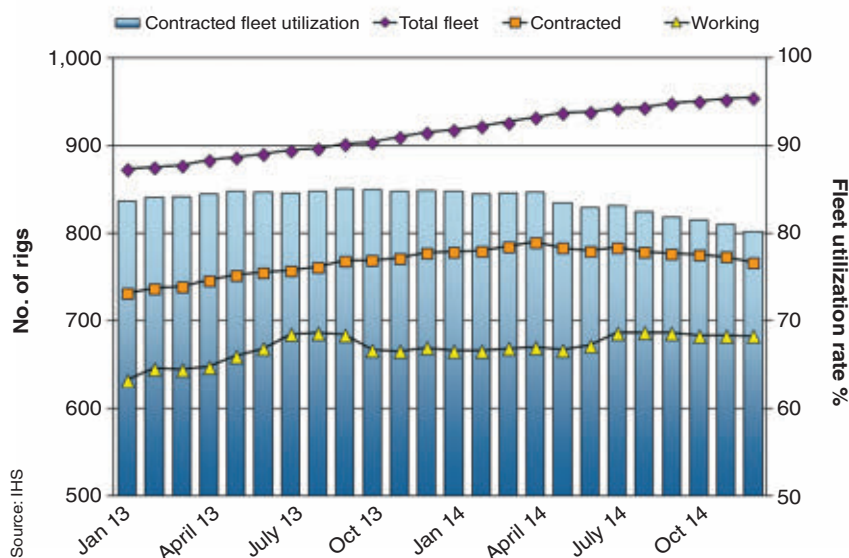
This month, Infield Systems looks at the prospectivity of Brazil's developments and forecast capex over the next five years. Altogether, capex on ultra-deepwater developments (at water depths of more than 1,499 m/4,917 ft) is expected to form 84% of offshore spend during the 2015-2019 timeframe. This compares with 60% of Brazil's total offshore capex over the previous five years.

Infield Systems expects about 73% of the capex to be directed toward developments within water depths of between 2,000 and 2,499 m (6,560 and 8,197 ft), which compares with the historical period where this water depth range held a still dominant, yet smaller 37% share. Key developments driving this trend include Sururu (ex-lara Horst) and Berbigao (ex-lara Northwest) at depths of 2,230 m (7,314 ft) and 2,222 m (7,288 ft), respectively.

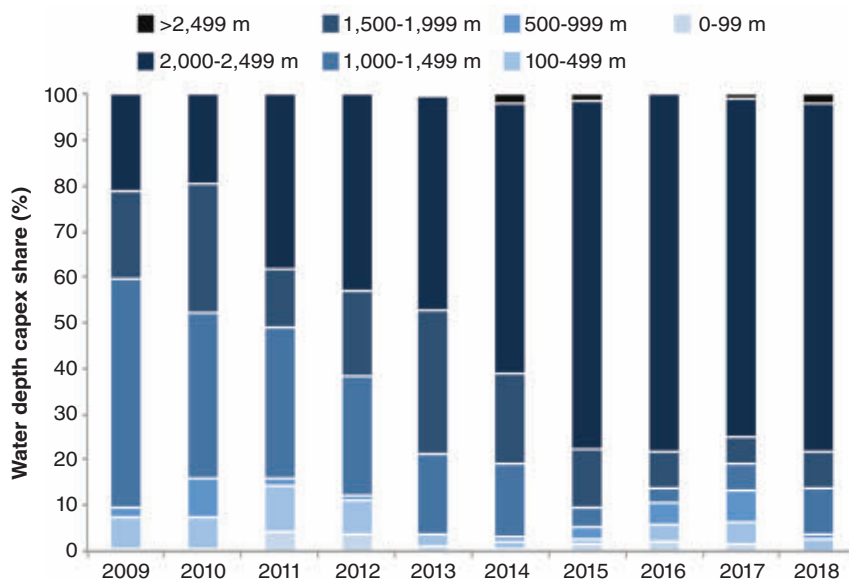
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January 2013 – December 2014



Brazil offshore capex by water depth 2010-2019



category Infield Systems expects key fields to include the Repsol/Sinopec-operated Gavea development, where capex is likely to be directed toward subsea infrastructure and a possible FPSO development. It also expects significant capex to be required by Petrobras' Iracema Sul field, at a depth of 2,500 m (8,200 ft) during 2015 and 2016.

In operator terms, Petrobras is forecast to account for a 96% share of total regional offshore capex during the period to 2019, with 10 additional operators anticipated to invest in Brazil's offshore sector. The most significant foreign operator active over the timeframe is likely to be Shell, with capex directed toward the Argonauta (BW, O-North, and O-South), Massa, and Ostra fields within the Parque das Conchas BC-10 area.

— Catarina Podevyn, Published Content Analyst, Infield Systems Ltd.



THINGS CAN GET UGLY AT DEPTHS OF 10,000 FEET WE SEE A BEAUTIFUL OPPORTUNITY

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Subsea intervention set to grow

Demand for subsea well intervention will remain high over the next five years, according to analysts Douglas-Westwood. Despite the oil price drop, they expect the number of subsea wells worldwide to rise by 41%, driven largely by an increase in ultra-deepwater developments. The fastest-growing market for intervention vessels and rigs will likely be Africa, while maturing subsea wells (more than five years old) will drive increased demand for workover units in North and South America and offshore Western Europe.

North America

Husky Oil expects first oil in mid-year from the South White Rose satellite extension offshore Newfoundland & Labrador. A Hibernia-formation well underneath the North Amethyst field is expected to enter production this summer, the company adds.

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Woodside Petroleum has completed a farm in to 20% of four licenses operated by BP offshore Nova Scotia. Water depths range from 500-3,600 m (1,640-11,811 ft). Exploration drilling is expected to start in 2017.

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Reliance Industries and PEMEX have entered a memorandum of understanding to jointly assess upstream opportunities in Mexico and internationally. They also plan to share their respective expertise in deepwater oil and gas E&P.

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McDermott International has won a second contract for PEMEX's Ayatsil field development in the Bay of Campeche. Two of its vessels will launch and install the 8,400-ton (7,620-metric ton) jackets and the 3,400-ton (3,084-metric ton) jacket for the Ayatsil-A drilling platform in 400 ft (122 m) water depth. Last summer McDermott delivered the eight-legged jacket and deck for Ayatsil-B.

Brazil

BG Group says operator Petrobras has submitted declarations of commerciality for three oil and gas accumulations in the Iará area in the presalt Santos basin, to be renamed Atapú West, Berbigão, and Sururu. All are in the BM-S-11 block, 250 km (155 mi) from the coast of Rio de Janeiro in waters around 2,270 m (7,447 ft) deep. Exploration started on the concession in 2008. Development will likely call for three new FPSOs.

• • •

Petrobras has clearance from Brazil's ANP to start up an early production system (EPS) on the Buzios oil field (ex-Franco area) in the presalt Santos basin. The seven-month program on well 2-ANP-1RJS is designed to provide information for optimizing the full pro-



Petrojarl I will be converted for use on the Atlanta field. (Photo courtesy Damen/Teekay Shipping)

duction system for the field, 200 km (124 mi) from the Rio de Janeiro coast in 1,600-2,100 m (5,249-6,890 ft) of water.

Another EPS is planned on the postsalt heavy-oil Atlanta field elsewhere in the basin in 1,550 m (5,085 ft) of water. Teekay Corp. has commissioned the Damen Shipyard Group's Schiedam shipyard in the Netherlands to upgrade the FPSO *Petrojarl I* for this task, with operations due to start during 1Q 2016 under a five-year charter to Atlanta operator Queiroz Galvão Exploração and Produção.

West Africa

African Petroleum has agreed to farm out 50% of its LB-08 license offshore Liberia to an unnamed London-based independent. Consultants ERC Equipose estimate potential resources at more than 2 Bbbl, and there is proven oil in an adjacent license.

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ExxonMobil has signed production-sharing agreements for two ultra-deepwater blocks in Côte d'Ivoire's portion of the Gulf of Guinea. Blocks CI-602 and CI-603 span a total area of 9,417 sq km (3,636 sq mi), in water depths of 3,000-4,000 m (9,843-13,123 ft).

• • •

Total has started harnessing associated gas from the shallow-water Ofon field in Nigeria's Offshore Mining Lease 102. The gas is compressed and exported via a pipeline to shore for feedstock for Nigeria LNG. Ofon came onstream in 1997 and early this year was producing around 25,000 boe/d of oil and gas. The Phase 2 investments – new and modified platforms – will eventually lift output to 90,000 boe/d, with gas production of around 100 MMcf/d.

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Lekoil and partner Green Energy have secured approvals for a well re-entry program at Nigeria's offshore Otakipo oil field. The company now expects production to start during the first half of this year, six months ahead of the previous target.

• • •

Eni has begun production from the 1.5-Bboe Nene Marine field in the Marine XII block, 17 km (10.6 mi) offshore Congo, 16 months after the initial discovery. The phased development will involve installation of production platforms and drilling of more than 30 wells with peak production of more than 140,000 boe/d (first-phase output is 7,500 boe/d). Water depth is 28 m (92 ft). Recently the company discovered more light oil and gas in the same block via a well on the Minsala Marine structure. In-place reserves could be 1 Bboe, of which 80% appears to be oil.

Southern Europe/Mediterranean Sea

Eni is taking a 70% operated stake in three unexplored permits offshore Portugal. The Gamba, Lavagante, and Santola concessions cover a total area of 9,100 sq km (3,513 sq mi). Portugal's government awarded all three to Galp Energia subsidiary Petrogal in 2007.

• • •

Italy's government was due to issue a verdict in January on the environmental assessment for the Ombrina Mare development offshore the Abruzzo region in the Adriatic Sea. Operator Rockhopper was hoping for a positive outcome, allowing it to negotiate the final award of the production concession. Late last year, the government passed new legislation through Italy's parliament that should speed up the planning process for various stalled oil and gas development projects.

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Croatia has awarded offshore licenses to five companies. (Map courtesy Croatian Hydrocarbon Agency)

Croatia's government has awarded licenses for 10 offshore blocks under the country's first licensing round. Marathon Oil, in partnership with OMV, secured seven blocks in the North, Central, and South Adriatic sectors. Croatian company INA-Industrija nafte gained two blocks in the southern sector, while Eni and partners Medoilgas (a subsidiary of Rockhopper) were awarded shallow-water block 9 in the prolific North Adriatic gas province. This includes the Ksenija discovery.

Israel's Anti-Trust Authority has decided against submitting a consent decree for the giant deepwater Leviathan gas field to the country's Anti-Trust Tribunal. Noble Energy and its partners in the field have requested a hearing with the Anti-Trust Authority. Noble Chairman Charles D. Davidson said the decision provided further evidence of Israel's uncertain regulatory environment.

Gazprom has agreed to acquire the combined 50% interest in South Stream Transport held by Eni, EDF, and Wintershall. The joint project company was formed to construct the offshore section of the South Stream gas pipelines through the Black Sea. Russia shelved the project late last year following a cooling of relations with the European Union.

Caspian Sea

BP has signed a production-sharing agreement offshore Azerbaijan with state-owned company SOCAR. They will jointly explore and develop potential prospects in the shallow-water area around the Absheron Peninsula. The contract area extends along the margins of the basin to the south of the peninsula in water depths of up to 40 m (131 ft).

Middle East

Iran Shipbuilding & Offshore Industries Complex (ISOICO) has started construction of two wellhead platforms for the latest development phase of the Hendijan oil field in the Persian Gulf. Production, which started in the 1960s, is currently around 25,000 b/d. ISOICO is also responsible for installation of offshore cables and pipelines.



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India

ONGC has two new discoveries offshore western and eastern India. In the Mumbai Offshore area, the company proved oil and gas via well WO-5-11, 160 km (99 mi) west of Maharashtra. In the KG basin off the east coast, the GD-11-1 well encountered gas in 812 m (2,664 ft) of water in block KG-OS-DW-III, with around 36 m (118 ft) of pay in the Pliocene section.

L&T Hydrocarbon Engineering has won a contract to build and install two wellhead platforms and subsea pipelines for ONGC's Vasai East project in the Heera-Panna-Bassein block of Mumbai Offshore. The operator is seeking to improve recovery from Vasai East where production started in 2008. All work, including modifications to existing facilities, should be completed by April 2016.

Asia/Pacific

EnQuest subsidiary EQ Petroleum Developments has contracted 2H Offshore to supply a lightweight conductor-supported platform for the Tanjong Baram field offshore Malaysia. The three-deck structure, to be built in Malaysia, will host two wells with a subsea template and will be linked via an 8-km (5-mi) flexible pipeline to the West Lutong-A facility. Installation is expected to be completed by mid-year.

...

CNOOC has discovered oil and gas in deepwater in the Lingshui 25-1 structure in a new province in the South China Sea. The well was drilled in 980 m (3,215 ft) of water in the northeast Ledong Sag in the Qiongdongnan basin. On test, it flowed 35.6 MMcf/d of gas and 395 b/d of oil.

In the eastern South China Sea, the company has started production from the Lihua 34-2 gas field via a single well tied into the Liwan 3-1 facilities. Output from Lihua 34-2 should peak later this year at 45 MMcf/d.

...

Indonesia's government has approved KrisEnergy's plan to develop the Lengo gas field in the Bulu production-sharing contract offshore East Java. The operator plans to install an unmanned wellhead platform with four development wells, with gas exported to shore through a 65-km (40-mi) 20-in. subsea pipeline. A successful appraisal well on the East Lengo accumulation could add a single-well tieback to the facilities.

The Husky-CNOOC Madura joint venture has contracted Bumi Armada Offshore and PT Armada Gema Nusantara to provide an FPSO for the Indonesia's Madura BD field development. The location is 65 km (40 mi) east of Surabaya and 16 km (10 mi) south of Madura Island. Operations on the field should start in late 2016.

Australia

Woodside Petroleum and its partners have agreed on a revised schedule for front-end engineering and design (FEED) for the Browse FLNG development off northwest Australia. They are looking to lower the overall cost. FEED should now begin in mid-year, followed by a final investment decision in 2016.

Additionally, the company has reached a deal to buy Apache's interest in the Chevron-operated Wheatstone LNG and the same company's 65% stake in the offshore WA-49-L block, which includes the recently onstream Balnaves oil field and the Julimar/Brunello oil/gas development.

Hess has signed a non-binding letter of intent with the North West Shelf (NWS) partners concerning development of the company's deepwater Equus gas discoveries in the WA-390-P and WA-474-P permits. Production would be sent to the NWS liquefaction facilities in Karratha for sale to customers in the Asia/Pacific region. ○



SUB-SEA VALVES



Oil price threatens UK's offshore future

Britain's government should take further action to ensure new North Sea projects go ahead, according to two reports. Analysts GlobalData claimed the recent reduction in the supplementary petroleum tax charge from 62%-60% would do little to stimulate investors if the oil price remains low. The generally accepted break-even price for a UK North Sea development is \$70/bbl.

Will Scargill, a fiscal analyst at GlobalData, called for more substantial changes to promote investment, not just in new fields but also in life-extension measures for producing fields. Otherwise, he suggested, existing UK offshore infrastructure may have to be decommissioned sooner.

Scotland's Energy Minister Fergus Ewing has put forward three main proposals for further reform of the North Sea taxation regime. He advocates the introduction of an investment allowance to provide support for higher-cost field developments; a phased reversal of the increase in the supplementary charge that the UK government introduced in 2011, which caused consternation in the industry; and an exploration tax credit to stimulate exploration and sustain future production.

Industry association Oil & Gas UK said it would respond to the Scottish government's request for feedback on the proposals. CEO Malcolm Webb added: "If the [UK] Treasury's new Investment Allowance is to have any impact it must be implemented by Budget 2015 at the very latest. However, with the oil price now at around \$50/bbl, it is becoming increasingly apparent that this measure is not enough and a significant reduction in the headline rate is required."

Late last year Sir Ian Wood, who led the UK government's review "Maximizing Recovery of the UK's Oil and Gas Reserves," said he believed the fortunes of the UK North Sea industry would revive by 2016. He pointed out that the UK's new regulator, the Oil & Gas Authority, has a charter to encourage exploration and new developments via improved collaboration with UK offshore operators. This is already having an impact on thinking on some new field developments, Sir Ian claimed, adding that the industry itself is undertaking a major efficiency review that should bring down costs per barrel significantly – hopefully by the second half of this year.

Chevron considers polymer for EOR project

One new UK project that appears to be going forward involves the addition of a new platform at Chevron's Captain complex in the Inner Moray Firth, dedicated to



Module installation on the Andrew platform. (Photo courtesy BP)

polymer injection for enhanced oil recovery via subsea wells. This would represent the fourth stage of development on the heavy-oil Captain field, which came onstream in 1997 through a wellhead platform linked to an FPSO.

Chevron has contracted Amec Foster Wheeler for a front-end engineering and design (FEED) study for the platform and brownfield tie-ins, while Wood Group Kenny is performing the FEED for the subsea trees, controls, and flowlines. If the project goes ahead and proves successful, it could lead to further use of polymer injection on other projects, Chevron said.

Also in the central North Sea, BP has started production from the Kinnoull field through a 28-km (17.4-mi) subsea pipeline bundle (said to be the world's longest) connected to the host Andrew platform. To accommodate Kinnoull's wellstream BP added a new 700-metric ton (771-ton) topsides processing module to the platform, which additionally underwent refurbishment to improve its integrity and operational facility. Trevor Garlick, the company's regional North Sea president, said this was one of the most challenging offshore projects BP had ever undertaken in the North Sea. Production from Andrew and Kinnoull should peak at 50,000 boe/d.

New Year boost to Norway's production

Three more field developments started up around the turn of the year in the Norwegian North Sea. ConocoPhillips began production from one of four pre-drilled wells at the new Eldfisk 2/7 (Eldfisk II) platform, 300 km (186 mi) from the southern Norwegian coast. Eventually the jackup *Maersk Innovator* will drill 40 new production and

water injection wells, designed to recover a further 220-280 MMboe from the Eldfisk field, according to analysts ScanBoss. The new platform has a design life of 40 years.

Statoil delivered first gas and condensate from the high-pressure/high-temperature Valemon field. The platform will be the company's first to be remotely controlled from shore, at the Bergen operations center. The facility will switch to normally unmanned status once development drilling is completed in 2017. At that point, 10 production wells are expected to be in service. The gas is sent via pipeline to the Heimdal platform for processing. This installation, which now serves as a gas hub in this part of the North Sea, was otherwise scheduled for closure in 2014. Statoil and its partners aim to recover 192 MMboe from Valemon.

Lundin Petroleum's Brynhild development is a subsea tieback across the median line to the *Haeuene Brim* FPSO serving Shell's Pierce field in UK waters. Eventually five wells will be drilled, with planned plateau production of 12,000 b/d.

Other new projects close to going forward include development of Statoil's Rutil gas/condensate discovery in the Gullfaks Rimfaks valley area of the North Sea. The company has submitted a plan for a \$617-million scheme involving installation of a subsea template in 135 m (443 ft) of water, with initially two gas producer wells. These will be connected via flowlines to Gullfaks A to the northeast, with production set to start in early 2017.

Wintershall expects to develop its Maria field in the Norwegian Sea via tiebacks to the Kristin, Heidrun, and Åsgard B platforms. A recent review has lifted the estimate of recoverable oil, gas, and natural gas liquids at the field by 40 MMboe to 180 MMboe. ●



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New rig tracking service sees modest decline in GoM activity

Gaffney, Cline & Associates (GCA) has launched a new weekly commentary and tracking service that reviews US onshore and Gulf of Mexico (GoM) rig activity. Based on the Baker Hughes rig count, it will highlight the reported week-on-week changes, and compare these to the evolving fall seen in 2009 during the financial crisis.

Figures released on Jan. 9, 2015, confirmed a fall of 60 in the onshore rig count, the largest weekly drop since early 2009. The count has now declined by 180 from a year high of 1,876 in November 2014 to 1,696.

The commentary follows two articles published by the company in the final quarter of 2014. The first reviewed the economics of the US shale oil development at a time when prices were testing \$80/bbl (<http://gaffney-cline-focus.com/oil-price-and-the-us-unconventional-boom>); the second focused on the economics of both unconventional activity and GoM activity as oil prices approached \$60/bbl (<http://gaffney-cline-focus.com/pain-likely-in-2015-but-deep-water-gom-should-be-better-placed-than-uncon>). The latter article noted US unconventional activity was likely to be the harder hit sector if prices continued to weaken into 2015.

GCA executive director and senior strategic advisor Bob George commented: "The drop is significant, and although it is not unusual to see drops at this time of year, it is now chasing down the 50% drop in oil price that has taken place since mid-2014. If it follows the trend seen in 2008-2009 following the financial crisis, the drop is likely to be very sharp indeed."

In contrast with the onshore rig count, GCA noted that the offshore GoM rig count is only showing a modest drop. Total rigs drilling have dropped from a high of 63 in August 2014 to 53 as of press time. However, rigs focused on oil drilling having dropped by only 2 to 42, and have actually showed a small increase since the start of the year.

Senior geoscientist and analyst Neil Abdalla added: "Price hedging for many companies has allowed them to continue selling their produced oil at prices far above current WTI trading ranges, often in the \$80-90 per barrel range. However these price hedges will run out heading into 2Q 2015, putting further pressure on activity."

"With oil prices having declined further in the opening days of the New Year, and now dipping below \$50/bbl on both sides of the Atlantic, we are instituting a weekly watch on both US onshore and Gulf of Mexico rig activity levels to assess how activity evolves," said Abdalla.

Chevron makes another Lower Tertiary deepwater discovery

Chevron Corp. says it has made a significant oil discovery at the Anchor prospect in the deepwater US Gulf of Mexico. Anchor is Chevron's second discovery in the deepwater Gulf in less than a year.

"The Anchor discovery, along with the previously announced Guadalupe discovery, are significant finds for us in the deepwater Gulf of Mexico," said Jay Johnson, senior vice president, Upstream, Chevron Corp.

The Green Canyon block 807 Well No. 2 encountered oil pay in multiple Lower Tertiary Wilcox Sands. The well, which was spudded in August 2014, is located approximately 140 mi (225 km) off the coast of Louisiana in 5,183 ft (1,580 m) of

water and was drilled to a depth of 33,749 ft (10,287 m). Appraisal drilling will begin this year.

"Chevron's leading position in the Gulf, where we are expecting further growth in the near-term from recent project startups at Jack/St. Malo and Tubular Bells, is further underpinned by this discovery," said Jeff Shellebarger, president, Chevron North America Exploration and Production Co. "We currently have five deepwater drillships operating in the Gulf, two of which are focused on exploration activities."

Chevron subsidiary Chevron U.S.A. Inc. is the operator, with a 55% working interest in the Anchor prospect. Anchor co-owners are Cobalt International Energy, Inc. (20%), Samson Offshore Anchor, LLC (12.5%); and Venari Resources LLC (12.5%).

Enbridge to build Stampede lateral

Enbridge Inc. has announced that it will build, own, and operate a crude oil pipeline in the GoM to connect the planned Stampede development, operated by Hess Corp., to an existing third-party pipeline system. The lateral pipeline is expected to cost approximately \$0.13 billion and be operational in 2018. The Stampede development was previously sanctioned by Hess and its project co-owners in October 2014.

Approximately 16 mi in length and 18-in. in diameter, the Stampede lateral will originate in Green Canyon block 468, located approximately 220 mi southwest of New Orleans. Water depth at the location of the planned pipeline is approximately 3,500 ft (1,067 m).

"The Stampede lateral is consistent with Enbridge's low-risk business model and furthers our objective to capture new deepwater Gulf of Mexico crude oil plays," said Greg Harper, president, Gas Pipelines & Processing, Enbridge Inc. "This project is an attractive investment opportunity for Enbridge and we are pleased to be working with Hess and the other producers on this development."

BSEE solicits oil spill response research projects

The Bureau of Safety and Environmental Enforcement (BSEE) issued a solicitation for proposals for oil spill response research projects, and will invest up to \$6 million to support these projects in 2015.

BSEE called for white papers focusing specifically on the following topic areas for proposed research covering oil spill response operations on the US outer continental shelf.

Topics should be limited to the following:

- Innovative methods to remove surface oil under arctic conditions
- Decanting recovered oil at sea
- Quantifying in-situ burn efficiency
- Innovative new uses of chemical herders to enhance oil spill mitigation efforts
- Develop an innovative dispersant spray drift model
- Determine the effect of various deep-ocean conditions on dispersant effectiveness
- Evaluate dispersant effectiveness of subsea applications in ocean brine pools.

The announcement, which came on Jan. 14, 2015, said that the deadline for submitting white papers was Feb. 9, 2015. So the deadline will have ostensibly passed by the time this issue hits mailboxes. However, more information can be found by searching for BSEE solicitation E15PS00027 on www.fbo.gov. ●



Chevron's Anchor well was drilled by Pacific Drilling's *Pacific Santa Ana* drillship (Courtesy Pacific Drilling)

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Trio formalizes well intervention alliance

Days into 2015, Helix Energy Solutions Group, Schlumberger, and OneSubsea executed agreements to create a non-incorporated alliance focusing on subsea well intervention.

In August 2014, the three intervention leaders announced an informal, non-binding letter of intent, saying that the agreement would leverage the trio's capabilities to provide a more holistic offering to customers, combining marine support with well access and control technologies.

In its statement on the signing, OneSubsea, a Schlumberger and Cameron company, said that the group will focus on the expansion of applications enabled by subsea well access technology. Additionally, it will concentrate on specific solutions for deep and ultra-deep-water basins and higher well pressure.

NPD processes plan for subsea development near Gullfaks

The Norwegian Petroleum Directorate (NPD) is reviewing the plan for the 34/10-53 S (Rutil) development in the Gullfaks Rimfaks Valley area in the Norwegian North Sea.

The regulator said that the licensees plan for a subsea development comprised of two simple gas production wells, with the potential to connect two more wells. The Norwegian operator placed development costs at NOK 4.6 billion (\$603 million).



The new well stream from the Rutil development will be tied-in to the existing Gullfaks A platform. (Photo courtesy Harald Pettersen - Statoil ASA)

Located in the western part of Gullfaks South, the well stream will be tied-in to the Gullfaks A platform, extending production from the asset, which was brought online in 1986. Two other platforms, Gullfaks B and Gullfaks C, comprise the Gullfaks field, located in block 34/10 of the Norwegian North Sea.

Operator Statoil estimates Rutil's recoverable reserves at 80 MM-boe. It will be located in a water depth of around 135 m (443 ft), 3,200 m (10,496 ft) below the seabed, with an estimated life span of 15 years. Production is scheduled to begin in 1Q 2017.

Ezra Holdings to provide Libra turrets

London Marine Consultants (LMC), Ezra Holding's FPSO turret design unit, was awarded a contract by Sembcorp Marine subsidiary Jurong Shipyard to supply an external turret mooring system for the Libra field's extended well test FPSO.

LMC's scope of work includes engineering, procurement, and construction of the complete external turret. The company will also design the mooring lines, analyze the risers, and provide engineering support for integration of the turret and swivel stack onto the FPSO at Jurong Shipyard.



Lewek Constellation, which will head to Julimar. (Photo courtesy EMAS)

The Libra oil field is a large, ultra-deepwater oil prospect located in the Santos basin off the coast of Rio de Janeiro.

Under a sub-contract from LMC, OneSubsea will manufacture an advanced swivel stack in Norway with six swivels, including two high-pressure gas injection swivels, in time for integration of the complete turret onto the FPSO in early 2016.

Chevron joins Viper Subsea JIP

Chevron is the latest major operator to join Portishead, UK-based Viper Subsea's joint industry project (JIP) to develop subsea integrity monitoring system V-IR. The system is used to identify and locate faults in remote subsea electrical distribution systems.

The project began in October 2013, through the Industry Technology Facilitator. In March 2014, BP and Total joined the project, with Shell coming onboard months later in May.

Under the agreement, Viper Subsea will carry out the research and development for the V-IR system, while the JIP partners will contribute funding and ensure the products are optimized for field use. Viper Subsea anticipates the system will be ready for a field trial later this year.

EMAS grabs Julimar contract

Apache Energy's Australian subsidiary has awarded EMAS AMC a \$105-million subsea construction contract for the Julimar project development, located 112 mi (180 km) west-northwest of Dampier in Western Australia.

The Julimar development, consisting of the Julimar and Brunello fields, is expected to supply gas to Chevron's giant Wheatstone LNG project. The scope of work includes project management, engineering, transportation, and subsea installation of an electro-hydraulic steel tube umbilical, two heavy-lift subsea manifolds, flying leads and jumpers as well as the procurement, fabrication, transportation, and installation of diverless tie-in spools.

The Julimar development project is expected to house more than 2.1 tcf (60 bcm) of sales gas from the Julimar and Brunello fields. The development project will consist of subsea gas production wells drilled from three drill centers and two satellite locations. Each well will be tied into a subsea manifold. The manifolds will be connected with flowlines and linked to the offshore Wheatstone platform through twin raw gas production lines.

Project management and engineering will begin immediately, with offshore execution scheduled to start in early 2016. EMAS AMC will use its flagship *Lewek Constellation*, a DP-3 heavy-lift and multi-lay deepwater offshore construction vessel.

In December 2014, Apache Energy announced that it was exiting the Wheatstone LNG project as part of a year-long divestment campaign. It agreed to sell its 65% interest in the WA-49-L block, which includes the Julimar/Brunello offshore gas fields, to Australia's Woodside Petroleum. The transaction is expected to close in 1Q 2015. ●

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More heavy lifting ahead

Last year's cargo volume increases were seen by most as the start of a trend growth, with this year pointing to better utilization factors across MPV/Project carrier fleets, according to Justin Archard, managing director, Asia Pacific and Oceania at SAL Heavy Lift Singapore.

"It is hard to say whether or not the oil price shock will have a sting in its tail. The oil and gas industry is laying off people across the board – staff and contractors alike. Project deferments have started. Down-

grading of global growth by the various global financial agencies was a regular feature in 2014; and today, the oil price correction may be the fillip that was needed to ignite growth. Uncertainty remains as the only constant and will, in my view, continue to dampen investment in capital projects and ships in the MPV/Project carrier segment. Oversupply has been a considerable factor in this segment for some time. This year, with its

uncertainties, is unlikely to be a catalyst year for significant newbuild orders, which is a good thing."

He stated that a further difficulty that shipowners face will be in freight rates. As cargo volumes trend upward, the fall in the oil price means lower bunker costs for owners, bringing a welcome margin against current market freight rates.



Justin Archard, managing director, Asia Pacific and Oceania at SAL Heavy Lift Singapore. (Photo courtesy Helix Media)

DOF Subsea wins GoM contracts

DOF Subsea has won several contracts for work in the Gulf of Mexico. The contract awards will give a utilization of the chartered-in vessels *Ross Candies* by four plus five months and *Chloe Candies* by about three months. The contracts will start this month, and the scope of work includes subsea installation, IMR, and survey work.

Bibby Subsea charters newbuild *Brandon Bordelon*

Bibby Subsea has signed a three-year contract with Bordelon Marine for use of the newbuild ultra-light intervention vessel *Brandon Bordelon*. The vessel is expected to operate primarily in the Gulf of Mexico.

The purpose built, high-specification vessel is designed for a variety of operations, including maintenance and repair, light construction, survey, and inspection work.

Seadrill acquires *West Polaris* drillship

Seadrill has exercised a purchase option for the ultra-deepwater drillship *West Polaris* from Ship Finance International.

The seller acquired the vessel in 2008 and subsequently agreed on a bareboat charter to Seadrill with purchase options starting in 2012. The purchase option price is \$456 million and the total consideration payable to Ship Finance is \$108 million.

Keppel to convert second vessel for FLNG role

Keppel Shipyard has confirmed a contract from Golar LNG subsidiary Golar Gimi to convert a second Moss LNG carrier, the *GIMI*, into a floating liquefaction vessel (FLNGV). The value of the order is about \$705 million. The work scope is similar to the conversion of the carrier *HILLI*, awarded six months ago.

Keppel Shipyard will be responsible for the design, detailed engineering and procurement of the marine systems, and all conversion-related construction services. It will re-engage Black & Veatch, its partner in the *HILLI* conversion, for design, procurement, and commissioning support for the topsides and the liquefaction process, us-

ing its established PRICO technology.

Full construction activities on the *GIMI* will start once Keppel Shipyard receives a notice to proceed, probably by November. The converted Golar Gimi FLNGV is expected to be delivered around 33 months after the notice to proceed.

McDermott vessels to install second Ayatsil platform offshore Mexico

McDermott International will install the jacket, deck, and piles for PEMEX's Ayatsil-A drilling platform in the Ayatsil field in the Bay of Campeche offshore Mexico.



The Ayatsil-A jacket on board the *Intermac 600* transportation and launch barge. (Photo courtesy Business Wire)

The *Intermac 600* will launch the 8,400-ton (7,620-metric ton) jacket and the heavy-lift *Derrick Barge 50* will complete installation of this structure, the 3,400-ton (3,084-metric ton) deck and other platform components in waters 400 ft (122 m) deep. The total weight of the facility is around 15,800 tons (14,333 metric tons).

Ayatsil, PEMEX's largest discovery to date, is expected to boost Mexico's oil production by 150,000 b/d.

Last summer, McDermott delivered the Ayatsil-B eight-legged jacket and deck.

Damen to convert *Petrojarl I* for Atlanta offshore Brazil

The Petrojarl I LLC consortium has commissioned Damen Shiprepair Rotterdam (DSR) to upgrade the FPSO *Petrojarl I*.

Owner Teekay Petrojarl plans to re-deploy the vessel, built in 1986, from the North Sea to the postsalt Atlanta heavy-oil field in the Santos basin offshore Brazil.

Queiroz Galvão Exploração e Produção (QGEP) has contracted the floater to serve as an early production system on the field in a water depth of 1,535 m (5,036 ft).

DSR's upgrade scope covers basic engineering, detailed and construction design and engineering, workshop drawings, interface engineering, marine and process equipment procurement, fabrication, construction, corrosion protection/coating, transport and lifting operations, integration, mechanical completion, performance testing, and commissioning activities.

The company will also perform upgrades and modifications related to the marine, hull, and life extension classification program; conversion of the process systems (separation train and produced water topsides) and integration; and Brazilian compliance procedures.

Under a partnership with DSR, Frames in Alphen aan den Rijn, the Netherlands will handle design and fabrication of the new topsides skids, while Alblasserdam-based Nevesbu is responsible for marine and topsides integration engineering.

Petrojarl I is expected to arrive at the shipyard next month and remain there for around one year. ●

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Industry advances dual gradient drilling technologies

A new dual gradient drilling technique was featured at the Gulf Coast Section SPE General Meeting. Successfully tested in the US Gulf of Mexico, the Norwegian North Sea and offshore Cuba, the technique holds promise for future development of areas characterized as having severe drilling challenges.

One such well, offshore Cuba, had a highly permeable carbonate section that created extreme lost circulation issues, defying all prior attempts to penetrate it to test promising strata lying below it. The operator reported both good news and bad news. The good news was that it was able to successfully penetrate the previously undrillable lost circulation zone using the new technique. The bad news was that the targeted reservoir was dry. Nevertheless, valuable learnings were derived from the event which have been implemented and tested on a subsequent well in Norway's Troll field.

A bit of history

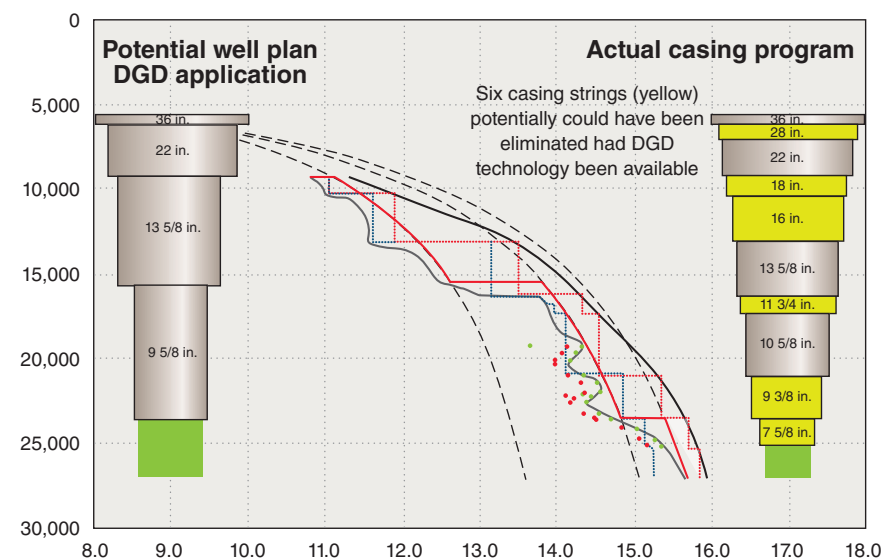
Two techniques are under study to successfully and safely drill those sections with tight drilling margins. The first, lately implemented by Chevron, follows the lead demonstrated by Diamond Offshore's semisubmersible *Ocean New Era* in conjunction with the DeepStar consortium. In 2001, the *Ocean New Era* drilled a test well using the seabed mud lift (SML) concept, which essentially placed a mud pump on the seabed to lift mud returns to surface in a dedicated conduit instead of conveying them in the riser-drill pipe annulus. The principle is simple. Imagine that the hydrostatic pressure of thousands of feet of heavy drilling fluid in the riser is removed—as if the rig were sitting on dry land. Since many shallow beds just beneath the mudline cannot withstand the hydrostatic pressure of a long column of heavy drilling fluid, the technique immediately enables safe drilling of those shallow unconsolidated sediments. It also reduces the need for multiple protection casings or liners, each one reducing the borehole diameter. The effect of multiple strings could be when finally the target formation is reached, the casing would be too small to accommodate the completion hardware.

DeepStar proved the concept. Static bottomhole pressure and equivalent circulating density could be controlled to maintain a safe drilling margin without exposing unconsolidated sediments to fracture pressures or risking influx of formation fluids.

Chevron has equipped one of its contracted drillships, the *Pacific Santa Ana*, to enable it to perform dual gradient drilling using the SML technique.

A different approach

Believing that a technique that eliminates the SML module would be more flexible and more



Many protective casing strings can result in a bottomhole diameter too small to accommodate the completion (right). The dual gradient approach allows TD to be reached safely and with fewer casing strings (left). (Courtesy Chevron)

easily adapted to any rig design, Transocean developed the continuous annular pressure management technique. With no subsea modules involved, all equipment can be continuously monitored and maintained. Basically, on the rig, the mud returns are separated in a centrifuge to segregate the weighting material, effectively diluting the mud. The heavy mud is returned to the suction pit where it can be circulated down to the drill bit. The light component is pumped down to the mudline, where it re-enters the riser and blends with the returning mud from the bit, thus reducing hydrostatic pressure at the seabed. The effect is not as great as that produced by the SML technique, but it is sufficient to permit safe drilling of tight drilling margins. Transocean maintains that its system can be deployed faster to any of the drilling rigs in its fleet. All rig equipment is modularized and can be installed and activated quickly using rig equipment and personnel.

A new approach

Under the sponsorship of Statoil, a new technique for managed pressure drilling has been introduced. Called EC-Drill, it promises to allow the quick, safe drilling of tight margins. The system can apply (or withdraw) hundreds of psi of mud pressure in a few minutes allowing equivalent circulating density (ECD) to be almost instantly controlled while drilling, or during connections and subsequently, when the rig pumps are re-engaged. At the heart of the new system is a subsea pump module connected to the riser on a special riser joint several hundred feet below the sea surface. Three disc pumps in series pull drilling fluid returns from a port in

the riser and route them to the surface in a mud return line using an unused slot in the riser system. The rig pumps operate as usual, supplying weighted drilling fluid to the bit. The ECD, however, is controlled by adjusting the level of drilling fluid in the riser using the disc pumps. Very precise sensors provide pressure data at the EC-Drill riser joint. They have the capability of instantly detecting, and quantifying an influx (kick) or a loss (formation breakdown). This gives the operators almost immediate response capability to mitigate ECD fluctuation. The mud level in the riser annulus moves up and down like the fluid in a manometer maintaining the desired bottomhole pressure. How deep the EC-Drill riser is deployed determines the pressure range under the system's control. Recent experience using a special riser deployed at about 1,000 ft (304.8 m) below the surface gave roughly a 700 psi (48.3 bar) range.

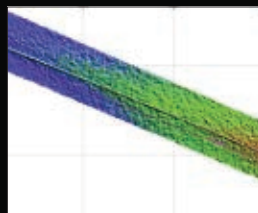
An operations module in the driller's cabin provides easy-to-read and interpret graphical readouts and the most critical data are remote to the driller's console. The downhole pumps, valves, and sensors are fed by an umbilical cable deployed from the surface. A 1.35 MW power supply with variable speed drive powers the downhole system. Safety is assured; if any of the EC-Drill system components fail, the rig pumps can take over and the principle mud pressure barrier maintained. Drilling can continue normally using the rig's circulation system.

To date, four wells have been drilled using the EC-Drill system and two more are under way. The technique has been vetted and approved by Norway's North Sea regulatory authorities and has received DNV certification. ●

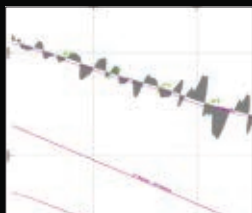
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NPD sheds new light on Barents Sea geology

Investigations conducted by the Norwegian Petroleum Directorate (NPD) have thrown new light on the geology of Svalbard and the northern Barents Sea. The studies contradict the hypothesis that sand and shale deposited around the Arctic archipelago derive from an early “microcontinent” called Crockerland.

“Nothing suggests that such a land mass ever existed,” said Bjørn Anders Lundschieen, project coordinator.

Initial drilling off Kong Karls Land in 2015 indicates the sand around the islands originated to the southeast from highlands and mountains in Russia’s Ural. Subsequent expeditions in and around Svalbard resulted in NPD Bulletin No. 11, which was issued at the start of this year.

The report says Triassic oil-prone source rocks were first deposited in the southernmost Barents Shelf and have sourced several hydrocarbon traps, such as the Kobbe formation reservoirs of the Goliat field. In the Svalis Dome area these source rocks (the Steinkobbe formation) were established at least as early as in latest Olenekian (late Spathian) and span the entire Anisian. In the northern Barents Sea and on central and eastern Svalbard the correlative organic rich shales of the Botneheia formation were deposited throughout the Anisian and Ladinian.

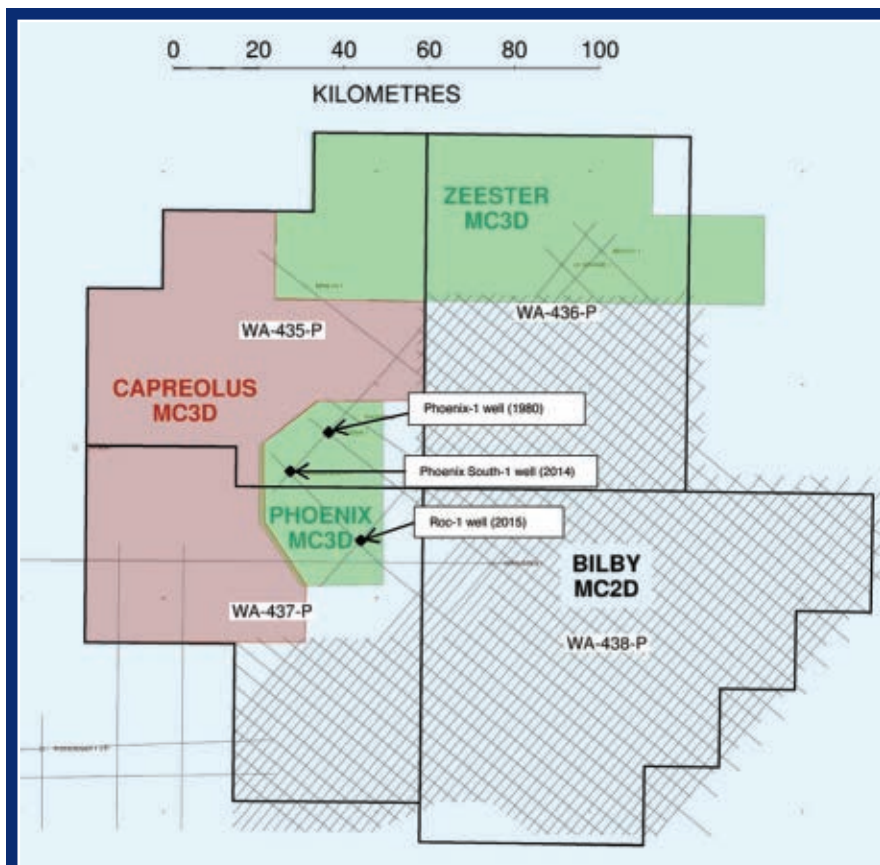
Triassic reservoir rocks were also first established in the southernmost Barents Shelf, in the Anisian, when the coastal sandstones of the regressive Kobbe formation were deposited. The regressive trend continued during the deposition of the Snadd formation from the Ladinian time close to the Norwegian mainland and in the Svalis Dome and Sentralbanken High areas. The prograding deltaic sediments of the Snadd formation first reached the northernmost Barents Sea (off Kong Karls Land) and Svalbard in the Carnian. These regressive sandstones represent the main reservoir potential in large areas of the Barents Sea as seen by seismic interpretation.

This evolution is favorable for Triassic play models with Lower and Middle Triassic source rocks of the Steinkobbe and Botneheia formations overlain by paralic sandstones of the Kobbe, Snadd, and De Geerdalen formations.

2D seismic survey set offshore Namibia in Walvis basin

Nabirm Energy Services is set to undertake a 2D seismic survey in license block 2113A in the Walvis basin offshore Namibia.

The proposed area of the 2D seismic survey will be approximately 1,050 km (652 mi) long, consisting of low-density spaced survey lines spanning approximately 2,500 sq km



Polarcus has started acquiring multi-client 3D seismic data offshore Western Australia in the Phoenix area in a venture with Carnarvon Petroleum Ltd. The survey uses two high-performance 12-streamer Polarcus vessels, *Polarcus Amani* and *Polarcus Asima*, operating in tandem to maximize production. The program, called Capreolus MC3D, is in exploration permit areas WA-435-P, WA-436-P, WA-437-P, and WA-438-P. This joint venture expects to license 5,100 sq km (1,969 sq mi) of Capreolus 3D in the area shown on this map. The first 3D seismic acquisition in this area (the Phoenix MC3D) covered 1,100 sq km (425 sq mi) and was acquired in late 2010/early 2011. In late 2011/early 2012, a second 3D seismic acquisition program (the Zeester MC3D) acquired an additional 3,854 sq km (1,488 sq mi). The current joint venture partners have recently agreed to license this data following the success of the Phoenix South-1 well. A new 2D seismic acquisition program (the Bilby MC2D) will acquire modern 2D seismic data over most of the remaining acreage. The data acquisition phase is estimated to last four months, with the data being processed through a pre-stack depth migration routine by DownUnder GeoSolutions in Perth. Final data products are expected to be available in 2Q 2016.

(965 sq mi). Water in the proposed survey area ranges between 50 and 150 m (164 and 492 ft) in depth, and the distance from shore ranges between 10 and 50 km (6 and 31 mi).

CCA Environmental (pty) Ltd. will examine the baseline environmental conditions of the survey area to evaluate any potential impacts of the proposed seismic survey and to present the findings in an environmental impact assessment and to ensure no negative impacts.

Geosciences business report

At its Capital Markets Day held in Oslo, Norway, TGS said that it expects multi-client investments of \$420 million plus an additional capex of \$15 million this year. The target

revenues for 2015 total \$750 million.

The 4Q 2014 results are expected to reach a record-high for the company of \$298 million, or 10% more than 4Q 2013. The full-year revenues are expected to be \$915 million.

CGG has reported a record in multi-client sales for a single quarter during 4Q 2014. The company also has said that its vessel production rate tallied 92% for the quarter.

It not only received client commitment for the StagSeis Gulf of Mexico program, but also sustained multi-client sales in the North Sea, West Africa, and Latin America over the time frame.

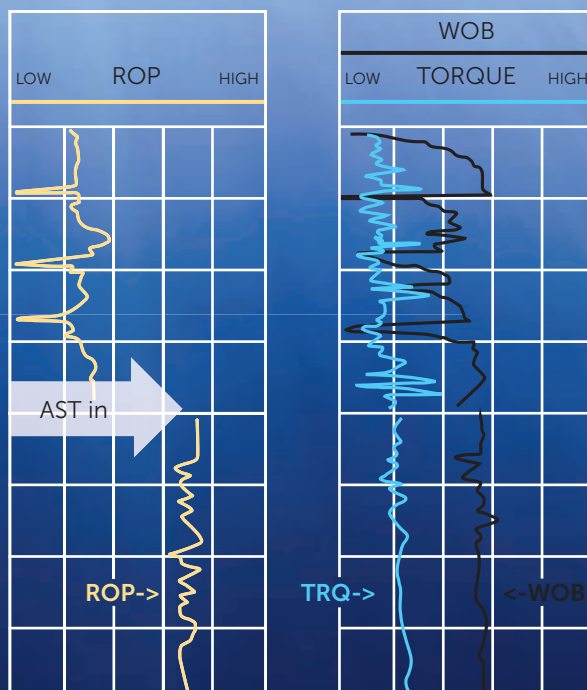
Jean-Georges Malcor, CEO of CGG, said the performance was positive news in light of the drop in oil prices. ●

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Offshore drilling market faces an uncertain year

Total number of rigs being built still growing, but lower than last year

Discoverer Clear Leader
(Photo courtesy Transocean)

Robin Dupre
Senior Technology Editor

As a slew of newbuild drilling rigs hit the market in 2015, coupled with oil companies slashing budgets due to surging costs, it is speculated that the industry will witness an acceleration in the rate of marginalization of legacy assets.

"We saw spending from operators dry up in 2014," said Terry Bonno, senior vice president, marketing, Transocean, in a recent interview with *Offshore* magazine. "And then the budget results just came out, so I am not sure if we fully understand, yet, the impact on the global universe, but initial signs are that they are reducing their budgets for 2015."

"If you are looking at the overall rig fleet right now, you are seeing a bit of idling of rigs in all of the asset classes," Bonno added. "In our last fleet status report that was filed, we stated that we intend to scrap some of our lower specification units. Our theme for 2015, once we saw this difficult market coming, is to fight for utilization."

As most drilling companies that have rigs without a contract, today, are idling or cold-stacking these rigs, it is estimated that around 140 rigs are heading toward retirement over the next few years as the industry makes way for the newbuilds scheduled for delivery by the end of the decade. Around 360 rigs that are in the current market fleet are more than 30 years old and must be retired at some point.

Moreover, analysts estimate that around one-third of the new vessels that are in the pipeline for the next three to four years still have no drilling contracts. Rune Magnus Lundetrae, CFO of Seadrill, was quoted by Reuters in September 2014 to say that the market could need another 24 months to bottom out, though for older assets, rates were already near the bottom and he expected older vessels to be idled.

Cinnamon Odell, senior analyst-rigs, IHS Petrodata, told *Offshore* that "we expect to see fewer orders for new rigs, as well as some cancellations and/or deferment of rigs that have already been ordered from yards."

Top 10 offshore drilling contractors by number of rig managed (total rigs includes rigs under construction).

Company	Total Rigs	Working	Under Construction	US GOM	Latin America	NW Europe	West Africa	Middle East	Asia/Pacific	Rest of World
Transocean	86	52	7	13	6	19	14	0	26	8
Ensco	72	53	7	17	4	12	9	12	16	2
Seadrill	62	37	12	6	15	0	11	6	22	2
COSL	46	39	3	0	3	3	0	4	36	0
Diamond Offshore	41	24	2	9	16	5	2	0	7	2
Paragon Offshore	40	26	0	3	14	8	5	9	1	0
Shelf Drilling	39	30	2	0	0	0	5	16	17	1
Hercules Offshore	35	15	1	24	0	1	3	3	4	0
Noble	35	24	1	11	2	3	1	8	7	3
Rowan	34	25	1	9	2	6	1	10	5	1
Top Ten Total	490	325	36	92	62	57	51	68	141	19
Entire Fleet	1188	680	180	121	219	101	96	167	414	70
Top Ten % of Total	41.2%	47.8%	20.0%	76.0%	28.3%	56.4%	53.1%	40.7%	34.1%	27.1%

Notes:

- Rig Types: Arctic, drill barges (but not inland barges), drillships, jackups, semisubmersibles, submersibles and tender-assists.
- Rigs en route between regions are shown in the destination region.
- Latin America includes all South America, Central America, Caribbean and Mexico.
- Seadrill numbers do not include rigs owned and managed by North Atlantic Drilling.

Data courtesy of IHS. All data as of December 31, 2014.



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For instance, Atwood Oceanics filed its fleet status report last month, announcing that it would postpone the delivery of two newbuild vessels. The *Atwood Admiral* will not be delivered until September 2015, while the *Atwood Archer* is delayed until June 2016. "More contract drillers are exploring this option to ease the pressure to sign contracts at less than ideal day rates," Odell said.

Seadrill's Lundetrae sounded an even more pessimistic note, with hope for the not-too-

distant future. "The market is going to be bad this year, it is going to be worse next year, then it will stabilize," Lundetrae told Reuters last September.

Day rates for the most advanced ultra-deepwater rigs peaked around \$650,000 last year and are now down in a range of \$375-\$500,000, though contracting activity by oil firms has slowed to a trickle, making it hard to establish the actual market rate, executives told Reuters.



West Vela
(Photo courtesy Seadrill)

Rates for jackups have also fallen, though not as much as deepwater floaters, with executives predicting rates at around \$160,000 per day, down from rates around \$225,000 at its peak.

The jackup market helped drillers last year, with Saudi Aramco, PEMEX, Oil and Natural Gas Corp., and China National Offshore Oil Corp. consuming around 30% of the business with return contracts. But this year, there are 138 jackups on order or under construction. The current rig order book, with deliveries scheduled for 2015, are at a plus or minus of 60: 20 to be delivered in the first half of the year, and 40 for delivery in the second half. This information was offered by John T. Rynd, CEO and president, Hercules Offshore, at a recent Wells Fargo Energy Symposium presentation.

"All of these orders are being financed by a shipyard, but the builder has full recourse back to the shipyard and can refuse to take delivery," Rynd observed. "I assume all will be built with delivery being pushed back to 2019. Thus far, we've seen four jackup contracts get canceled, so let's see what happens in the near future."

This is a temporary phenomenon, says John Breed, director, investor relations and corporate communications, Noble Corp. Breed offered remarks at the Capital One Securities 2014 Energy Conference. "This business will balance itself out, with part of that being because of attrition," Breed commented. "It is a word that we do not spend a lot of time talking about in this business, but I think it will become a real issue as we go forward because of the average age of the fleets."

Transocean's Bonno agrees with that sentiment. "If older rigs can't economically remain as part of the core fleet or in the global fleet, I think a decision has to be taken on attrition,"

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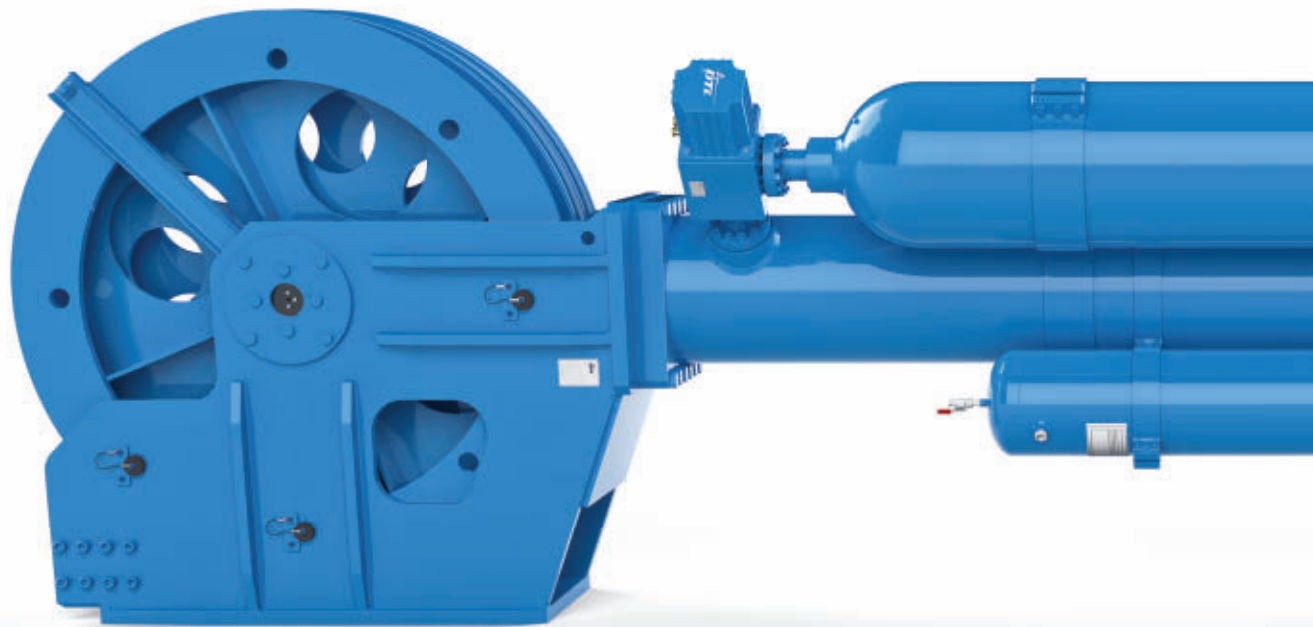
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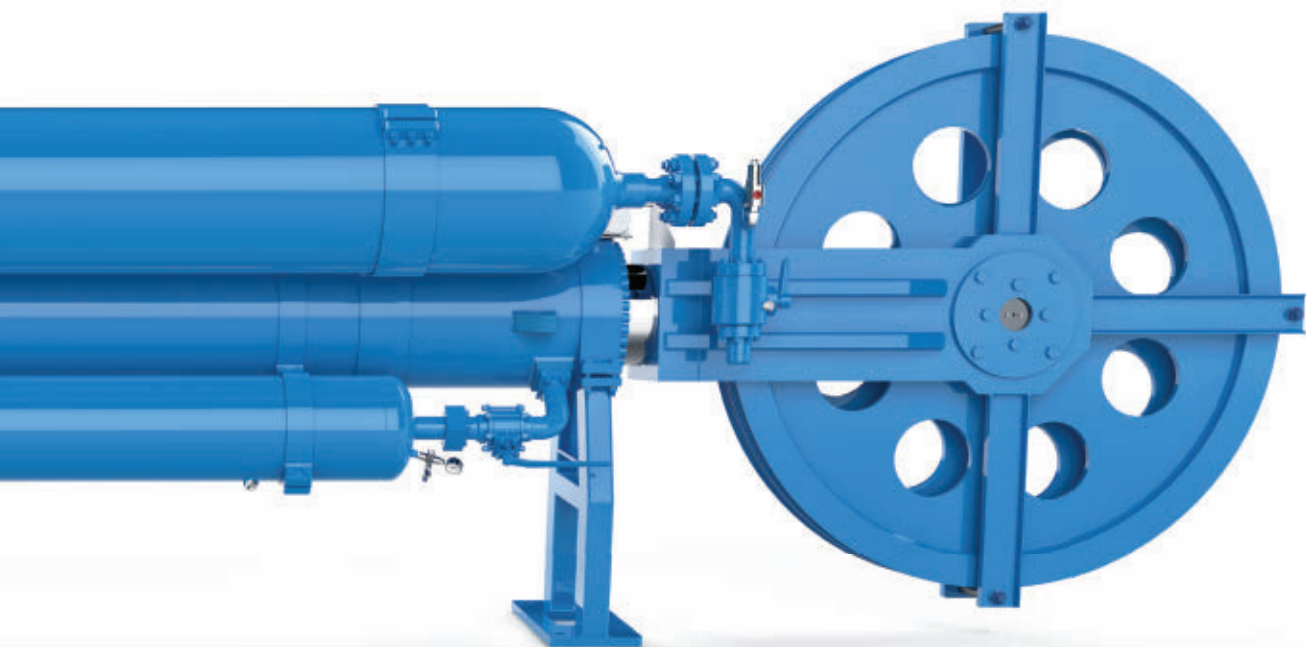
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she said. "As we move forward in the over-supplied market, certainly attrition is going to be a factor in bringing this market back into balance. This is what the cycle is going to be marked for: reassessing the current rig fleet."

As for geographical areas, it is predicted that offshore Mexico and Brazil could pick-up some of the slack while drilling in the North Sea, Africa, and the Gulf of Mexico could slow down even further.

...

The names on the accompanying list of the Top 10 drilling contractors by number of rigs are similar to those presented last year, with a few noted changes. Noble, No. 2 last year, dropped to ninth place as it now possesses fewer rigs, due to its recent spin off of Paragon Offshore, a standard offshore drilling company. Paragon has entered the list at No. 6, as well as COSL Drilling Europe AS and Shelf Drilling, a private company headquartered in Dubai.

The number of rigs under construction has continued to grow, but is lower than last year's numbers, for a total of 36. This growth has been driven by a number of new high-specification jackup orders.

Now that commodity prices have declined, the industry will see a direct effect on the jackup market, which is a different experience from last year's overview. "We don't think that the jackup demand is going to help keep rates like it did in 2014, especially if the commodity prices stay low," Odell observed. "Further impacting the problem for this market is the influx of rigs that are scheduled for delivery. There are over 70 jackups that are scheduled for delivery in 2015 alone."

If all of those jackup rigs actually come out on the market on time, with commodity prices so low, that would be a huge problem, Odell comments. "Rates would plummet. These newbuilds would either be canceled or be delayed. There's not a demand in the market for an-

other 70 rigs."

As for what to expect with the newbuild contracts and/or orders, Odell states that as delivery dates approach, drillers are going to be cautious, resulting in a case-by-case basis. As the year progresses, the industry will have a more defined picture of what to expect going into 2016.

While the ultra-deepwater arena typically has weathered the storm in past down cycles, it is predicted that this will ring true again, near-term. "We're not expecting for the UDWs to be cold-stacked this year or next," she added. "Those rigs will likely have either small gaps or work down specifications. By that, I mean the rigs that are capable of working in water depths greater than 7,500 ft [2,286 m]."

As for floaters, many already have contracts in hand, but the industry will expect to see re-negotiation of the daily rate or terms adjusted to make it more palatable for the operator and contractor. For those coming out of the shipyard without contracts, expect to see some time gaps, but they will not stack them right away, Odell says.

...

Transocean, which came in at number one on the list, recently provided an update on its activities. In conference calls with analysts last quarter, Transocean officials stated that the company's new-build program remains on track, with near-term drillship deliveries backed by long-term contracts at "attractive" day rates.

Transocean received encouraging interest from customers for five of its speculative jackups that are under construction. "We will continue to pursue corporate contracts for the 2016 and 2017 deliveries," said Steven Newman, Transocean's president and CEO.

As for the company's non-core fleet, Transocean intends to scrap cer-



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tain cold-stacked rigs, recognizing their limited potential to re-enter the market, while continuing to assess the competitiveness of non-core assets on a case-by-case basis with the likelihood of retiring additional rigs.

The company announced it signed a one-well extension on the *Discoverer Enterprise* drillship with a rate of about \$398,000 per day. The agreement also includes four, one-well pricing options.

Bonno added in the analyst call that UDW day rates and utilization have remained under pressure while customers continue to focus on short-term cash flows and capital allocation. "We are pleased to see the supply of available rigs decline as a result of the recent and expected announcement of contract awards in Brazil, US Gulf of Mexico and West Africa," she said. "However, we continue to expect challenging conditions as we work to contract our rigs in an oversupplied market, and are likely to experience inter-contract idle times and significant competition on the limited tendering opportunities available."

Bonno added that deepwater and mid-water markets remain weak as higher-specification units compete for lower specification jobs, with the expectation that this will drive older, less capable units out of the market and additional units will be retired.

The company also expects Petrobras to announce the Libra field development tender winners, which could involve up to three Transocean rigs in 2015.

As for other geographical areas, in 3Q 2014, the company secured a contract for its deepwater semisubmersible *Jack Bates* in Australia, with hopes of securing three long-term tenders in India in the very near future for rigs capable of drilling in 5,000 ft (1,524 m) of water.

Midwater and harsh environments tendering activity also remained slow in 3Q 2014, and Transocean expects it to remain that way in 2015. "The recent contract terminations and suspensions by Statoil in Norway, the Russian sanctions, delayed programs, and limited programs overall

continue to challenge the UK and Norwegian market," Bonno commented.

The *Transocean Spitsbergen* recently received a contract suspension notice from Statoil, reducing the day rate by about 25%. The company recently secured a four-year contract for the *Transocean Leader* in the UK. The rig will move south upon completion of her contract in Norway. The rate is favorable, say Transocean officials, as the first three years will be paid at a rate of \$335,000, and the last year will be at a rig market rate between \$335,000 to \$365,000 per day.

In October 2014, Transocean signed a contract to return *Transocean Amiante* to work on a one-year charter in Libya at a rate of \$335,000 per day.

Transocean also extended the contract for *Transocean Honor* for one year at a rate of \$194,000 per day for work in Angola, but it expects new fixed rates to decline for high-spec jackups over the next 12 months.

...

In November 2014, Seadrill Ltd. entered into an agreement with Seadrill Partners to sell all of the ownership interest in the entities that own and operate the drillship *West Vela* to Seadrill Capricorn Holdings LLC, Seadrill Partners' 51%-owned subsidiary.

The *West Vela* is a sixth-generation, dynamically positioned drillship delivered from the Samsung shipyard to its current customer, BP, in November 2013. The *West Vela* is expected to carry out operations in the US GoM until the end of its contract in November 2020.

The implied purchase price of the acquisition is \$900 million, less \$433 million of debt outstanding under the existing facility financing the *West Vela*. Based on Seadrill Partners' 51% ownership of Capricorn Holdings, its portion of the net purchase price after debt will be \$238 million.

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Noble Corp. predicts that 2015 will pose a challenge for the drilling industry, but officials deem the company to be well positioned to move forward during this down cycle.

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"We believe younger fleets are preferred in this business as we go forward," said Noble's John Breed, "because they will have limited exposure to the market meaning utilization will remain high and they will get the best rates that the market is paying at the time. Ultimately, the company will receive a premium evaluation as the result of our new fleet."

As for its fleet going into 2015, there are several secured contracts, but a few rigs will sit idle:

- *Noble Paul Wolff* has sat idle in a shipyard in Singapore since late October 2014, and the company plans to leave it idle in 2015. Noble states that it is undergoing regulatory survey and repair and maintenance projects.
- *Noble Homer Ferrington* has been cold-stacked and will not be active in 2015.
- *Noble Max Smith* has sat idle in a shipyard in Singapore since late October 2014 and it is currently available.
- *Noble Paul Romano* is currently in the Canary Islands and is available.
- *Noble Sam Hartley* will remain idle in 2015.
- *Noble Tom Prosser's* contract is expected to begin in 1Q 2015, following transit from Singapore to Australia, and upon successful acceptance testing by Apache. The rig will stay with Apache until 2Q 2016 at a day rate of \$203,500.
- *Noble Lloyd Noble* is under construction at the Jurong Shipyard. Statoil contracted the rig for four years and it is anticipated to commence during 3Q 2016. The ultra-high specification jackup is an enhanced version of Statoil's "Cat J" specifications, and will be designed to operate in water depths of up to 150 m (492 ft) in harsh environmental conditions, with a maximum total drilling depth capacity of 10,000 m (approximately 33,000 ft).

• • •

In its 3Q earnings call, Hercules Offshore stated that it had cold-stacked four jackups: *Hercules 202*, *Hercules 204*, *Hercules 212*, and *Hercules 213*.

It is expected that the *Hercules 208* will come off the contract from Cairn in March, and will then be sent to Singapore. "The outlook on that rig is [that] it will sit idle until at least October 2015 with opportunities, hopefully, presenting itself later in the year," said Rynd, "but [we expect] nothing in the interim."

As for *Hercules 261* and *262*, both have secured contracts until 2019; and the outlook for *Hercules 266* and *267* is very good. "We are looking to contract them through 2015," Rynd added.

• • •

Rowan Companies, last on the Top 10 list, has several projects in the works.

- *Rowan Relentless*, contracted for construction by Hyundai Heavy Industries (HHI), is expected for delivery at the end of March 2015. The rig is contracted for a two-year drilling term commencing 3Q 2015.
- The *Rowan Reliance* rig departed HHI shipyard early November 2014. The rig is contracted for a three-year drilling term commencing late February 2015. The expected off-rate time for annual dynamic positioning trials will occur sometime during 2015, the company stated in its 3Q earnings call.
- Middle East: *Hank Boswell*, *Bob Keller*, *Scooter Yeagain*, *Rowan Mississippi*, and *Bob Palmer* all secured contracts with Saudi Aramco.
- Southeast Asia: *Gorilla II* has secured a contract through late 2015. This may be mobilized out of Southeast Asia after the contract ends, the company said.
- *Rowan Juneau* and *Rowan Alaska* have been cold-stacked and are available. ○



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The drillship *Dhirubhai Deepwater KG1* will operate offshore Brazil at a rate of \$440,000/d. (Photo courtesy Transocean)

Brazil remains center stage in rig market

Petrobras revs up its deepwater drilling program

Justin Smith
IHS Petrodata

Brazil has ambitions to become one of the largest oil exporters in the world over the next decade or two, but the country's ability to reach that goal is the pressing question. In September 2014, Brazilian federal energy planning company Empresa de Pesquisa Energetica (EPE) laid out its 10-year plan for energy expansion, which foresees that the country will be able to produce 5 MMb/d of oil by 2023. That would be a significant jump from the roughly 2 MMb/d of oil the South American nation currently produces. According to the EPE, domestic demand will only consume approximately 3.5 MMb/d, leaving 1.5 MMb/d to be directed for export to the international market.

A significant level of investment will need to be placed in Brazil's hydrocarbon segment if this goal is to be reached. Of the BRL 1.26 trillion (\$540 billion) the EPE believes will be spent on energy projects in the country over the next decade, including electricity generation and bio-fuels, 61.6%, or BRL 778 billion (\$332.7 billion), will need to go toward the exploration of oil and natural gas. It is likely that a large portion of that investment will be spent on presalt areas, as the EPE expects two-thirds of oil production to come from those fields by 2023.

Libra to lead presalt movement

To meet these targets, Brazil's largest producer, Petrobras, will need to keep ramping up production, which is something the operator has been doing with regularity during 2014. The company achieved new record production levels in December, hitting 2.286 MMb/d of oil and natural gas liquids. The majority of this volume is coming from the historically prolific postsalt areas of the Santos and Campos basins, and new facilities came online in 2013 and 2014 at several fields including Papa-Terra, Roncador, Baúna, and Parque das Baleias.

However, presalt production also hit a new high point in December when Petrobras crossed the 700,000 b/d mark, which is a fairly significant jump from the 500,000 b/d the company was drawing from presalt fields only six months earlier. Each presalt well is highly productive, because while a total of 12 facilities are currently pumping from presalt fields, including newer FPSO vessels at Sapinhoá, Lula and Iracema, the entirety of the volume is coming through a mere 34 wells.

While this clearly demonstrates that presalt fields are increasing in importance, one in particular, Libra, is the field du jour in Brazil. Discovered in 2010 and covering an area of 1,548 sq km (598 sq mi), the Libra oil field is located in the Santos basin presalt layer in water depths of around 2,000 m (6,562 ft). This gigantic field is of such importance in the mid-to-long-term future in Brazil that national regulator Agencia Nacional do Petroleo, Gas Natural e Biocombustiveis

(ANP) held a lease sale for solely this field in 2013. Petrobras, which was guaranteed at least a 20% operating interest in the block, now holds 40% interest, while Shell and Total each hold 20%, and CNPC and CNOOC each hold 10%. In addition to the signing bonus of \$6.9 billion, the group will have to conduct a minimum exploration program valued at approximately \$281.1 million.

The reservoir depth at Libra is around 3,500 m (11,483 ft) below the seafloor, for a total depth of approximately 5,500 m (18,045 ft). According to estimates by the ANP, the field holds an expected recoverable volume of 8 to 12 Bbbl of oil, plus total gross peak oil production could reach 1.4 MMb/d. That said, further appraisal is required to firm up that estimate, as well as the full development plan and a first oil date.

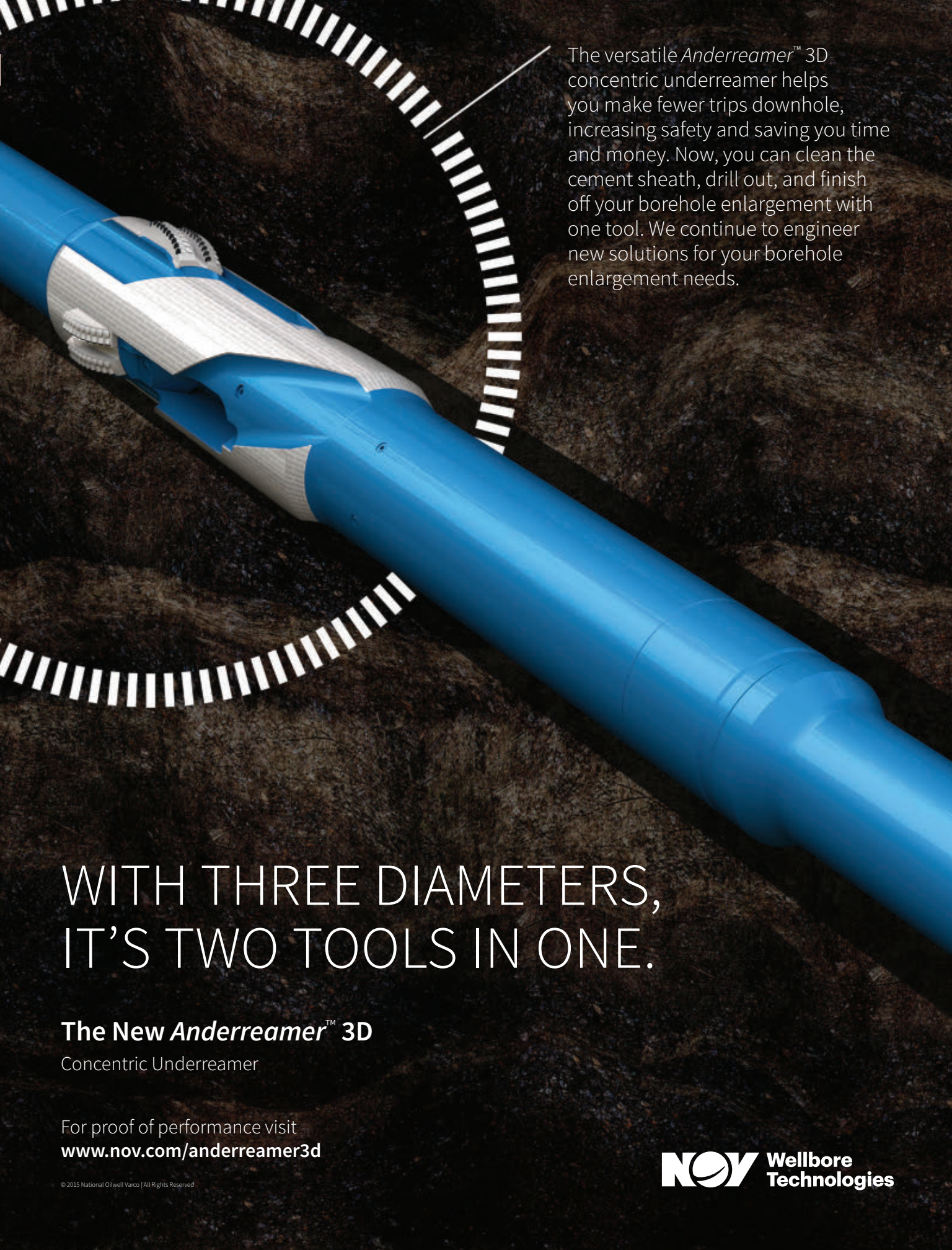
To that end, Petrobras started drilling the first two appraisals well in the Libra area in August. Being drilled by Schahin drillship *Cerrado*, this is the first of two wells planned for the first phase of the block's minimum exploration program, while the second well is being drilled by another Schahin drillship, *Sertao*. Both of these wells have encountered oil and gas in the anticipated layers. The exploration program also calls for the acquisition of 3D seismic data over the block, which the operator has already completed, as well as an extended well test (EWT). Petrobras plans to start the EWT in December 2016 and wrap up the appraisal program by the end of 2017.

Frontier areas beckon

Libra may have gotten its own bidding round in 2013, but it was not the only recent lease sale. The ANP's 11th Licensing Round, the first such bid round held in five years, earned record revenue with signing bonuses in the amount of \$2.8 billion. Of the 289 blocks that were offered across 11 sedimentary basins both onshore and offshore, 142 were sold.

Presalt areas were not the focus of that sale, which instead favored mature and frontier areas. Blocks located in the frontier regions of the country, primarily those around the north and northeast coasts, garnered serious attention from international operators. In fact, the largest signing bonus during the sale, which was approximately \$171.4 million, was offered for block FZA-M-57 in the Foz do Amazonas basin by a consortium operated by Total (40% interest) with partners Petrobras (30%) and BP (30%). That consortium beat five other bidders to secure the block.

At least one operator has already started making moves to explore the frontier areas it won in that sale. In July, Premier Oil released a request for information for a floater capable of working in at least 2,100 m (6,870 ft) of water to undertake an exploration program in the Ciara and Potiguar basins. The 400-day firm program, for which a tender should



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be launched soon, is scheduled to begin in late 2016 or 1Q 2017, and could be made into a rig-share. It is understood that the requirement covers seven firm wells plus four optional wells, with work involving at least two wells for Premier Oil and the rest to be divvied up among its rig-share partners.

However, it should be noted that obtaining drilling permits, and even seismic permits, in Brazil's frontier areas is becoming a lengthy process. Operators are looking at roughly two years to get an environmental permit to drill in these relatively unexplored areas, although that period could shrink somewhat over time. The odds of numerous operators using one rig to fulfill all of their drilling requirements on those blocks before the deadline, which is 2018 in most of the cases, would be a tall order considering permitting issues alone could prevent them from starting much prior to 2017. With that in mind, it is likely at least a few rigs will be needed to meet the demand in these areas.

In the long term, the ANP is looking to hold its next licensing round, the 13th overall, probably in June 2015. ANP Director Helder Queiroz said the regulator plans to include a diverse set of blocks in both mature and frontier regions in the offering. According to local media reports, Queiroz also indicated that future lease sales for standard concessions, like the planned 13th round as well as the 11th round held in 2013, could take place annually, while presalt lease sales, for the time being, will still be held once every two years.

Petrobras returns to the rig market

While it is good for Brazil to have a diverse group of operators working in country, Petrobras has been and will continue to be the overwhelming juggernaut there, so when the state operator decided to take an almost complete hiatus from rig contracting for over two years, it did not go unnoticed.

Petrobras signed a plethora of long-term contracts for Sete Brasil's newbuild units in February 2012, but since then, the operator signed only seven charters for floating rigs through April 2014, all of which were extensions for rigs already in the country, and only two of those were for more than a year (five-year jobs for semisubmersibles *ENSCO 6001* and *ENSCO 6002*). In fact, of those seven charters, two went to semi *ENSCO 6000*, a unit that has since completed both gigs and left the country. From February 2012 until now, the number of drillships in the country has only seen a small decline of a couple units to 23, according to IHS Petrodata's online database RigPoint, but the number of semis in Brazil has tumbled from 56 to 39, with at least two more scheduled to depart soon.

In the meantime, Petrobras started and stopped several tenders and renewal programs for deepwa-



The deepwater drillship *West Tellus* will work for Petrobras at the Libra oil field in the Santos basin presalt layer. (Photo courtesy Seadrill)

ter rigs. Finally, in May 2014, the company signed contracts for two ultra-deepwater drillships based on offers contractors made during the previous tender, which had actually been canceled. Petrobras awarded three-year charters to Transocean drillship *Dhirubhai Deepwater KG1* and QGOG Constellation newbuild drillship *Brava Star*, with day rates of \$440,000 and \$530,000, respectively. *Dhirubhai Deepwater KG1* arrived in Brazil in December, while *Brava Star* is scheduled to commence its contract in late 1Q or early 2Q 2015.

Since those deals were done, several more floater contracts were signed in October and November, all of which are for three years each. The company approved contracts for Seadrill deepwater drillships *West Tellus* and *West Carina* for work on the Libra field. *West Tellus* is currently stacked in the Canary Islands, and *West Carina's* delivery from Samsung in South Korea is expected in late 1Q 2015. The operator also approved three-year contract extensions for Seadrill semis *West Eminence* and *West Taurus*, drillships *Ocean Rig Corcovado* and *Ocean Rig Mykonos*, and Diamond Offshore semis *Ocean Baroness*, *Ocean Courage*, and *Ocean Valor*. All of these units will now be working in the country into 2018.

In addition, the Brazilian company recently opened up two tenders for work offshore Brazil, one for rigs rated to operate in up to at least 2,000 m (6,561 ft) of water, and the other for ultra-deepwater units that can work in water depths of at least 2,400 m (7,874 ft). The operator is looking to sign at least one rig from each tender. Market sources indicate that the term period for any eventual contracts is likely to be two or three years, starting in late 2015 or the first half of 2016. It is also possible that another extension or two could be in the works for rigs already in the country.

Setting up Sete Brasil

As mentioned previously, Petrobras has contracted a large number of newbuild floaters from domestic, presalt-focused contractor Sete Brasil, in which Petrobras also holds 10% interest. All but one of the 29 rigs Sete has ordered from five yards across Brazil have contracts with Petrobras with firm periods ranging from 10 to 20 years. Options could extend those terms by an additional

five to 10 years each. However, the issue with these units is the time and money it will take to build and deliver them.

Construction has started on a number of them, but primarily at yards in Asia, including at Jurong in Singapore, Kawasaki in Japan, and Keppel in the Philippines and Singapore. When those hulls are done, they are then mobilized to the builder's corresponding yards in Brazil for the installation of engines, drilling equipment, and other topsides.

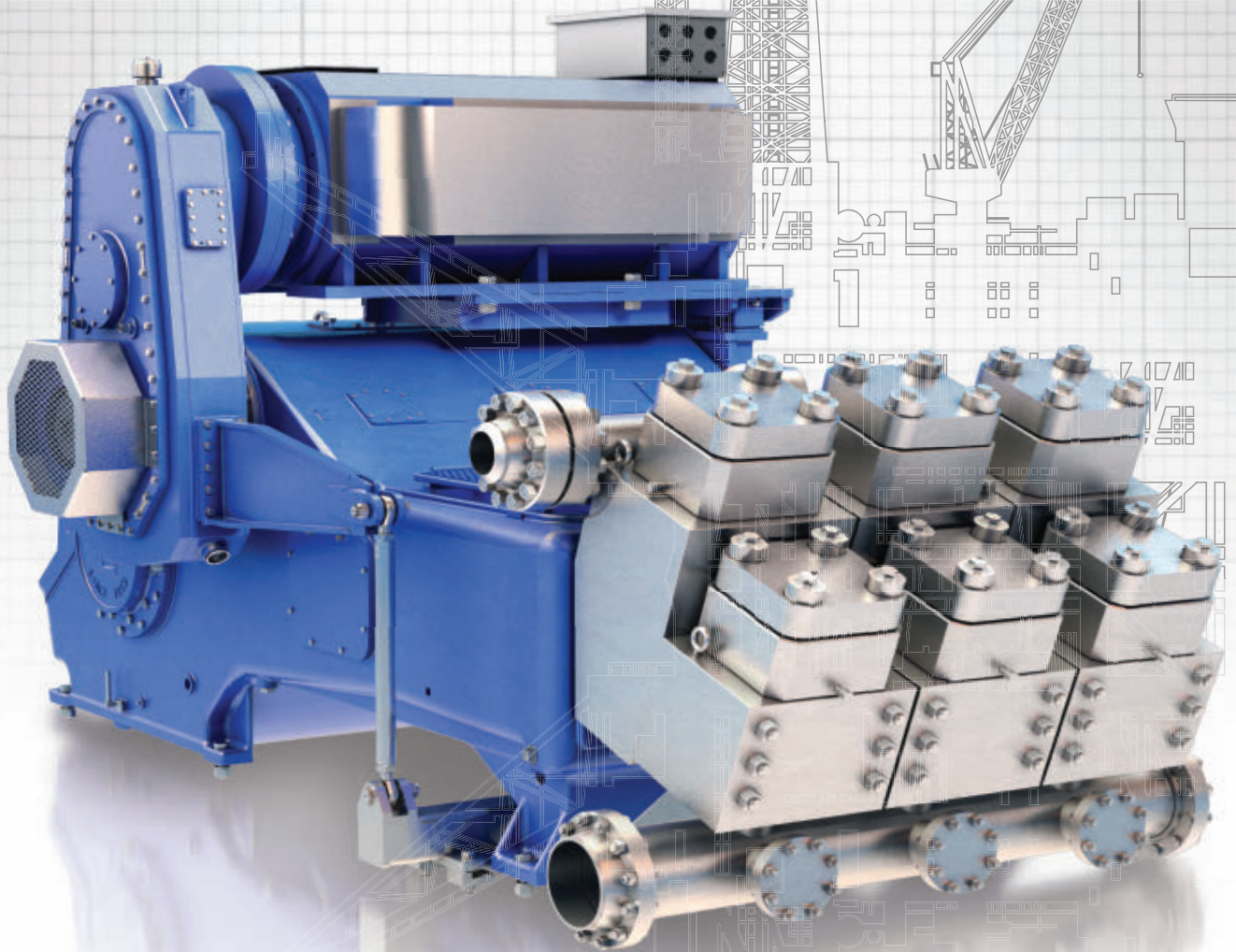
The primary reason the construction of these rigs starts overseas is because some of the Brazilian shipyards themselves are not yet completely built. Keppel's BrasFELS has made significant process on the semis it is assembling since the pontoons arrived from Asia, and the first two, which are named *Urca* and *Frade*, could very well meet its previously expected delivery of December 2015 and December 2016, respectively. Conversely, the first of all the rigs that was scheduled for delivery, drillship *Arpoador*, was originally slated to leave Singapore last year, but construction of its destination yard in Brazil, Jurong Aracruz, fell considerably behind schedule and the unit only arrived in late 2014. To compensate, Jurong had to do much more work on the rig in Singapore, so while it is still expected to meet its currently scheduled delivery date in August 2015, this could now potentially conflict with the company's local content requirements.

That said, following this initial batch of hulls being built overseas, Sete plans to build the remainder of the rigs almost entirely in Brazil, which should fulfill the high local content requirement mandated for the construction of this fleet. It is still very much a question as to when, and possibly even if in some cases, all 29 of these rigs will be delivered, partially because of the time it will take to build them, but also due to growing concerns regarding Sete's ability to amass the funds necessary to build them. Consequently, Petrobras may need to look to the international drilling fleet to meet its demands until these rigs are available, especially as the operator, and the nation, strives to keep expanding oil production in the future. ●

The author

Justin Smith is senior rig specialist, IHS Petrodata, Houston, Texas.

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HP/HT solutions are a key focus, says OneSubsea CEO

In May 2013, Cameron and Schlumberger announced the creation of OneSubsea, a company that specializes in the manufacture and development of products, systems, and services for the subsea oil and gas market.

The new company was designed to offer a step change in reservoir recovery for the subsea oil and gas industry through integration and optimization of the entire production system over the life of the field.

Under the terms of the formation agreement, Cameron contributed its existing subsea division and Schlumberger contributed Framo Engineering, as well as its surveillance, flow assurance, and power/controls businesses.

In September 2014, Mike Garding was appointed CEO for OneSubsea. Prior to joining the new joint venture, he had served as president of completions for Schlumberger. Garding began his career with Schlumberger in 1984 as a wireline field engineer in the Gulf of Mexico.

He has held various management positions since then, including vice president and general manager of engineering, manufacturing and sustaining; director of human resources for North America; and vice president of wireline, North and South America.

Bruce Beaubouef
Managing Editor

Recently, *Offshore* met with Garding to discuss the company's achievements to date, the challenges he sees for the industry going forward, and the ways in which the new venture can help the offshore oil and gas industry address those challenges.

...

Offshore: What led to the creation of OneSubsea? Can you elaborate on the market forces, or conditions, that led to the creation of this new company?

Garding: Schlumberger and Cameron have had an excellent working relationship for many years, collaborating on various projects and having sold products to each other. The creation of OneSubsea began with discussions as to how we might work together to optimize the various components of a subsea production system, incorporating critical information from the reservoir and the well in order to improve production and enhance recovery for our clients. We had many ideas and could see a number of opportunities



Mike Garding

to do this. We discussed various options in order to develop and deliver these ideas. It did not take very long before we came to the

realization that the creation of a new company, which brought together the necessary expertise from both Cameron and Schlumberger, would be the best approach and would be unique within our industry.

Offshore: How does the combination of Schlumberger and Cameron offer the subsea market a unique service or capability? What advantages does this type of venture offer subsea operators?

Garding: OneSubsea provides Pore to Process solutions, which are based on our unique approach for optimizing production and enhancing recovery. The Pore to Process approach delivers advantages by integrating expertise, knowledge, and technologies from the reservoir pore space all the way through the well, through the completion, through the production system, and up to a host facility. By collaborating with clients, OneSubsea aims to help them achieve their production,

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Offshore: What has been the biggest technological advantage of the combination?

Garding: The combined expertise, knowledge, and wealth of experience of both parent companies is our distinct advantage. We are able to leverage Cameron's long history of innovation and industry firsts in the subsea market, as well as their industry-leading design capability and manufacturing and aftermarket capabilities. Couple that with Schlumberger's deep understanding of the reservoir, petrotechnical leadership, reservoir and production technology, leading well completions, boosting leadership, and R&D capabilities, and OneSubsea is strongly poised to offer best-in-class subsea solutions for our customers.

Offshore: Where does OneSubsea stand in developing equipment for HP/HT service, i.e. 20,000 psi+ and 350°F+?

Garding: One of the main technology initiatives at OneSubsea is to develop HP/HT solutions. Our parent company Cameron has already developed solutions for drilling and surface wellhead applications for 20,000 psi, 25,000 psi and 30,000 psi, as well as some applications to 450°F. We are using a great deal of what was learned in those developments

within the scope of new industry standards to design and qualify these new subsea solutions. The technology effort began in 2013 and is ongoing, with several interested operators that seek this technology in the next five years.

Offshore: How do your subsea tree offerings figure into the HP/HT environment, and where do you see subsea tree development going in the future?

Garding: We have already delivered several 15,000 psi and 250°F+ subsea trees to the market, and we expect to be a leader in delivering some of the early 20,000 psi trees to the industry. We also have unique offerings in boosting and metering, as well as intervention given our alliance with Schlumberger and Helix. They are engaged with us in our new technology development to create a new level of tree features that will reduce rig time and cost, as well as improve functionality for lifting and metering capability.

Offshore: What are the key challenges and issues facing the subsea industry and how are subsea processing solutions addressing these challenges?

Garding: Since its beginning, the subsea industry has continuously been moving into more challenging areas, stretching the boundaries of available technology. Not only does water depth continue to increase, but the produced fluids are becoming more challenging, as are the reservoir conditions with combinations of high pressure and high temperature, and possibly even lower productivities. As a consequence of these factors, the development solutions and base investments tend to become ever more complex and costly. Over the last decade, the cost of subsea developments has exhibited an upward trend, and the lifting cost per barrel is revealing a potentially non-sustainable trend.

The subsea industry as a whole, operators and contractors, is currently engaged in a large number of initiatives to address these issues. Standardization, reuse of existing designs, rationalization of project execution, and more efficient engineering and manufacturing processes are just some of what everybody in the industry is looking into. OneSubsea is no exception, and we are convinced that there is a large potential for improvement in all of these areas. We are also 100% convinced that the only way to overcome these current challenges is through the active use of technology. The industry has a need to reduce costs, but much more importantly we need to increase the recovery rates of old and new oil and gas fields around the world, i.e., get much more return on the invested capital. Increasing the oil recovery rate by about 10% from a field without any significant additional investment in the infrastructure will significantly reduce the average lift cost per

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Many technologies and sciences have a role to play in this, but experience has shown that one of the most effective and easily adaptable methods could be subsea multi-phase boosting. This technology reduces the back-pressure on the reservoir and adds energy to the well stream, thereby allowing more of the hydrocarbon to be produced to the surface. With increasing water depth, reservoir depth and tieback distance combined with heavier fluids, this becomes even more effective, resulting in an even higher relative impact on the production and ultimate recovery.

Offshore: What are the key issues with regard to wet gas and multi-phase fluid compression?

Garding: The wet gas multi-phase compressor serves the same function for a gas field as the multi-phase pump does for an oilfield; it is primarily a tool to improve or increase the production and recovery rates. Due to the market mechanisms for gas and the nature of the produced fluid, the potential for long and ultra-long tiebacks directly to shore becomes feasible.

Wet gas compression offers a very compact and robust solution for unprocessed gas compression subsea. The OneSubsea Multiphase Wet Gas Compressor, or multi-phase compressor as we call it, is capable of operating in an envelope of 100% liquid and 100% gas even though optimization is for 0–5% liquid by volume. This capability is what enables a very compact and cost-effective subsea infrastructure. The multi-phase compressor has a lot of common components with our range of very successful multi-phase pumps, and is designed from scratch for subsea applications without marinization of topsides technology. This allows OneSubsea to design for easy installation and intervention using light vessels, the latter being of extreme importance for system uptime. The delivery of gas is often executed on fixed contracts, either as feed for a liquefied natural gas (LNG) plant or trunk line sales, making the aspect of uptime even more important for gas compression than for our highly reliable multi-phase pumps.

Offshore: How do you see the evolution of subsea processing progressing, including separation?

Garding: Subsea separation, to date, has only been applied in a handful of experimental applications and one commercial application, the Total CLOV project in Angola. OneSubsea, incidentally, has been involved in all of these systems, having supplied the rotating machinery for all of these—subsea multi-phase pumps and high-pressure pumps for reinjection of the separated produced water.

Subsea separation may have a role to play in the debottlenecking of brownfields. It enables tie back of high water cut satellites to

mature field centers, which may already be maxed out on water production. It also allows the ability to cope with flow assurance issues, like hydrate prevention and high back pressure on deepwater tiebacks due to high water cut. Certain combinations of extreme oil qualities and gas production could also benefit from subsea processing or separation.

In the interest of minimizing installation and equipment costs, especially when applied in deepwater, we are confident that modular and compact systems will be required; in subsea separation, there is no one size that fits all. Therefore, our strategy is to qualify compact technologies from our parent companies, both of which have considerable experience in this area either as a user or as a leading supplier of topsides separation systems, or from third parties offering a special technical solution.

OneSubsea is equipped with a strong portfolio of proven separation components and modules, including advanced rotating machinery and high-reliability control systems from our expert environment in Celle and Bergen. We are confident that we will be able to offer a unique solution for any challenge presented before us.

Offshore: Is there a practical limit to water depths that can be accommodated with subsea equipment?

Garding: There is no real practical limit, up to 5,000 m (16,404 ft) is achievable; it just takes more work and qualification. There is, however, a limit on drilling technologies. As of now, we do not anticipate there will be many wells drilled over 3,000 m (9,842 ft) until the development of additional technology. Once there is a complete understanding of the drilling technology and well control for depths beyond 3,000 m, we can fully assess what our technology requirements will need to be.

Offshore: Where does the industry stand regarding deepwater intervention capabilities?

Garding: The industry is well-placed to perform riser-based interventions on deepwater wells with less than 10,000 psi pressure; however, most times it involves using a drilling rig as marine support. Where a real difference can be made going forward is by decoupling the drilling rig from the intervention equation and replacing it using a cost-effective vessel as marine support. Additional technology is required to perform cost-effective intervention on a routine basis on high-pressure wells, as well as to further increase the capability of riserless operations to drive down intervention costs. We recently executed the definitive agreements for the non-incorporated alliance with Helix and Schlumberger to focus on bridging these technology gaps and delivering end-to-end, integrated intervention solutions to our customers. This alliance is unique in the

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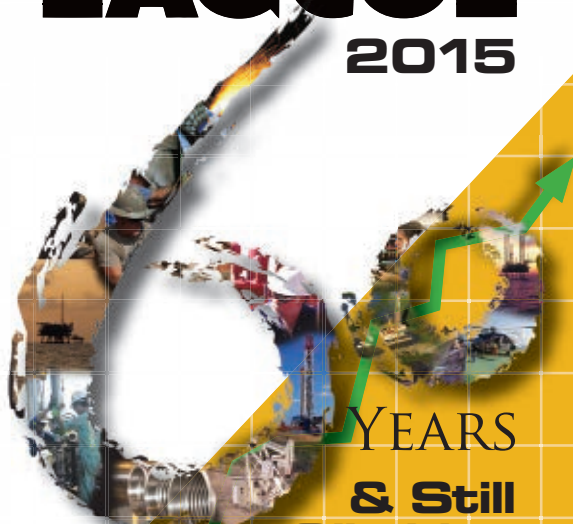
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industry in that it contains all principle domain competencies encompassed in a subsea well intervention operation. We will draw on these competencies to develop innovative equipment and methodologies, allowing the industry to expand the existing intervention pressure envelope, as well as to enable more services to be performed from these cost-effective intervention vessels.

Offshore: What new technologies or approaches is OneSubsea offering with regard to flow assurance?

Garding: Flow assurance is the basis for specification and, consequently, the design of almost all production hardware and solutions we put on the seafloor. It actually starts at the outer reservoir no-flow boundary and follows the fluid journey through the reservoir, the well, the production gathering system, and through the topsides facilities. Through our parent companies, we have access to state-of-the-art simulation and assessment solutions and workflows that allow us to look at the entire process as one, and not in individual, compartmentalized domains. This allows for the running of upstream petrotechnical evaluations in parallel with production assurance and design processes, and cross checking this with our detailed knowledge about subsea hardware and solutions available.

Offshore: Discuss the pros and cons of electrical versus hydraulic control approaches to subsea equipment.

Garding: The use of electrical motors provides unparalleled advantages in regards to control, real-time feedback, and condition monitoring. Varying the output to the electric motor allows for partial stroke testing and increased power; features not possible with traditional hydraulic actuated valves and chokes. Another advantage is the speed of actuation. For a traditional hydraulic actuated choke installed at increased water depths, a fully open/fully closed cycle can take 20 minutes or more, whereas the use of electric actuated chokes can reduce the cycle time to several seconds if need be. Use of an electric system can continue for fields in extreme water depths, where enhanced availability and functionality are a must, and traditional hydraulic systems will no longer work.

Another positive aspect of an electric system is the short system start-up time. There is no need to pressure up hydraulic lines and/or to wait for accumulators to fill after multiple actuations or even after a total black out. An electric control system is fully operational within several minutes after start-up, in comparison to several hours for traditional hydraulic systems. An electric system is also more environmentally friendly, with zero discharge and no dumping of fluid, whereas with a traditional hydraulic system some control fluid may reach the sea.

As it stands now, the biggest drawback of an electric system is the pricing level. Current pricing levels are higher than for a traditional hydraulic system as a result of the small number built at this time. However, over time, as all-electric systems become more commonplace in the industry, these higher pricing levels should begin to decline.

The industry continues to move further offshore, into deeper waters, in a direction where a more sophisticated system requiring fast and accurate controls needs to be applied to subsea processing. The faster it is, the smaller it can be. By nature, electrical is faster than hydraulic, and in the long run can drive down costs for more complex seabeds. Electrical is the future, providing a more efficient and effective way to get the job done.

Offshore: Operators are increasingly looking to maximize recovery from brownfield projects. How do the OneSubsea offerings figure into these types of projects?

Garding: We are actively working to address this emerging market through our BrownFEED redevelopment service, a unique approach to re-engineering existing developments in order to boost production and

extend field life. OneSubsea's Integrated Solutions division provides customers with state-of-the-art technical services for brownfield developments and enhanced asset recovery. The division comprises the best and brightest from the diverse fields of petrotechnical engineering, integrated asset modeling, and production assurance. Subsea multi-phase pumping technology from our processing systems division also plays an important role with boosting pumps that are field-proven to extend the production life of many of these aging fields. Furthermore, the OneSubsea Production Systems division is also consulted and works with both groups in an integrated manner to advise operators on how to maximize recovery from brownfield projects. We have already performed a number of studies for some of our most valuable customers, and that is just the tip of the iceberg.

In addition to boosting, we consider other ways to increase recovery from a brownfield, such as improved oil recovery—water, gas or water alternating gas injection, or chemical injection. Although placing injection facilities on the field is not enough to increase recovery, the key is to understand the reservoir response. OneSubsea has unlimited access to petrotechnical experts and industry-leading software to assist here. We are able to provide full field optimization studies, from pore to process, as well as expertise in needed fields such as geomechanics (very important for deepwater fields) and asphaltene evaluation in the reservoir.

Offshore: As you know, many offshore field development projects fail to produce even 50% of the hydrocarbons in the targeted reservoir. How can OneSubsea help operators increase ultimate recovery?

Garding: As the industry moves toward an ever-increasing need to maximize recovery rates, multi-phase pumps are becoming more and more of a necessity; more than any other technology, they are key to increased recovery rates. At OneSubsea, we are unique when it comes to subsea multi-phase boosting in that we have been working in this field, through our Framo Engineering legacy, since the 1980s. We have installed all currently operating subsea multi-phase pumps in the world today. More than two million running hours have accumulated on the more than 85 seabed pumps delivered. The meantime to failure for these units is statistically in excess of 15 years, an impressive number that very clearly demonstrates the robustness of this technology. Combined with the cost-effective and efficient installation and intervention method, this has proven to be an effective tool to increase production and recovery rates from roughly 30 oil fields worldwide. Multi-phase pumps are a very effective tool to increase oil recovery and reduce the overall cost per barrel, and our experience with this technology makes us a lead-

er in the quest to achieve ultimate recovery.

Offshore: What is OneSubsea's approach to asset integrity?

Garding: Condition monitoring based on real-time data is an integral part of the operational support that we provide for all of our products and systems. The OneSubsea FRIEND Remote Surveillance and Diagnostic System provides valuable diagnostic information that enables proactive support for operational challenges and early detection of potential equipment upsets, thereby avoiding interruptions to production, extending equipment life, reducing operational costs, safeguarding equipment uptime, and reducing unplanned interventions.

Offshore: Which part of your business shows the greatest prospects for growth?

Garding: We see multi-phase subsea boosting/compression and life-of-field services, including brownfield redevelopment efforts and intervention, showing the greatest prospects for growth. The industry has only scratched the surface in its use of energy creating technology on the seafloor. We are seeing incredible results and better than expected reliability with our rotating equipment on the seafloor. As more operators get comfortable with the technology, this will surely be an area of explosive growth for OneSubsea. Additionally, every operator would like to get more out of their existing wells. We are getting pulled into many brownfield activities, and our portfolio of services and products addressing this space has tremendous growth potential.

Offshore: What will be the biggest challenges to subsea oil and gas development in the years ahead?

Garding: Cost reduction and improving recovery factors are the biggest challenges facing subsea oil and gas development in the years ahead. As those in the industry know, these are challenges that have existed for many years, and now more than ever, the industry has a need to reduce costs and increase recovery rates from both mature and new fields. We are working closely with operators to reduce overall development costs by offering more standard products and processes. The adoption of industry and customer specific standards will lead to significant reductions in cost and development time. Additionally, we believe the development of new, cost-effective and efficient technologies – of which OneSubsea finds itself on the cutting-edge – and the active use of these technologies is the only way to attack these challenges; significantly reducing overall investment in field infrastructure, improving recovery rates, and maximizing return on investment. Embracing these innovative technologies will lead the industry to overcoming the financial challenges in subsea developments. ●

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Industry addressing challenges of deepwater, data management

Subsea pumping will be major growth area, says new INTECSEA president

Bruce Beaubouef
Managing Editor

For 30 years, INTECSEA has provided frontier technology leadership for the energy industry's most challenging offshore field development and pipeline projects. The company has designed subsea production systems, pipelines and floating systems for operations in some of the harshest environments, and in locations as diverse as the Black Sea, Arctic Ocean, Mediterranean, the Gulf of Mexico, offshore West Africa, and the South China Sea.

As part of the WorleyParsons Group, INTECSEA offers the industry engineering and project management expertise in its five core areas: subsea systems, offshore pipelines, marine riser systems, floating systems, and Arctic development.

Neil Mackintosh was appointed president of INTECSEA in July 2014, and has more than 30 years' experience in the oil and gas industry. As president, he is responsible for maintaining the company's leadership as a global provider of engineering and project management services for offshore oil and gas developments.



Neil Mackintosh

Throughout his career, Mackintosh has successfully established businesses in multiple markets, including Malaysia, Australia and Brazil.

His experience covers engineering, construction, project management of marine pipelines, as well as subsea and riser developments, and fixed and floating offshore facilities.

Recently, Mackintosh met with *Offshore* to discuss the latest trends in offshore oil and gas development, subsea engineering, data management, and the outlook for the industry in the next five to ten years, and beyond.

...

Offshore: INTECSEA is involved in a number of technologies. Where do you see the most opportunity for the next 5-10 years, and beyond?

Mackintosh: One of the key areas of technology development for INTECSEA is in data processing and data management. As an industry, we are installing large numbers of sensors and collecting substantial amounts of data on our subsea equipment, flowlines, and risers. However, we need to do a much better job of managing that data. We have so much information that it is sometimes difficult to determine what is important and what is irrelevant.

We are working on an extended web-based environment, designed to capture, integrate, and visualize key data through the asset lifecycle. We can add information through each stage of the project development, then continue to record and update the data through the full field life. As the development matures, the integrated dataset evolves into a "digital asset," which is populated with data, including links to existing operator-specific systems for IMR records and process moni-



In order for subsea pumping to be successful, the industry will need to be able to transmit a lot of power down to the seabed, says INTECSEA president Neil Mackintosh. (Photo courtesy OneSubsea)

toring to provide a comprehensive, flexible platform to support integrity management through the life of the field.

Offshore: There's been a lot of talk about standardization. What do you think about its place in the industry?

Mackintosh: Various operators and manufacturers have tried to provide some degree of standardization for their developments. This has worked very well for most companies and adds a significant amount of value in terms of equipment change out, manufacturing flexibility, and simplicity in offshore operations. Can more work be done in this area? Yes, absolutely, and subsea companies are taking the lead and moving this forward for our industry.

Offshore: How does INTECSEA respond to calls for more local content in places like Brazil, Mexico, West Africa, etc.?

Mackintosh: This is an absolute requirement for our company. We

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have to find ways to work closely within the frameworks that are requested by local governments. This is easier to do in some places than others, but we continue to open local offices to meet the local requirements. However, we have to make sure that we have the same quality of engineering in our local offices that we do in our main offices. This means that our subject matter experts have to support engineering in all parts of the world and in several different time zones. One of the areas that we are particularly keen on developing is India. We see a growing market for deepwater subsea and floating systems engineering to support the major East Coast developments by companies like ONGC and Reliance.

Offshore: Back to Mexico – there's a lot of optimism following the passage of new regulations. Do you see that part of the GoM becoming a hotspot for operations?

Mackintosh: Yes, I am very optimistic about the Mexican market in the long term. It is going to take some time before foreign operators start to participate in a meaningful way, but PEMEX is developing its first deepwater fields and will always have a crucial role to play.

Offshore: What is your view of the “seabed factory” idea of having as much production equipment as possible in the subsea environment? Is more than basic separation/multi-phase flow seabed processing likely?

Mackintosh: The whole topic of subsea processing has been discussed for many years. However, I think we need to be a little bit more specific about the opportunities that subsea processing and the seabed factory can bring over the next five years or so. The major area for growth is in subsea pumping, especially taking the back pressure off the reservoir and getting more oil out of the ground. In order for subsea pumping to be successful, we have to be able to transmit a lot of power down to the seabed and I think that's where the biggest advances in technology have to come: in the delivery of efficient power to the subsea processing systems. This means high-quality, ultra-reliable subsea electrical power connectors and distributed power systems. These advances will come more quickly than processing and compression solutions.

Offshore: The industry is increasingly facing the challenges of deeper water, deeper wells, higher temperatures, higher pressures, longer tiebacks, and extended field life. Are there limits to any of these sorts of trends, whether technical or economic?

Mackintosh: The limits are purely economic. If it makes financial sense, then the investments in technology will occur and projects will get developed. Once we get past the “first-of-a-

kind” scenario, more companies will invest in the technology, costs will come down, and the solutions become increasingly mainstream.

Offshore: The Arctic has a whole new set of design influences compared to other offshore operating arenas. INTECSEA is involved in these influences. What are the biggest issues for those conditions?

Mackintosh: Work will continue to happen in the Arctic, in Alaska and Northern Canada,

but projects have taken time to mature, not due to technical reasons, but due to permitting and environmental permissions. Not too long ago, I would have said that one of the key elements for long-term success in Arctic design is the ability to speak Russian, but times change. INTECSEA is a global leader in Arctic design, and we continue to execute cold-weather projects, where understanding the ice interactions with offshore facilities and pipelines is an essential part of the design process. ●

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Unstructured data management shifts industry to unified IT infrastructure

Manuel Terranova
Peaxy

Managing the associated unstructured data generated by seismic images is a major investment of money, resources, and equipment. Moreover, as increased resolution continues to come online, survey technologies in-field and processing techniques stretch decade-old computing constructs. Raw data sizes are also growing exponentially. The advances made in seismic data acquisition technology factor in this growth; however, post-processing, compression, high-fidelity master archiving, and data redundancy schemes all serve as multiplier effects on the raw data ingest rate. For many organizations, this compounding problem quickly translates to 20 to 50 petabytes per annum saved onto one hard drive or tape among thousands.

This rapidly-increasing accumulation of data will further challenge an industry that already struggles to give scientists and researchers ready access to data and management tools that enable advanced analytics.

Unlike structured data, moving or migrating, unstructured data often has a negative effect on its value. Unstructured data, when moved—and by definition, renamed—makes finding data again very difficult. Stated differently, because of the way today's dominant traditional storage systems are architected, hardware upgrades often orphan data from core analytics processes and the geoscientists who need it to inform interpretations and decision-making.

At multi-petabyte ingest rates, seismic analytical tools—many of which were designed decades ago—are quickly showing their age. The industry is at the doorstep of a shift to more flexible, scalable constructs designed to specifically solve the problems of data access, data longevity, data management, and storage. While traditional storage technologies often perform effectively over the near term, traditional seismic architectures and monolithic data constructs leave a good deal of unstructured data value untapped. Generally, these systems were not designed to span multiple-technology refreshes or facilitate data access over longer periods of time.

Multi-national offshore drilling companies, oil and gas companies, and others involved in



Hyperfiler is a data management system that allows companies to create a petabyte-scale "dataplane" that logically combines disparate datasets. (Photo courtesy Peaxy)

seismic pursuits are starting to realize that the inability to re-harvest this data over decades is not just a technical issue, but also a business problem that can affect future competitiveness. Companies that treat this data as a business-critical asset are becoming aware of the shortcomings within the current systems of architectural constructs, upon which organizations have relied for the past 30 years. Finding and accessing data readily are two must-have features that now threaten traditional storage approaches that for decades have focused on getting data into their system. Until now, getting the data out again has been a tertiary or, at best, a secondary consideration, but not for much longer.

Mission-critical data

At a basic level, seismic surveys collect very large amounts of raw data from sensors that are then filtered by supercomputers or other computational constructs to extract useful information to be analyzed by geoscientists. When a seismic survey is under way, the initial concern centers on the massive and unstructured nature of the raw data produced, which can range in size from 100 to 400 TB a day. These files are subject to further processes that can distill useful information from the sea of noise. Today's practice is to put this information into a physical storage construct of some sort, a process that will eventually fail to maximize the availability of data to teams spread over time and space. The problem is that once the data is dropped into this "storage bucket,"

major hurdles are encountered when scientists try to repurpose these datasets.

To maximize the production levels of reservoirs, companies need to be able to compare surveys of the same reservoirs taken five, 10, or 30 years apart from one another. While this is technically possible with systems currently in place, as a practical matter, traditional data architectures require too much pre-processing or specialized technical expertise to readily facilitate that kind of comparison. In many cases, decisions about where datasets should be stored are driven by tactical considerations such as costs and dwindling storage space. The end-user access need has little bearing on where and how data is stored. This makes things challenging enough, but the ever-persistent IT technology refresh cycle presents an even more formidable challenge for engineers trying to keep track of and access this data.

Lost data

The main problem is that every time data is moved, pathnames change, links get broken, and the data map—where particular datasets are stored and the knowledge of how to access and use them—becomes increasingly fragmented. This approach relies on so-called tribal knowledge of this map in order to be effective over time, but when employee turnover over decades is factored in, that knowledge is almost certain to be lost. When it does inevitably break down, data can no longer be reasonably located and is, in effect, gone.



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Expensive seismic surveying data “going dark” is a major cost; either that data will have to be re-collected, or in the case of historic data, it may simply be irretrievably lost and unavailable to future projects and new opportunities.

Simply put, there is a disconnect between the fundamental way data needs to be accessed and the structure of the underlying hardware and storage systems. Engineers and geoscientists need to access seismic data today which years from now is at odds with the nature of technology upgrades and the physical structure of storage systems that change and evolve over time.

Infrastructure for data longevity

Fortune 1000 companies and smaller seismic players that serve the offshore industry are expected to confront a cataclysmic change over the next 24 months. Given the exponential growth and revenues associated with the data, companies will have to find a way to not only locate all of this “dark” data, but also re-architect their computing infrastructure so that research teams can immediately access and collaborate on it just as easily 30 years from now as they can this week. Additionally, they will have to do it in a cost-effective manner in both the short and long terms without compromising scale and performance.

For example, GE Oil & Gas is one of a number of organizations tackling the inconvenient realities of constantly shifting hardware through a virtualization-centric data architecture that creates a unified namespace for large unstructured datasets. These new approaches essentially make data accessible—even datasets that are highly distributed across storage mediums and across the globe—from a single virtual space, which does not change over time. From the user’s perspective, it eliminates the heavy dependence on tribal knowledge for data location and preserves access to these datasets that would otherwise be lost in the next refresh cycle.

Solutions like these ultimately require a rethink of the modern IT infrastructure. It requires oil and gas companies to collaborate with engineering teams to design a new technological approach to managing and optimizing seismic data based on the following tenets:

Mission-critical unstructured datasets. These are precious assets that need to be maintained and re-harvested over their lifespan. Business leaders and heads of engineering need to be actively involved with IT in preserving these datasets and enabling geophysicists to manipulate them at any given time. These new requirements of data access, data longevity, and data location will join the traditional storage

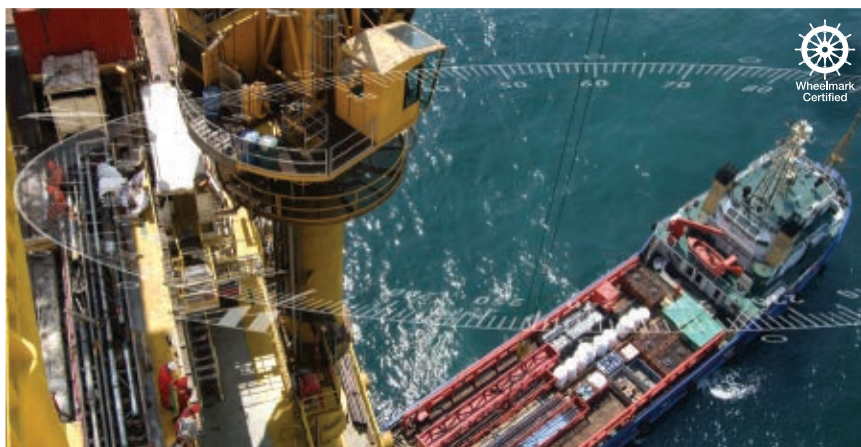
considerations: scale, performance, and cost.

IT architecture needs to evolve. Geoscientists’ and data analysts’ fundamental need for ready access to data needs to be resolved with an IT architecture that has not evolved to meet their needs. Today, it is too costly in terms of money and man hours to keep track of mission-critical seismic datasets over time. Many researchers and engineers lose 45 to 120 minutes a day managing, deleting, and finding unstructured seismic and related data.

Tribal knowledge is an ineffective long-term strategy. Over the course of decades, people who know where data is stored will leave the organization, and knowledge of its location will deteriorate over time. The amount of value organizations can derive from their unstructured seismic datasets depends on hosting the data in a solution that allows end users to find and access data easily and readily—even without tribal knowledge. ●

The author

Manuel Terranova is president and CEO of Peaxy. Before co-founding the company, Terranova spent 13 years in various roles at General Electric, most recently as senior vice president at its Drilling and Production business.



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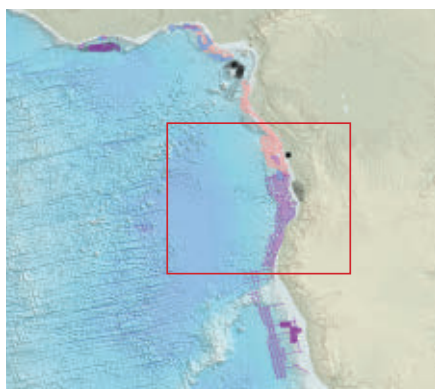
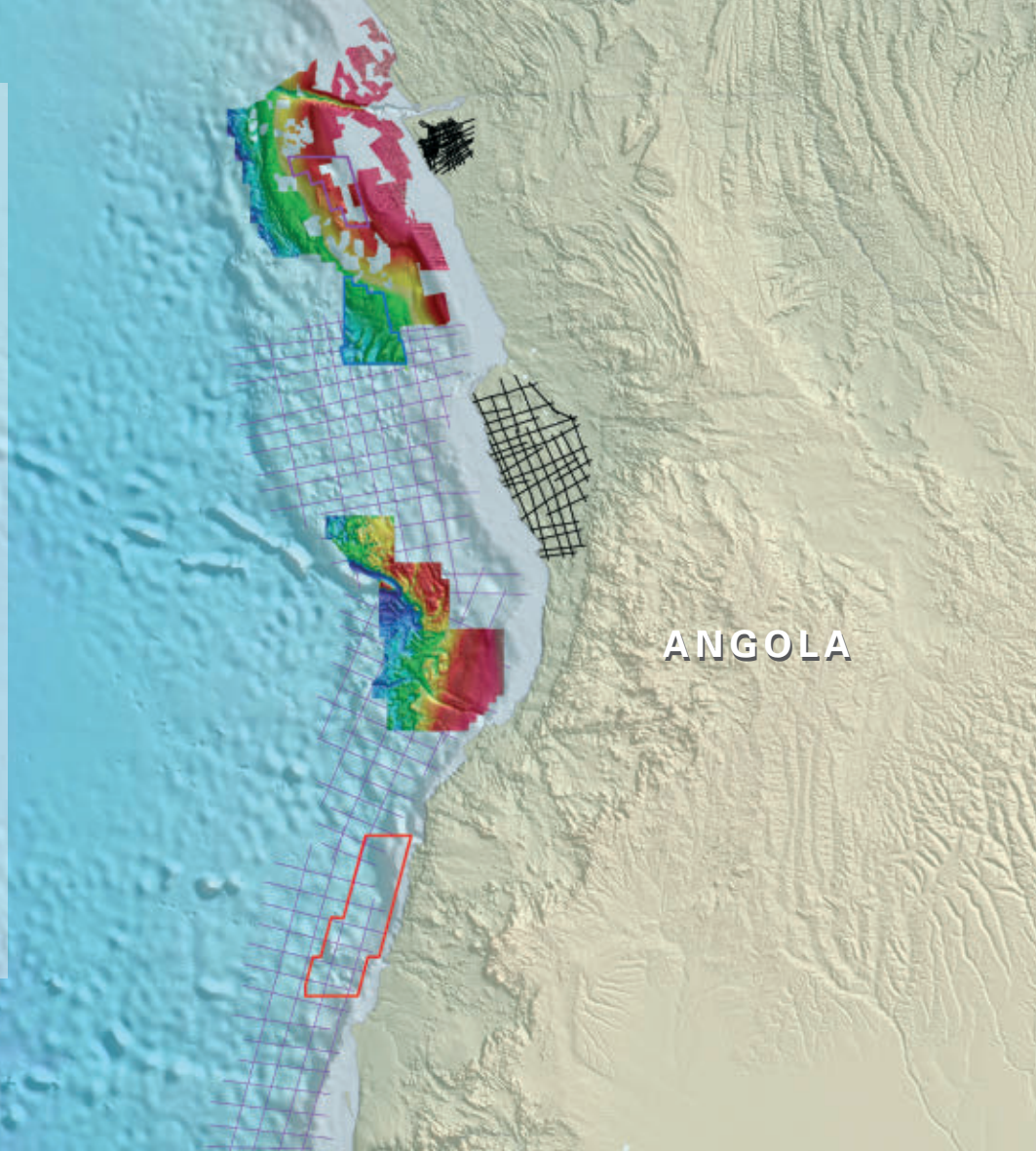
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Ice data management system improves Arctic operations

Terry Kennedy
ION Geophysical

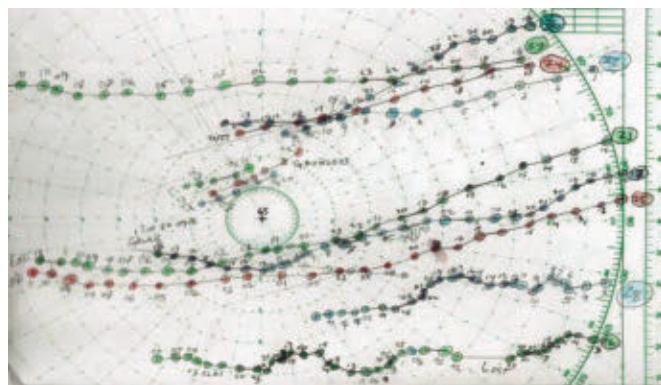
Operators can now accurately pinpoint dangerous ice incursions

More than 100 years ago when the *Titanic* struck an iceberg and sank in the North Atlantic Ocean, the only ice detection technologies available to the captain and crew were visual sightings and wireless transmissions in Morse Code from other vessels. Over time, additional ice detection technologies have emerged to protect cruise vessels and other commercial operations from the threat of sea ice and icebergs. These include aerial photography, marine radar, satellite imaging, infra-red cameras, weather bulletins, and sea ice charts from government agencies and service providers.

With so much ice data available, the risk of a collision today would seem remote. Nevertheless, in recent decades, collisions with icebergs have occurred at a rate of more than two per year. Why? More tourists are visiting Antarctica each year; a growing number of commercial vessels take the Northern Sea Route across the Russian Arctic to reduce time and fuel costs; and because the US Geological Survey estimates that one-quarter of the planet's undiscovered but technically recoverable hydrocarbons lie above the Arctic Circle. With the intensification of maritime activity in ice-prone waters, the risk increases.

Even with many sources of ice data, a single piece of missing or overlooked information can lead to a collision. In 2007, the *MS Explorer*, an ice-reinforced cruise ship, sank in the Antarctic Ocean due to a misjudgment. The captain and crew were experienced ice navigators, but they underestimated the thickness and density of sea ice they began to plow through one night. They mistakenly believed that they were entering a thin first-year sea ice field and maintained full speed. The vessel then struck a 15-ft (4.6-m) "wall" of older, harder glacial ice that exceeded the *Explorer's* ice classification, slicing open the hull. The ship sank days later. All passengers and crew were rescued safely.

One reason ship captains and professional ice observers can still misjudge ice conditions is that, even today, most of them still depend largely on a disparate mix of manual methods to make sense of diverse ice information. This is, however, no longer the only option.



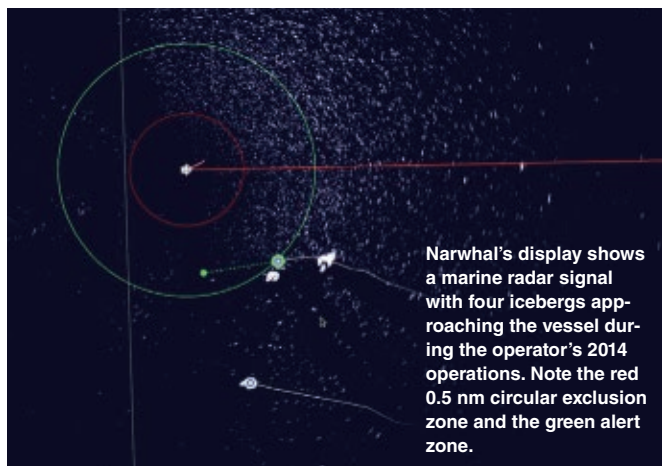
The standard manual method used to display iceberg observations. (All images courtesy ION Geophysical)

In 2011 and 2012, an E&P operator conducted site surveying, scientific coring, and high-resolution seismic streamer operations near the coast of Greenland. In this area, the frequent presence of both large and small icebergs needs to be carefully managed in order to keep personnel and equipment safe. To assess the risks from hour to hour, dedicated ice observers tracked bergs around the clock using marine radars and satellite images, calculated their mass using spreadsheets, and posted their speed, direction, and position on paper polar plots. Critical ice information was scattered around the bridge. Obtaining up-to-date data required ice specialists to print hardcopy plots and images elsewhere on the ship. Keeping the captain well informed, especially under extreme conditions, was both challenging and time-consuming.

The operator's ice management plan prescribed a threshold perimeter around the survey vessel, based on the time required to safely suspend operations and move out of harm's way. However, for mobile seismic operations, there was no way to plot the constantly moving perimeter on paper along with iceberg positions. Working closely with the captain, ice observers had to estimate where an encounter might occur and exactly when to move off site/line. To guarantee the safety of the vessel, crew, equipment, and environment, they frequently decided to move off location sooner and wait longer to return than was absolutely necessary. This resulted in nonproductive downtime.

Prior to the 2013 operating season, the operator learned about recent advancements in ice data visualization and decided to optimize and field test Narwhal, a new, integrated ice management system developed by ION's Concept Systems. Narwhal evolved from the company's 30-plus years of experience in data management and software development, as well as knowledge and experience gained during eight seasons acquiring seismic data in Arctic waters.

Relevant ice information was automatically updated via ION's remote data-hosting service and combined, in multiple GIS layers including marine radar, on a single screen. Geo-referenced map and satellite data were blended with temporal dimensions in an animated "calendar" or time-slider. Using existing ice data, Narwhal predicted iceberg positions



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Narwhal set-up on the bridge of the vessel.

over ensuing 24-hour periods and automatically displayed current iceberg locations, forecasted trajectories, and the limits of the ship's safe perimeter on a single screen, even during mobile operations.

Because the captain and crew could view data in one place, they could quickly assess risks. It was estimated in 2013 and 2014 that designated ice observers gained roughly 30% more time per shift to make visual observations and to discuss options and risks with the bridge officers. Communications were deemed more effective and decisions were made faster, and with greater confidence. With better ice intelligence, the vessel could remain safely on site longer and could resume operations faster following an ice incursion into the safety perimeter. This was demonstrated in September 2014, when ice downtime was reduced by a factor of three compared to September 2012 at the same location under similar operational and ice conditions.

Advanced ice data management and visualization technology can also protect stationary or fixed offshore drilling and production facilities. For example, many oil fields are located along the infamous "Iceberg Alley" off the Grand Banks of Newfoundland (where the *Titanic* went down.) Every minute the bit stops turning or oil stops flowing, asset owners lose money. Normally ice management vessels (IMVs) keep icebergs from penetrating the safety perimeter. At times, however, IMVs may not be able to defend all the FPSOs and drilling rigs. During the heaviest ice seasons like 2014, hundreds of bergs can threaten operations. Recently, a rig had to be towed off site for a week and another for two weeks until the ice threat passed, an expensive course of action. Rig day rates and associated costs offshore Newfoundland are roughly \$1 million. Offshore Greenland, they may be twice as high.

So how can Narwhal's new ice management technology help? By integrating more data in one place, automating tasks, and tracking more icebergs in a timely manner, operators can pinpoint the arrival and departure of dangerous ice incursions more accurately than before. Narwhal enables these savings automatically and does so while also increasing the safety of personnel, equipment, and the environment.

Another new valuable tool is Narwhal's "traficability" or routing capability. Every vessel has a specific ice class classification, indicating the maximum concentration of sea ice it can safely navigate. Combining vessel classes with

satellite images and color-coded ice charts (updated daily) ice analysts can graphically identify "go" and "no-go" zones. They can quickly determine appropriate routes for tankers and supply boats to traverse icy waters between producing fields and the mainland, ensuring safety and minimizing fuel costs. In the past, even with radar, satellite images and ice charts, it was very time consuming for

ice observers to integrate or update reams of ice, weather, and ocean information. Using Narwhal's fully-integrated ice management tools, every piece of information is loaded automatically, time-stamped, and geo-referenced in a single database. As a result, ice observers, captains, and management can make more informed decisions, reduce downtime and costs under extreme conditions, and maximize the effectiveness of every operating season in icy waters. ●

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The Rig-Free Light Duty unit provides a solution for platforms with space and structural limitation. (Photos courtesy Weatherford)

Integrated approach enhances conductor removal efficiency

P&A in maturing wells becoming a growing priority

Cham Soon Hoe
Weatherford

As an integral and critical component of well P&A, conductor removal requires efficiency and safety in order to ensure operating companies comply with increasing regulations and maintain environmental stewardship. Globally, Weatherford estimates 20,000 idle offshore wells are currently in need of P&A services, which account for around 43% of total well abandonment costs. The spend globally for decommissioning over the next 20-year period is estimated at \$400 billion, the percentage of that associated with well abandonment and pre abandonment intervention is estimated at circa 40%.

Regulations require that wells must be abandoned when they have matured and are no longer productive due to depletion or damage, or cannot be revitalized cost-effectively. In some regions, governing bodies will not issue new permits to an operator until the company's idle wells are formally abandoned.

In the Gulf of Mexico, if a well has not been productive for three or more years, the operating company must develop an abandonment plan specifying a timeframe and methodology for the process. The maturing North Sea sector is also highly regulated when it comes to well abandonment. Stricter regulations are being developed for the Asia/Pacific region, where a large number of old wells are now candidates for P&A, the overwhelming majority of them on platform wells.

For service companies, P&A operations require thorough planning and operational excellence. Projects must be carried out in an efficient, safe, and in an environmentally-responsible way while complying with regulatory framework that varies from region to region.

In response to this growing market, Weatherford has developed a portfolio of services designed to facilitate single-source well P&A operations, including conductor removal from multi-well and single-jack platforms and mono-wells. In June 2014, the company completed a four-well conductor removal project for a major operator in Brunei, successfully recovering 24 joints and a total of 1,129 ft (60 m) of pipe in just over 100 hours.

The suite of services used for the operation provided a one-time solution, minimizing overall costs related to non-productive time (NPT) and additional remediation that can result from poorly-planned and executed projects. Safety was enhanced by using equipment that mitigated the risk of lifting and eliminated manual handling and gas torch/hot work issues.

Conductor removal

Removal of the conductor, the outer pipe casing that houses the internal casing string, can be facilitated with an existing rig at the well site, or by using a rigless solution with a light-duty pulling and jacking unit. If executed properly, conductor removal also provides a secondary benefit of facilitating slot recovery on multi-well platforms. After the conductor is removed below the mudline, the operator can install a conductor-type whipstock and drill a new well in the same platform, taking advantage of the existing infrastructure.

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The conductor removal technology has enhanced safety by eliminating manual handling and hot work issues.

As the abandonment portion of a well abandonment project, conductor removal is essential, and requires a full suite of complementary tools and technologies. The conductor is typically run about 200 ft (61 m) below the mud line from an offshore platform, and its assembly consists of one or more strings cemented together. In a well P&A project, after the reservoir's production zone is successfully plugged to prevent any hydrocarbons from leaking back to the surface, conductors are abandoned, or removed, to a point 3 m to 5 m (10 ft to 16 ft) below the mudline in order to leave a flat, clear ocean floor surface. Operational complexity varies depending on the water depth, total weight, and number of strings.

The Weatherford conductor removal technology family includes boring, pinning, sawing, and lifting systems to remove multiple subsea casing strings safely and quickly. A four-unit conductor cleaning system eliminates the exterior casing of any marine growth. After the initial cuts to the external and internal multi-string casing, the system bores holes through the strings, enabling the installation of pins through the holes. This process also provides a lifting mechanism that binds and secures the group of strings together. The secured strings are lifted by blocks or casing jacks with no slippage. Depending on the weight, length and the ability to pull and lay down each section of casing safely, a predetermined length is for each section is cut.

An external reciprocating saw cuts 2-in. to 32-in. pipe to enable sectioning of most material or grade. The saw provides fully-automat-

ed clamping, cutting feed, and cutting speed capabilities that allow the operator to maintain cutting consistency and control remotely. All moving parts are equipped with guards.

Brunei project

The four-well conductor removal project in Brunei was completed with an existing rig on a multi-slot platform, and involved the removal of multiple casing strings in various sizes and configurations. With each well, the time and efficiency improved. The first well involved laying down six 12 m (39 ft) sections of 13 $\frac{3}{4}$ -in.-by-20 in.-by-26-in. casing. The job was completed in 38 hours, including 90 minutes average boring time and 60 minutes average cold-cutting time.

Based on lessons learned in the first well, the second operation was completed in 24 hours, and involved laying down five 12-m (39-ft) sections of 20-in.-by-30-in. casing. Average boring time was reduced to 60 minutes and average cold-cutting time maintained at 60 minutes. Conductor removal on the third well took 24 hours, with average boring time improving from 60 to 40 minutes. The job involved laying down six 12-m (39-ft) sections of 20-in.-by-30-in. casing. Average cold-cutting time remained at 60 minutes.

The fourth well showed the most improvement in time, with the operator laying down six 12-m (39-ft) sections of 18 $\frac{3}{4}$ -in.-by-30-in. casing in 22 hours. Average cold-cutting time remained at 60 minutes; however, average boring time improved from 40 to 30 minutes. In all operations, the boring,

pinning, cold-cutting, and laying-down activities were completed safely with no lost time incidents or environmental events, with total conductor removal completed in 108 hours.

In situations where a rig is not available or where space and structural limitations and/or downgraded and damaged derricks prevent the use of a rig, a light-duty pulling and jacking unit (P&JU) that can handle conductors up to 36-in., pull 13,607 kg (30,000 lb) and jack (13,607 kg) 1 million lb is available. The unit has a hydraulically-powered telescoping mast positioned just above the well center, allowing the BOP to be positioned underneath in compliance with regulatory requirements and the ability to accommodate changing well conditions. The P&JU also has an integrated jacking system and power swivel stand that requires minimal rig-up time. It is equipped with a self-clamping system and can skid from well to well on a platform.

Abandonment is the final and inevitable stage of every well. Safe and efficient P&A programs, including conductor removal, are increasingly becoming a priority for production companies to ensure they are in regulatory compliance, maintain high environmental standards, and can move forward with new exploration and production initiatives. An integrated portfolio that provides the necessary fit-for-purpose and latest technologies and expertise, as well as flexibility, is critical in carrying out complex conductor removal operations efficiently, while avoiding risk, and NPT remediation costs. ●



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New prototype device advances decommissioning technology

Cutting system aims to increase safety, efficiency

Peter Devine
Versabar



Operated by hydraulic winches, the wire sawed through a pipe 24 in. in diameter with a 2-in. steel wall in less than one hour. (All photos courtesy Versabar)

As mandated by the federal government, so-called idle iron – wells, platforms, and pipelines that are no longer producing or serving exploration or support functions related to the company's lease – are being removed from the Gulf of Mexico.

Since October 2010 when the Bureau of Safety and Environmental Enforcement's (BSEE) Notice to Lessees mandate was issued, the removal of non-producing or damaged platforms (estimated to be as many as 650 at that time) has become an urgent matter for offshore operators. According to BSEE, not only do these damaged platforms pose a threat to the environment due to potential collapse under hurricane conditions, but they are also considered hindrances to navigation and to the safety of workers who are tasked with the repair or the removal of these structures.

Topside removal can be accomplished by welder's torches and derrick barges. However, the jackets or caissons upon which they stand present a more complex set of issues. These structures require the use of pile jacking along with mechanical or abrasive cutting devices or explosive charges, as they must be severed a minimum of 15 ft (4.6 m) below the mudline. In some cases, when internal cutting is not an option, operators must excavate below the mudline and send down divers with external cutting devices to perform the task. All of these processes present technical and operational challenges and involve considerable offshore exposure of personnel and marine assets. Versabar and Chevron teamed up with the intent of producing a safer, more efficient, and environmentally-friendly method of severing sub-sea structures. Their goal was to find a way to cleanly sever jackets and conductors 15 ft (5 m) below the mudline with a minimum of direct personnel exposure and at the same time remove the accompanying structures following completion of the cutting operation. An additional consideration was to accomplish these objectives without the damage to the marine environment caused by explosives.

While Versabar committed to engineer a working prototype, Chevron provided a 250-ton caisson-mounted topsides 3 mi (5 km) offshore near the Texas-Louisiana border to test the prototype.

Versabar President Jon Khachaturian said the challenge of the project was twofold. First, the company had to develop a cutting wire powerful enough to cut through piles and conductors with internally grouted casing strings. Second, it had to design a delivery system for the cutting wire.

Over a two-year period including months of testing at the company's Belle Chasse and Houston facilities, Khachaturian and his engineering team determined that the optimum cutting solution was a standard 2½ wire rope threaded with custom-engineered tungsten-carbide beads 6 in. long and 4½ in. in diameter.

Meanwhile, the company's engineers addressed the delivery system for the cutting wire. They needed to develop a structure strong enough to support the wire during the cutting process while affording



The cutting wire sawed through the mud and cleanly severed the 60-in. caisson along with both internal and external conductors.

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the capability to penetrate and anchor itself to the sea-bottom to maintain operational stability. It also needed to accommodate the winches, hydraulic power units, and other equipment needed to operate the system.

Khachaturian said the Versacutter prototype was purpose-engineered to be used in conjunction with the VB 10,000 heavy-lift vessel. The result was a lift frame composed of two multi-pronged anchor arms to stabilize the cutter in place, and two sharply pointed digger arms to penetrate the mud with the cutting wire and guide it into position against the structure. The 1,300-ton cutting frame itself was lowered from the twin gantries of the VB 10,000, which also provided the deck space needed for the winches, hydraulic power units, and operators' stations.

On April 22, 2014, after dockside testing was complete, the prototype was deployed to the project site. With anchor arms and digger arms working in unison, the cutting wire sawed through the mud and cleanly severed the 60-in. caisson along with both internal and external conductors, a total of eight interfaces of steel and concrete. Total elapsed time for the entire process was 10 hours. "As far



The VB 10,000 lifted the structure and carried it back to port.

as personnel exposure goes, our technicians basically stood by and watched while the cutter did its job," said Khachaturian.

Following the successful cut, the VB 10,000 lifted the entire structure and carried it back to port where it was placed on a barge for the trip to a salvage facility, completing the assignment.

Ian Todd, Versabar's director of Marine Projects, said: "One of the most important features of this approach is that it removes the uncertainty that often accompanies conventional cutting methods. This system proves the cut by passing the wire through.

You make the lift and go home."

Khachaturian and his team are quietly confident of the future of their technology. "Given what we learned by developing and operating the prototype, we're building a production model that will give us a powerful, efficient, and reliable cutting system which can be deployed on a wide range of structures in differing water depths," said Khachaturian. "Most important to the decommissioning industry, it will be an environmentally friendly and remotely operated system. We feel that this technology can have a positive impact." ●

The author

Peter Devine is a widely-traveled Houston-based writer, photographer, and graphic designer who serves as Versabar's director of publications. For 20 years, he has photographed and written about offshore Gulf of Mexico projects, including extensive coverage of the company's offshore heavy-lift vessels, Bottom Feeder and VB 10,000. More of his work can be found at www.apeterdevine.com.

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Multiple platforms facing removal after cessation at North Sea gas complex

The end of production from the Thames gas field and its satellites in the UK southern basin could trigger the most extensive decommissioning program yet performed in the North Sea. Perenco and Tullow Oil are the two operators responsible for the campaign.

Altogether, 12 fields are involved, comprising six in the Thames Complex – Thames, Bure Oscar, Bure West, Thurne, Wensum, and Yare – and six more in the greater Thames area – Arthur, Gawain, Horne, Orwell, Wissey, and Wren. They are spread out over 13 blocks and five quadrants. Cessation of production was officially declared for all the fields on May 14, 2014, ending more than 25 years of gas supply to the UK mainland via the Thames offshore infrastructure.

Original operator Arco made the first discoveries, Yare and Thames, in 1969 and 1973, respectively. However, it was not until the 1980s that gas prices and technological advances made development economical. Initially Thames, Bure Oscar, and Yare came onstream in 1986, followed by Wensum in 1987.

At start-up, the Thames field center consisted of two fixed installations, the AW wellhead platform and the AP processing platform, with 420 MMcf/d capacity (12 MMcm/d). Gas was exported to Phillips' Bacton terminal through an 89.5-km (55.6-mi), 24-in. pipeline. Thames was expected to be fully depleted in 1998, but due partly to the added satellite gas flowing through its facilities, remained in production for 16 more years. One advantage of this longevity is that decommissioning will take place under new rules introduced by the UK government in 2013 that guarantee tax relief and other advantages.

In 1990, the Welland and Tristan fields were jointly developed and tied back to Thames. Welland, which is now operated by Perenco, ceased production in 2003 and has been separately decommissioned.

Another milestone was reached in 1993 with first gas from the Orwell field. Orwell was developed with three subsea wells tied back 35 km (21.7 mi) to Thames, which at the time was the longest step-out on the UK continental shelf. Compression facilities in the shape of two 5,000-bhp units had been placed on Thames in 1989, but in 1994 a 14,700-bhp unit was added to assist recovery from Orwell and Welland. At the same time control was moved

Nick Terdre
Contributing Editor

onshore to Arco's Great Yarmouth base, making Thames the first remotely controlled processing center in the UK southern gas basin.

The next satellite tieback was Gawain, a 20-km (12.4-mi) step-out, also with three subsea wells, which came onstream in 1995. It was followed in 1998 by Bure West and Deben, both single-well developments within the Thames Complex. At the same time, a riser platform, AR, was installed with a bridge-link to AP to handle the increasing number of tiebacks. Deben ceased production in 2005, but a side track was drilled in the well to bring the Thurne reserves onstream in 2008, allowing re-use of the subsea tree, pipeline, and umbilical.

In 2005, Arthur, too, had been developed with three subsea wells and Horne and Wren with one well each drilled from a wellhead platform. In 2008, Wissey started production as a single-well subsea tieback to the Horne/Wren platform. The main mover behind these developments was Arco, which operated Gawain and Orwell as well as the Thames Complex. However, after BP acquired Arco in the late 1990s, ExxonMobil took on operatorship of the complex, eventually passing it on to Perenco in 2007. However, several of the fields

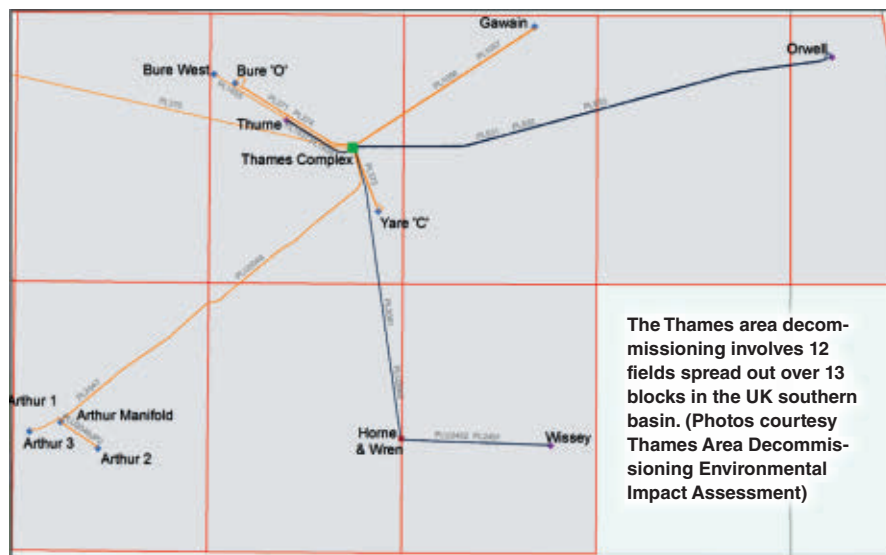
– Thurne, Horne, Orwell, Wissey, and Wren – are now operated by Tullow.

Full removal

Measures to prolong production, such as additional compression, greater liquid handling and subsea well stimulation, have been considered and discarded. Under current regulations, the licensees are obliged to entirely remove all the platforms. The largest is Thames AP, which has a 6,488-metric ton (7,152-ton) topsides supported on a six-legged, 1,100-metric ton (1,212-ton) jacket. The AW wellhead platform has a 2,035-metric ton (2,243-ton) topsides on a four-legged, 950-metric ton (1,047-ton) jacket. The AR riser platform features a 406-metric ton (447-ton) topsides on a four-legged, 600-metric ton (661-ton) jacket. Water depth at the field center is 32 m (105 ft).

Topsides removal will be performed by a heavy-lift vessel (HLV), single-lift vessel, (SLV) or a combination of a crane vessel and the piece-small method. The decision will be based on the bids submitted. Jacket removal will be performed by an HLV or SLV, or by attaching the structures to an up-ended barge, a method untried to date in the North Sea.

The Horne/Wren platform is a small, unmanned installation with a 90-metric ton (99-ton) deck supported by a 455-metric ton (501-ton), tripod jacket in 41 m (134 ft) of water. Following a conceptual platform removal study



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by Xodus in 2013, the platform will be removed by reverse installation.

On Thames itself, there are five platform wells to be P&A'd, comprising three producers and two water disposal wells. One of the producers was drilled into Wensum. A rigless method will be used to plug the platform wells. There are also five subsea wells, one each for the four fields in the complex, plus a suspended subsea well located beneath the AW platform.

In the fields outside the Thames Complex there are a further 12 wells to be plugged – 10 subsea and two platform drilled. There are also subsea structures on the Arthur, Gawain, and Orwell fields. The Arthur wells are tied into a manifold while the wells on Gawain and Orwell are each housed on a template/manifold. The structures vary somewhat in weight. The Arthur manifold weighs 23 metric tons (25 tons) with a protection frame of 355 metric



Three platforms make up the Thames field center.

tons (391 tons). The Orwell template weighs 250 metric tons (275 tons) and the protection frame in which the manifolds are incorporated, another 200 metric tons (220 tons).

Templates, manifolds, and protection structures will be retrieved and disposed of onshore. However, a survey of the pipelines and umbilicals, including the export pipeline to Bacton, showed that they are trenched and buried, and should therefore be left in place after flushing and cleaning and cutting off any exposed ends.

Stabilization materials such as rock, frond mats, and grout bags will be assessed for integrity and burial depth, although the bulk of this material will also likely be left in situ. Attempts will be made to remove the concrete mattresses safely, but if these fail, a proposal will be made to leave them in place.

There is no recommendation concerning drill cuttings piles. Due to the strong seabed currents in the shallow waters of the Thames area, no cuttings piles have been found, so they are all presumed to have been dispersed.

The overall cost for the multi-field program is estimated at £221.5 million (\$336 million). Decommissioning the Thames field center and complex will cost £96.1 million (\$145.9 million), or 43% of the total, with the platform removals costing £43 million (\$65 million) and the well P&A another £40 million (\$60.7 million).

Of the outlying fields, Arthur will be the most expensive to decommission, with an estimated cost of £44.1 million (\$66.9 million), of which the P&A accounts for £33 million (\$50.1 million). Then comes Gawain, with an overall cost of £31.8 million (\$48.3 million), of which P&A is £25 million (\$37.9 million), followed by Orwell at £19.5 million (\$29.6 million), with P&A accounting for £14 million (\$21.2 million). For Horne and Wren, the estimated cost is £21.5 million (\$32.6 million), of which platform and pipeline decommissioning account for £13 million (\$19.7 million).

Decommissioning operations such as well abandonment will be coordinated on the various fields where possible. Activities were due to get underway in the latter months of 2014 and are expected to be completed by 2018. ●



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Smart valve system provides interventionless completions

Technology applied for gas lift offshore Thailand

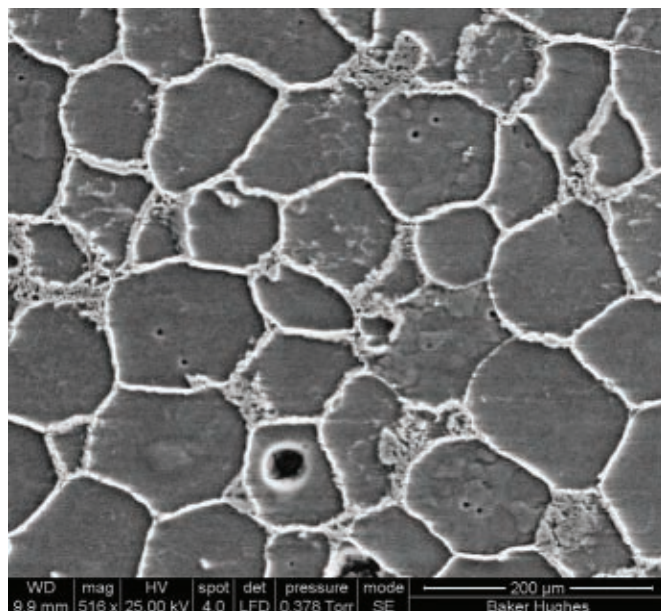
Zhiyue Xu
B. M. Richard
James H. Kritzler
Baker Hughes

The artificial lift method of gas lift is an increasingly popular means of boosting production from wells with lagging reservoir pressure. The method injects a compressed gas into well annulus between the production tubing and casing. Tubing and casing pressures cause the valve to open and close, which introduces the gas into the produced fluid in the tubing. The injected gas aerates the fluid to reduce its density, thus allowing the reservoir pressure to push the mixture of produced fluids and gas up to the surface.

Multiple gas lift valves are typically installed in a well to ensure optimal production as the well's pressures, fluid compositions, and productivity change. In a representative four-valve gas lift system, each gas lift valve is installed in a side packet mandrel (SPM), which in turn is placed on the production tubing of a gas lift well. Gas lift valves are designed for installation and removal by wireline while the mandrel remains in the well, which eliminates the need to pull the tubing to repair or replace the valve (as is required in a conventional gas lift mandrel).

After initial installation of a live gas lift valve system, pressurization is required to confirm the pressure integrity of the tubing or annulus, set a hydraulic packer, activate an isolation device or run cement through completion. Any unplanned pressure reversal or cement debris may damage the live gas lift valve, resulting in costly well completion failures.

Dummy valves are commonly deployed as a means of avoiding damage to a live valve. These higher pressure-rated dummy valves are loaded in the SPM to isolate the annulus from the tubing during initial pressurization or the cementing-through operation. Should the well then require gas lift to unload the completion fluid or to get the well flowing, the dummy valves must be replaced with the live gas lift string via a wireline intervention. Not only can an inter-



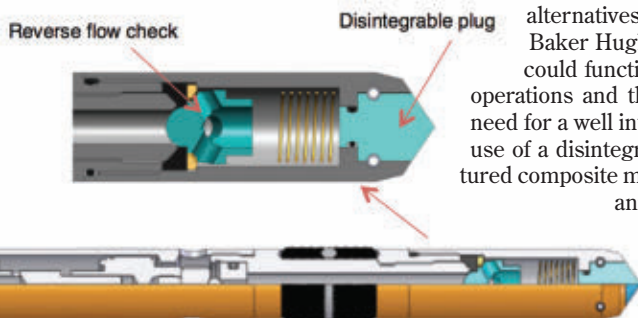
A representative scanning electron microscope micrograph of a nanostructured composite shows the cellular nanomatrix (white grain boundary) and metallic grains dispersed in the nanomatrix. (All images courtesy Baker Hughes)

vention be a time-consuming process that poses risks to the existing well infrastructure, but it also delays the onset of production. Slickline crews are a finite and in-demand resource, and sometimes cannot be scheduled for a valve change-out project for many weeks. Some industry estimates suggest that waiting up to one month for a valve change out on a 20-well platform translates to as much as 100,000 bbl in lost production.

A nanostructured solution

The industry need for lower risk, interventionless alternatives to gas lift valve changeouts prompted Baker Hughes to develop a smart gas lift valve that could function as a dummy valve during completion operations and then convert to a live valve, without the need for a well intervention. This is achieved through the use of a disintegrable barrier or plug made of nanostructured composite material. This plug provides the necessary annulus isolation while performing completions work, and then disintegrates in the presence of brine during the cleanup process, thus increasing completion operation efficiency of offshore wells. The nanostructured composite

Design of smart gas lift valve showing the time-controlled disintegrable plug assembled in the nose section of a standard gas lift valve.





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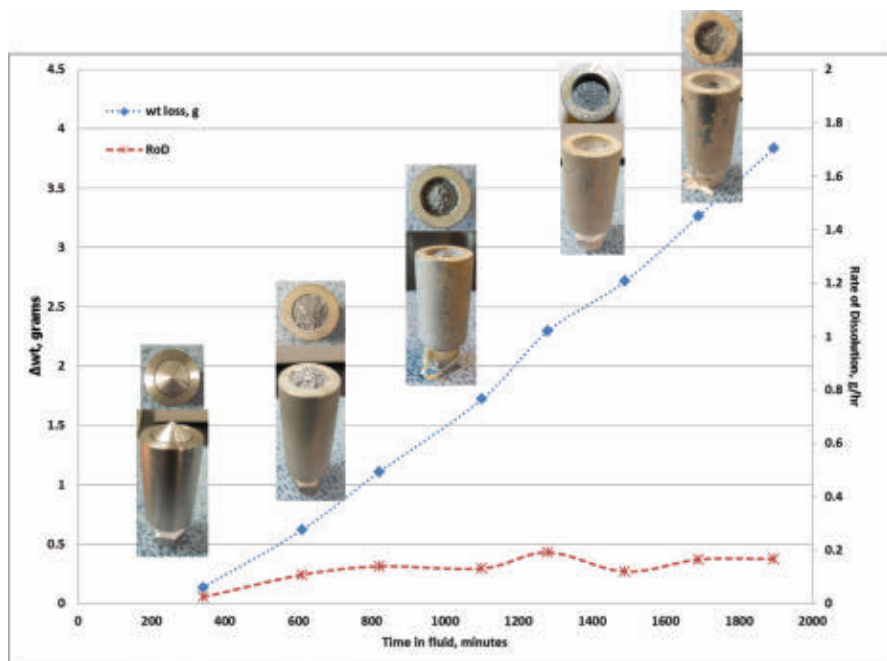
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Rate of disintegration of nanostructured composite material in various operations.

plug is rated for high pressures, chemically resistant to drilling mud, slightly reactive with fresh water, and disintegrates within 12 to 50 hours in salt water.

The smart material used to make the time-controlled barrier is a nanostructured powder metallurgy composite manufactured by consolidating reactive metal powders coated with metallic and/or ceramic reinforcements. Material composition and structure can be engineered at the micro- or nanoscale to vary the material strength and disintegration rate. The combination of high-strength and controllable disintegration rate is accomplished through engineered nanostructures between metallic grains. These grains become activation points for dissolution that can be triggered on demand. The nanostructures also act as strengtheners, which yield a composite material with high strength and toughness.

Typical concentrations of ions present in seawater, completion brines, formation fluids, or remediation acids, as well as typical downhole temperatures of 120°F (49°C) or higher, trigger a predictable and homogeneous dissolution of the nanostructured composite.

The nanostructured composite was then incorporated into a smart gas lift valve design in the form of a time-controlled disintegrable barrier or plug. Assembled in the nose section of the valve, the disintegrable barrier replaces the two nose holes in a standard valve design, while retaining the same geometry, cone-shaped nose tip and the reverse flow check dart design of a standard gas lift valve.

Prior to introducing a smart gas lift valve into the field, extensive laboratory testing was performed to determine the in-field operating parameters within which the valve would safely and reliably operate. Disintegration tests were conducted in different fluids at 200°F (93°C) and 1 atmosphere pressure. The results of these tests showed that the composite material is resistant to oil-based drilling mud, slightly reactive with fresh water or cement, and rapidly disintegrates in 3% KCl brine or seawater. This makes it ideal for offshore gas lift valve applications.

In another series of disintegration tests, the time-controlled disintegrable plug was assembled in a fixture that duplicated the standard gas lift valve nose design and was submerged in seawater at 275°F (135°C) and 500 psi (34.5 bar). The mass loss of the plug due to the disintegration reaction with seawater was measured at various time intervals. The test was stopped at 31.6 hours, when the plug lost most of its fluid-sealing dimension. The plug disintegrated uniformly throughout the test period at an average rate of 0.18 g/hour. The test verified that the plug design could meet the required 12-to-50 hour disintegration/conversion time for the dummy valve to become a live valve for gas lift.

Field trial in Thailand

In the Gulf of Thailand's Platong field, located 245 km (152 mi) east of mainland Thailand, the number of wells on gas-lifted production has gradually increased from 10% in June 2008 to more than 50% of current

total field production. A major driver for this increased usage of gas lift is the reduced cost of installation. For example, in a monobore completion (a process in which a single production tubing size is used from the pay zone all the way to the surface of the well), the total cost of a one-trip cement through completion with gas lift is \$1.67 million. This is a one-third reduction when compared to the \$2.50 million cost of a conventional completion with casing and a separate upper and lower completion.

In a one-trip monobore gas lift completion, operators installed SPMs with the conventional live orifice or gas lift valves in the production tubing to prepare the wells for gas lift. Multiple slickline trips were necessary and costly completion failures occurred, including flow cutting of the reverse flow check valve during an unplanned pressure reversal. The failures occurred because the live gas lift valves were unable to hold the pressure as well as dummy valves while pumping cement through the SPM or activating the hydraulic packer.

The operator called Baker Hughes to install its time-controlled disintegrable plugs as part of a smart gas lift valve solution. The smart valves were installed in the SPMs prior to running the SPMs downhole, and then performed precisely as designed. The nanocomposite temporary dummy valves successfully isolated the annulus from the tubing and provided a proper pressure seal time for cementing and pressure testing operations to be completed. The plugs then disintegrated in brine during the cleanup process, converting the system to live valves for gas lift. The use of smart gas lift valves eliminated multiple slickline trips or well interventions after completion, saved service costs, and reduced health, safety, and environment risks.

The major benefit of the new gas lift technology was the immediate recovery of oil and an earlier return on investment, as time delay waiting for slickline service was eliminated. Because of the success of the smart gas lift valves with time-controlled disintegrable plugs, the operator requested the smart gas lift valves for all future projects in the Gulf of Thailand. ●

Acknowledgment

Based on a paper presented at the SPE Deepwater Drilling and Completions Conference, held Sept. 10-11, 2014, in Galveston, Texas.

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Onshore pipe-in-pipe assembly.
(Photos courtesy Technip)

Pipe-in-pipe technology adapts to changing needs in deep and shallow water

Sylvain Denniel
Technip

Over the past two decades, the pipe-in-pipe (PiP) product has become an essential part of the subsea field development engineer's "tool box." Due to its high insulation performance it minimizes heat losses from the transported fluid to the environment that more traditional subsea coatings cannot provide. This is achieved using thermal insulation of very low thermal conductivity, such as aerogel, encased in dry atmospheric conditions between the inner pipe or "flowline," which transports the fluid, and the outer pipe or "carrier," which provides the mechanical protection from the subsea environment.

Other benefits of the PiP solution include compatibility with high temperatures (in terms of material and enhanced compliance with large axial loading), stability on the seabed, and protection by the outer pipe against external loads. In some cases this may obviate the need for burial.

In 2014, Technip installed its 50th PiP via the reel-lay method; the first project was in Australia in 1989. Along the way, the company has advanced the technology at various points. For example, the company's third PiP project in 1997 on Statoil's Gullfaks field in the Norwegian North Sea. This represented the first implementation of a corrosion resistant alloy (CRA) flowline, but more importantly, the un-bonded design was to become the essential DNA of the product for the projects that followed.

During manufacture, flowline and carrier pipeline stalks are first welded and inspected. Then the flowline stalk is progressively sleeved into the carrier pipe stalk, while thermal insulation panels and nylon rings are hand-applied at regular intervals. The function of the nylon rings, known as centralizers, is to maintain the two pipelines concentric and to mechanically protect the thermal insulation during each phase of the PiP assembly, installation, and operational life. Once full PiP stalks are completed, they are spooled onto the reel-lay vessel following intermediate tie-in connections.

The next major milestone was the first implementation of a reeled PiP on a deepwater project, BP's Nile field in the Gulf of Mexico (GoM) in 2001. Novel features introduced for this installation included microporous insulation, designed to meet the field's challenging thermal demands, and the implementation of qualified buckle arrestors and waterstop features. The aim was to limit the potential consequences of a (very unlikely) wet buckle event. Experience gained on this deepwater project proved important for future projects in the GoM, West Africa, and Brazil.

In 2002, Technip installed the first reeled PiP steel catenary risers on Shell's Nakika field in the GoM in water depths of more than 2,100 m (6,890 ft). Four years later, Total's Dalia field development offshore Angola featured the first qualification and industrialization of superior aerogel insulation to achieve exceptionally high thermal performance.

But there have also been technical advances in the shallower environment of the North Sea. In 2011, the first implementation of a fully reelable bulkhead on BP's Devenick project in the UK central North Sea was a breakthrough for the reeled PiP product. It enabled



Spooling pipe-in-pipe onboard reel-lay vessel.

tight separation of a PiP in independent sections, permitted the first implementation of a fully reeled T-piece, and led to major enhancements in pipelay schedule efficiency.

In January 2012, the first electrically trace heated (ETH) PiP was deployed on Total's Islay field in the UK northern North Sea. This transformed the technology from a simply passive flowline to an active system. The ETH-PiP technology allows active control of the temperature of the transported fluid, including monitoring in real time of the pipeline temperature profile, using fiber-optic technology.

Subsequent offshore testing campaigns on the installed system demonstrated the efficiency of this active heating technology, which exceeded expectations in terms of reactivity and accuracy. The results also enabled the calibration of comprehensive and sophisticated computational fluid dynamics (CFD) models to accurately predict the ETH-PiP performance in service and underlined the benefits of the technology for addressing complex flow assurance issues.

In parallel, Technip has been performing a comprehensive full-scale hydrate plug dissociation test program. This is designed to demonstrate the capability of the ETH-PiP technology to identify, characterize, and melt hydrate plugs in a safe and fully controlled manner by turning on and then carefully adjusting the external heating power provided by the ETH cables, as monitored by the optical fiber system. This three-year R&D initiative will be completed during the current quarter, and has been supported by several majors in the framework of a joint industry project.

As a result, loops for flowline preservation purposes can be eliminated and field lay-outs can be simplified by considering single line architectures for all the production flowlines.

Furthermore, since the Islay project, a second generation of electrical trace heating cables has been developed and qualified to enable the heating of much longer flowlines. Long tiebacks of satellite fields to existing facilities more than 40-50 km (25-31 mi) with minimum electrical power requirements (i.e. only 1 MW typically) are now feasible.

Finally, the ETH-PiP technology is now reaching a maturity level which should help operators to develop increasingly complex and challenging offshore fields in the future while optimizing the SURF-related capex by minimizing the number of flowlines and risers. ●

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People

Polarcus has appointed **Rod Starr** as CEO. He succeeds **Rolf Ronningen**.

AGR has appointed **Olav Fjell** as chairman of the board of directors.

Electromagnetic Geoservices has appointed

Bjarte H. Bruheim as CEO.

Secretary of the Interior Sally Jewell has named **Abigail Ross Hopper** as the director of the Bureau of Ocean Energy Management.

Trans Adriatic Pipeline AG has hired **Ian Bradshaw** as managing director. He succeeds **Kjetil Tungland**.

Hyundai Heavy Industries has promoted **Park Jong-bong** to senior executive vice president and has appointed him as COO of its Offshore & Engineering Division.

Tanzanian President Jakaya Kikwete has appointed **Dr. James Mataragio** as director general of the Tanzania Petroleum Development Corp.

Petrobras has appointed **João Adalberto Elek Jr.** as governance, risk management and compliance officer.

Bureau Veritas has appointed **Mathieu de Tugny** as senior vice president in charge of offshore activities within the Marine & Offshore Operating Group.

Chris Weston has officially assumed the position as CEO of Aggreko. He succeeds **Ken Hanna**, who has reverted to his previous role as non-executive chairman.

Roy Buchan has joined Ithaca Energy Inc. as COO.

Randall P. Bergeron, president and CEO of Tesla Offshore, has retired. He will assume the role of executive director. **C. D. Schempf Jr.** has been named president.

Sterling Energy has appointed **Matthew Bowyer** as exploration director. He succeeds **Dr. Phil Frank**.

Jason Steward has joined BMT Nigel Gee as business development manager.

LyondellBasell has appointed **Bhavesh V. Patel** as CEO. He succeeds **James L. Gallogly**, who announced plans to retire.

Dr. Charles Woodburn has joined Seadrill Ltd.'s board of directors.



Jong-bong



Weston



Bergeron



Schempf Jr.

Company News

McDermott International and **GE Oil & Gas** have launched **io oil & gas consulting**, a new independent venture for front-end offshore field development.

CGG has confirmed that its new Multi-Physics business line is now up and running within its Acquisition Division. The new Business Line combines all of the company's airborne capabilities with its GravMag business.

Sound Oil has withdrawn its proposed public offer for the entire share capital of UK North Sea specialist **Antrim Energy**.

ABB UK has signed a memorandum of understanding with **Baku Higher Oil School** to develop training for oil and gas personnel in Azerbaijan. This aims to give the university access to technology and engineering expertise. ABB aims to raise awareness of local graduates of the benefits of a career in oil and gas control and instrumentation engineering.

In Memoriam

Lawrence Sanford, founder of **TAM International, Inc.**, passed away on Jan. 7, 2015, following a long-term illness. He was 90 years old. He purchased **TAM Products Inc.** in 1972, and rebranded the company as **TAM International Inc.** in 1973 to expand the company's market presence and capitalize on global opportunities.



Bentley Systems Inc. has acquired **C3global**, including its web-based Amulet operational analytics software.

Shipdock Amsterdam and **Shipdock Harlingen** have changed their names to **Damen Shiprepair Amsterdam** and **Damen Shiprepair Harlingen**, respectively.

Prospect Flow Solutions has joined **Wild Well Control** to serve as its new Advanced Engineering group.

Elite Control Systems has opened its first office in Aberdeen, Scotland.

Palfinger Marine has acquired **Norwegian Deck Machinery AS**.

Pegasus Vertex Inc. has launched the new **DR.DE Lite** mobile app for both Android and Apple devices.

Superior Drilling Products Inc. has purchased the exclusive manufacturing, marketing and sales rights and the current inventory of the **OrBIT** completion drill bit product line from **Tenax Energy Solutions**.

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Culture change critical for offshore competitiveness

Growth and volatility are driving global demand for change in the energy industry. There is a mission critical need for leaders who can successfully face persistent and continuously emerging challenges that drive change in the industry. Nowhere is this more evident than in today's offshore E&P environment.

Bruce Bullock, director of SMU Cox's Maguire Energy Institute, boils down the industry's challenges to financial performance: "The industry has to find ways, through technology, efficiency, science and other strategies to really improve its financial results over the next several years." The drive for financial performance demands change leadership skills from all levels of management and a new perspective on change.

Business typically has used three perspectives on change, each with its own implementation methods. They are:

- Transitional change: implementation of a known new state
- Developmental change: improvement of what is
- Transformational change: emergence of a new state, unknown until it takes shape, out of the remains of the chaotic death of the old state.

It can be argued that the US government support for General Motors and Chrysler during the 2008-2010 financial crisis saved these firms—and the domestic US auto industry—from a chaotic death. Meanwhile, Ford implemented transitional and developmental changes to effect a transformational change without government support.

The scope and speed of change in today's energy industry requires a fourth perspective on change. The industry must create an asset that did not exist before – a learning organization capable of adapting to a continuously changing competitive environment.

What can oil and gas company leaders do to create such an organization? They must lead change from the periphery. This requires managers to do two things: create an internal market for change and use revitalized units as organizational models for the entire company. More specifically, unit managers create ad hoc arrangements to solve concrete problems by directing employees' responsibilities and relationships toward the company's central goal. Top managers specify the firm's general direction without dictating solutions to individual operations, and spread lessons of revitalized units throughout the company.

Change is mobilized by joint diagnosis of business problems, creating a shared vision of how to organize and manage an operation. This yields consensus for the new approach, requires the development of new competence to execute it, and results in cohesion to move it along. Then the new idea can be spread to other departments. After that, formal policies, systems, and structures

can institutionalize revitalization. Ongoing monitoring will allow for adjustments and responses to new problems and changes in the competitive environment.

Accomplishing this will require new skills of managers. They must encourage problems to surface and resolve them at the lowest possible level. In order to promote the skills of problem solving and teamwork in their employees, managers must abandon a traditional control orientation for one of involvement. They must become facilitators rather than "bosses." They delegate; they maintain open doors, and they lead by example. They have skills in networking, trust building, and transparency of communication.

In order to develop these skills in managers, energy firms must use all the tools at their disposal. Leaders have three primary learning resources to draw on to help them maintain their competitive edge. They are:

Workplace. Structured on-the-job situations and projects allow leaders to apply new learning. Challenging new assignments can focus on cross-functional growth, multi-cultural experience, business opportunities in growth, new ventures, and turn-arounds, plus informal and formal mentoring relationships.

Classroom. Today's action-oriented classroom provides access to subject matter experts and practitioners. It provides new insights and encourages experimentation with new ways of thinking and behaving by incorporating assessment instruments, simulations, exercises, team projects, case studies, executives who serve as classroom advisors, and instructors who are skilled in facilitating experienced managers to learn from their past experiences—and those of their peers.

Community. The most progressive learning organizations are also using the community as a learning resource to develop critical leadership skills among their managers. These organizations encourage managers to intentionally pursue volunteer activities and service on non-profit boards as part of learning and development plans.

Use of all three of these learning resources promotes continuous learning and develops the skills of flexibility and adaptability. They also develop leadership skills in trust building, networking, communication, and empowerment needed to promote teamwork and problem solving at all levels. Leaders with these skills will inspire change from the periphery—a hallmark of organizations capable of adapting to continuous change in an uncertain business environment.

Frank R. Lloyd, Ph. D.
Associate Dean, Executive Education
SMU Cox School of Business



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No structure is stronger than its weakest part. To avoid disasters in offshore oil and gas field operations, it is essential that the strength analysis is done before the structures are put into operation.

Ole Jan Nekstad, product director at DNV GL, holds a vital part of those analyses. Through DNV GL developed software, he enables the industry to calculate the risk from wind, wave and fatigue impact, something that will determine the safety, lifetime and profitability of the total operation. The software is called

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12 in the Cyprus EEZ, by the off-
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CYPRUS

LIFTING THE LID ON AN OFFSHORE NATURAL GAS BONANZA

When Texan independent E&P player Noble Energy unexpectedly uncovered substantial quantities of offshore natural gas deposits within Cyprus' exclusive economic zone (EEZ) in late 2011, it set the scene for wild celebrations and marked a turning point in the history of a nation hitherto known more for its tourism, shipping and financial services. Three years later, the heady optimism shows little sign of relenting with many believing that the country's hydrocarbons endowments will provide a speedy route back to economic prosperity following Cyprus' banking meltdown and near bankruptcy last spring. "To a great extent, I would expect our rapidly emerging hydrocarbons industry to assist in rebalancing the economy while simultaneously furthering the stabilization of our banking sector," confidently predicts Angelos Gregoriades, chairman and head of tax at KPMG.

DAWNING OF AN ENERGY EXPORTER

There can be absolutely no doubt that the discoveries will have a transformative impact on the local economy. A country that formerly relied on imported oil to cover 94 percent of its energy consumption requirements and nation once subjected to the EU's highest electricity prices can now contemplate a future of energy autonomy and exports. In the words of Yiorgos Lakkotrypīs, Cyprus' energetic Minister of Energy, Commerce, Industry and Tourism, "natural gas discoveries deliver an entirely new dimension to the Cypriot economy affording a range of great opportunities over the short, medium and long term."

"Initially we are witnessing significant investment from international E&P outfits, from independents such as Noble Energy to super-majors like Total, and equally from the types of firms that service the upstream segment of the gas value chain such as Schlumberger and Halliburton," he explains. "Then, in the mid-term, the country will enjoy the revenues accrued from the sale of hydrocarbons on European and global markets. Finally, we should be able to develop a knowledge-based community specializing in oil and gas related services, which can continue to nourish the economy even after our reserves have been exhausted," he asserts.

This is, however, uncharted territory for a nation formerly unfamiliar with the industry, and thus needs careful management. "We



Yiorgos
Lakkotrypīs,
Minister
of Energy,
Commerce,
Industry and
Tourism

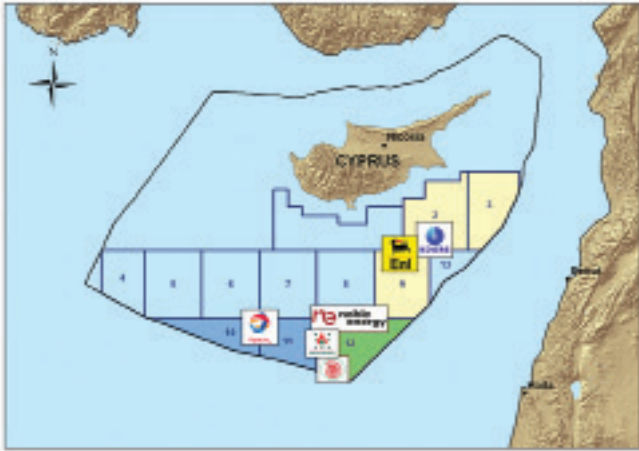


Evgenios
Evgeniou, CEO,
PwC

must not become sheikhs," exclaims George Shammas, chairman of the Cyprus Energy Regulatory Authority, while unveiling his proposal for a sovereign wealth fund to recycle gas revenues into sustainable, equitable human-centered development. "What we are doing today in the hydrocarbons sphere should be for future generations and provide the foundation for the next cycle of the island's economic growth, rather than regarded as shortcut to solve problems of the past," counsels Evgenios Evgeniou, CEO of PwC in Cyprus.

"To think of it as a silver bullet to solve all of today's problems would be fundamentally the wrong approach," agrees Nicos Papakyriacou, partner and Cyprus oil & gas leader at Deloitte. "The real benefits will come in the mid- to long-term. In the meantime, we must not lose focus by putting all our eggs in one basket and overly relying on hydrocarbon revenues. We must resist the temptation to place all our expectations in this one industry," he warns.

MAP OF THE EXCLUSIVE ECONOMIC ZONE OF CYPRUS



MIGHTY APHRODITE, UNTOLD RICHES

Just how extensive, then, are Cyprus' natural gas reserves? Currently 13 exploration blocks have been drawn up south of the island, the rights to six of which have been awarded during the course of two licensing rounds in 2007 and 2011 respectively. Noble Energy's original headline discovery in block 12, which was subsequently christened 'Aphrodite prospect,' was initially thought to contain some 3.6 tcf (trillion cubic feet) of gas. This figure was very recently raised to 4.54 tcf by Noble's Israeli partners (Delek Drilling and Avner Oil Exploration which together hold a 30 percent stake in the field). The figure for condensate, a liquid byproduct of natural gas that can be sold separately, meanwhile was also raised to 9 million barrels from a previous calculation of 8.1 million.

To date, Aphrodite represents the sum total of proven Cypriot reserves. On its own, this makes for quite a conundrum when it comes to selecting monetization options. On the one hand, the island's domestic energy consumption is too meagre to justify development of the play and thus at least a portion of the gas produced must be exported. On the other hand, the revised numbers still do not come close to the minimum amount of gas which the operator Noble Energy says is needed to make the government's preferred choice of an onshore LNG plant commercially feasible. According to Keith Elliott, Noble's senior vice chairman

for the Eastern Mediterranean, the threshold would have to be "well north of 5.5 tcf...preferably between 6 and 7 tcf."

This sobering news, however, has to be considered alongside US geo-seismic survey data that estimates possible total gas reserves in the Levantine and Nile Delta basins at 122 tcf and 223 tcf respectively, not to mention oil deposits equivalent to some 3.4 billion bbl. Also to be considered is the Cypriot government's distinctive exploration and production sharing contracts (EPSCs) that commit the licensee holders of each of the awarded blocks to executing 'aggressive' exploration work programs to short deadlines. In other words, further discoveries, probably of a significant stature, can be expected.

Outlining his exploration roadmap, Minister Lakkotrypis explains that the Cypriot state has signed "three EPSCs with a consortium comprising ENI and Kogas, two with the super-major Total, and one with the Noble / Delek / Avner partnership." Looking ahead, "ENI / Kogas are well underway with a very extensive exploration program, lasting 12 to 18 months depending on findings, while Noble will be drilling at least another exploration well in 2015 and conducting subsequent appraisals of Aphrodite. Concurrently Total is in the process of interpreting the thousands of kilometers of seismic data they have acquired for a completely new zone in the Nile Delta Basin," he explains. "We believe that the next six months will be critical in determining the future direction of the Cypriot gas with additional information on new discoveries imminent," agrees Toulia Onoufriou, president of the national oil champion, the Cyprus Hydrocarbons Company (CHC).

Others are even more bullish on discovery prospects. "The Eastern Mediterranean is nothing short of a 'North Sea Mark II'," says Solon Kassinis, managing director of his own energy consultancy and erstwhile director of energy at the ministry. "The Israelis claim to have discovered 37 tcf, while Cyprus anticipates an estimated 60 tcf in blocks that only represent a fraction of our EEZ. Then there is the reserves potential of Greece, Lebanon, Palestine and Egypt to add to the mix...we are all Norwegians now."

CROWNING PIECE OF THE JIGSAW?

Cyprus' true potential in oil and gas, however, transcends upstream production of its hydrocarbon endowments. "What would attract real investment into Cyprus is not so much the reserves

THE MARKET KNOWS BEST: DECODING THE CYPRIOT REGULATORY REGIME

Cyprus has so far avoided the 'dash to tax' hydrocarbons that plagues many resource-rich states and this laissez faire stance on taxation seems more than likely to continue. "Cypriot governments are renowned for adopting policies that foster stable and business-friendly regulatory regimes recognizing the economic reality that true wealth for the nation arises from employment and prolific business activity, rather than by heavily taxing specific sectors," explains PwC's Evgenios Evgeniou. "We are an economy based on free enterprise where the private sector forms the backbone of economic activity," adds EY's country assurance and oil & gas leader Stavros Pantzaris.

Indeed, there is no specific regime within Cypriot income tax legislation relating to oil and gas with profits from trading operations instead taxable at the standard corporate income tax level, which in turn ranks the lowest within the EU. Furthermore, many analysts see little need to start tinkering with the existing framework. "Instead of overhauling its tax structures, Cyprus has opted for a profit-sharing contract context. If we follow this trend, there may well be no need to have a specific oil and gas tax system as such. Regarding high-wealth individuals working in this sector however, there could, of course, be

new provisions introduced," muse KPMG's Angelos Gregoriades and board member Iakovos Ghalanos.

Meanwhile the government certainly appears well attuned to the need to cultivate the right enabling environment for the fledgling natural gas industry to thrive. In the words of Energy Minister Lakkotrypis, "Cyprus is at a critical juncture in its development path. We are overtly seeking investment and I urge the community to investigate Cyprus as an epicenter of new frontier ventures." So as to incentivize them, "we are hard at work creating a local business climate that these companies will find very much to their liking," he adds, pointing to a raft of new policy measures aimed at fast tracking the permitting process for energy projects and allocating land to energy infrastructure developers at favorable terms.

"Over and above an extensive double tax treaties network, Cyprus ranks 39 out of 189 countries in ease of doing business, has no foreign exchange controls and market entrants enjoy low set up and maintenance costs along with a wide range of supporting services provided by local professionals so the island is truly attractive from a business standpoint," concludes Pantzaris.

DECIPHERING CYPRUS' GAS MONETIZATION OPTIONS

Cyprus, to this day, remains an isolated energy island with no interconnections with trans-European electricity and gas networks. The 'great unknown' is therefore how Cyprus can best bring its newfound gas wealth to market. Reserve size will play a decisive role in determining the type and volume of investments made both upstream and downstream, so ultimately much will hinge upon the next round of discoveries. Nevertheless, the following represent the main options currently under consideration:

LIQUEFIED NATURAL GAS (LNG)

The Cypriot government has been vigorously promoting the concept of a USD 10 billion liquefied natural gas facility to be built by private groups in Vasiliko enabling the country to ship gas to Asian markets and adjust its customer base in line with spot market prices.

TRANS-MEDITERRANEAN PIPELINE

DEPA, the Greek natural gas operator, has been conducting feasibility studies into connecting Cyprus with the Greek Peloponnese via an underwater gas pipeline. Depths exceeding 2,000m combined with an active seismic environment pose substantial technical challenges.

CYPRIOT-EGYPTIAN PIPELINE/FPSO COMBINATION

British entity BG Group has approached the operators of Aphrodite play with

a view to securing gas for their Idku LNG plant in Egypt. The proposition comprises a 600km pipeline coupled with a floating production, storage and offloading (FPSO) unit over the gas well.

GAS-TO-WIRE (GTW)

The idea of a 'great 2,000-Mw Eurasia interconnector' has been mooted by a consortium led by DEH Quantum Energy in which natural gas would be converted to electricity within Cyprus then transmitted by submarine cable to European markets routed via Crete and mainland Greece.

COMPRESSED NATURAL GAS (CNG)

Pipeline-quality natural gas would be compressed to 20 MPa and transported in small quantities by vessel to relatively near markets such as Lebanon and the Greek Islands. This 'more interim' solution would deploy techniques hitherto never commercially tested in the Mediterranean.

FLOATING LIQUEFIED NATURAL GAS (FLNG)

Woodside Petroleum, an Australian outfit with LNG expertise, is still pondering an ambitious proposal to construct a floating LNG platform. Again this would be highly capital intensive.

themselves, but rather the regional function that the country can fulfill as the primary market outlet for LNG for the entire Eastern Mediterranean region," surmises Kassinis. PwC's Evgenios Evgeniou concurs. "From my perspective, it's very clear: the added-value to be accrued from being part of an energy hub is potentially an even better prospect than the natural gas discoveries

themselves. The Eastern Mediterranean and the Levant region are developing as a new frontier in terms of natural gas and oil, and Cyprus has the prospect of establishing itself right at the heart of this cluster," he observes.

With its geo-strategic location at the gateways to Europe, Africa and Asia, the island would certainly seem appropriately situ-



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BOOM TIME FOR PROFESSIONAL SERVICES

Traditionally Cyprus enjoys a strong competitive advantage in the professional services sector especially in ancillary support segments such as audit, tax management and legal consultancy. The sector, whose ascendancy actually predated the banking surge of the past decade when the country decisively leapfrogged conflict-torn Lebanon as a preferred business services hub, is now set for another growth spurt as it extends out into the hydrocarbon domain. The island's foremost consultancies are already jockeying for position to attain a slice of the new markets opening up.

"The blossoming of Cyprus as an offshore financial center jurisdiction generated not only substantial short-term income, but also considerable *savoir-faire* in specialist fields such as accountancy much of which remains to this day. That legacy will prove highly useful when applied to the nascent oil and gas industry," opines KPMG's Angelos Gregoriades. "All the ingredients are already in place towards building a sound industry capability so as to cover the whole range of services for oil companies, from risk management and compliance to business optimization, human capital sourcing and corporate finance capabilities," agrees PwC's Evgenios Evgeniou.

Many of these market offerings will be targeted towards incoming energy firms with a view to mentoring them in their alignment with local tax provisions, the indigenous business context and regulatory sphere. "Our oil and gas tax professionals already work with many of the leading players to help our clients render tax a more controllable and predictable cost in what is, after

all, a highly dynamic and ever-changing market," reveals EY's Stavros Pantzaris.

There will also, simultaneously, be much scope for advising the Cypriot state in how to manage and configure what is, in effect, an entirely new industry for the country. "We will be on hand to promote best practice and assist the government in correcting bottlenecks that pose problems for the operators and in formulating the sorts of legal frameworks in order to be able to attract new players to the region," promises Deloitte's Nicos Papakyriacou.

Meanwhile the government's agenda is yet more ambitious: aiming to render the island the 'go-to' focal point for hydrocarbon support services for the entire region. "It makes sense that we develop a specialization in oil and gas services that can then be exported throughout the Eastern Mediterranean. Neighboring states will be commencing their own exploration activities in the near future and the demand for technical, commercial and legal support will be vast. Our aspiration is to position the Cypriot economy so that it provides this scientific expertise, due diligence, business know-how and manpower," declares an ebullient Minister Lakkotrypīs.



Angelos Gregoriades, Chairman and Head of Tax, KPMG

ated for performing the role of energy hub to the region. "Cyprus enjoys a number of unique attributes that make it ideally suited: its central geographical placement, its renown for professional services, its fully transparent legislative framework and its reputation for a rule of law that is predictable and stable," points out Minister Lakkotrypīs. "If you look at the map, there is only one

country that has the political and economic stability to act as the hub and it's us... when you consider the volatility and instabilities afflicting the region, it's little wonder more and more energy companies are looking to Cyprus as a safe and stable base for their regional operations," adds Evgeniou.

Were the island to actually achieve 'hub' status, the economic benefits could be expected to cascade across auxiliary industries such as the engineering and construction sectors. Some international EPC contractors are already contemplating such a scenario. "We see Cyprus' oil and gas outlook as highly promising, expect there to be many related infrastructural projects over the coming years and seek to position ourselves right at the forefront of any such developments," elaborates J&P Energy & Industrial Projects' CEO, Marios Patsalides.

Nor should the significance of Cyprus' EU membership be overlooked. "We are actually the only EU member state in the Eastern Mediterranean making us the obvious candidate as a conduit for channeling Eastern Mediterranean natural gas to European markets," observes Toulia Onoufriou of the CHC. In fact, Cyprus actually straddles the crossroads of major energy exchanges, according to VTT Vasiliko general manager George Papanastasiou. "You get greater quantities of diesel consumed in mature Europe and higher gasoline demand in the developing eastern Mediterranean region. Therefore you see middle distillates—diesel, gas oil, jet fuel—making their way over to Europe from the Arab Gulf and trade in gasoline flowing in the opposite direction. This often entails vessels needing to make and break bulk. Cyprus enjoys the double dividend of lying along these critical pathways while simultaneously possessing the sort of deepwater environment where these activities can take place," he analyses.

Whether such grandiose schemes can ever reach fruition remains a moot point. "The main brake is a lack of political will for regional co-operation rather than a shortage of hydrocarbons," laments one industry insider. Only time will tell.

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The Project Takes Shape

A model for development in the Gulf of Mexico

The Delta House deepwater floating production system (FPS) and its subsea infrastructure are parts of a field development plan that has been one of the most efficient in the industry. Delta House Phase One taps three Mississippi Canyon fields where the average water depth is around 4,500 feet and reservoirs range from 12,000 to 18,500 feet. First oil

is expected by mid-2015. According to the current plan, at least four more LLOG fields could eventually tie into the host platform.

Working Against Time

In early 2010, a handful of joint venture partners were just beginning to realize the potential of their recently-acquired portfolio. The challenge was how to drill them before the 20 or so deepwater leases they'd purchased timed out. They had less than 36 months left on the clock.

The schedule would have been tough in any case, but following BP's Macondo event, operators in the Gulf of Mexico were granted a one-time 'presidential' lease "Suspension of Operations" due to the drilling moratorium. While these special Suspension of Operations gave LLOG and its partners more time to study their leases, no one was sure when drilling could resume.

"LLOG used the time to study the leases and pick the most valuable ones to explore. While we weren't able to drill in time to save all the leases, we did save the ones that we felt were





most important.” says Rick Fowler, LLOG vice president of deepwater projects.

What's in a name?

“It’s typical with a project like this to let the geologists name the reservoirs based on a common theme, like the names of mountains or rivers,” Fowler explains. “Others have used rock bands or even cartoon characters. Our guys used a movie.”

The informal naming scheme was based loosely on *Animal House*, a 1978 comedy about a renegade college fraternity in the early 1960s. Two of the memorable characters in the film were named Bluto and Marmalard.

“Around the office, we started calling the project Bluto,” Fowler says. “The first discovery well became Son of Bluto Two. Now we have a Son of Bluto Three and Son of Bluto Four, but mostly we use the acronyms. Once *Animal*

House became entrenched in everyone’s mind, the only logical name for the hub was Delta House, the fictional fraternity’s home base.”

Securing the Leases

The majority of the acreage that makes up the Delta House development and some of its secondary prospects was initially gained through a participation agreement with Houston Energy, an exploration company that had purchased 26 deepwater blocks from ConocoPhillips.

“We already held some nearby acreage and had an interest in the ConocoPhillips blocks, but we were beaten to the altar by Houston Energy,” says Mike Altobelli, LLOG vice president, land. Soon after, we reached a deal with Houston Energy that gave us 32.5 percent in those leases.”

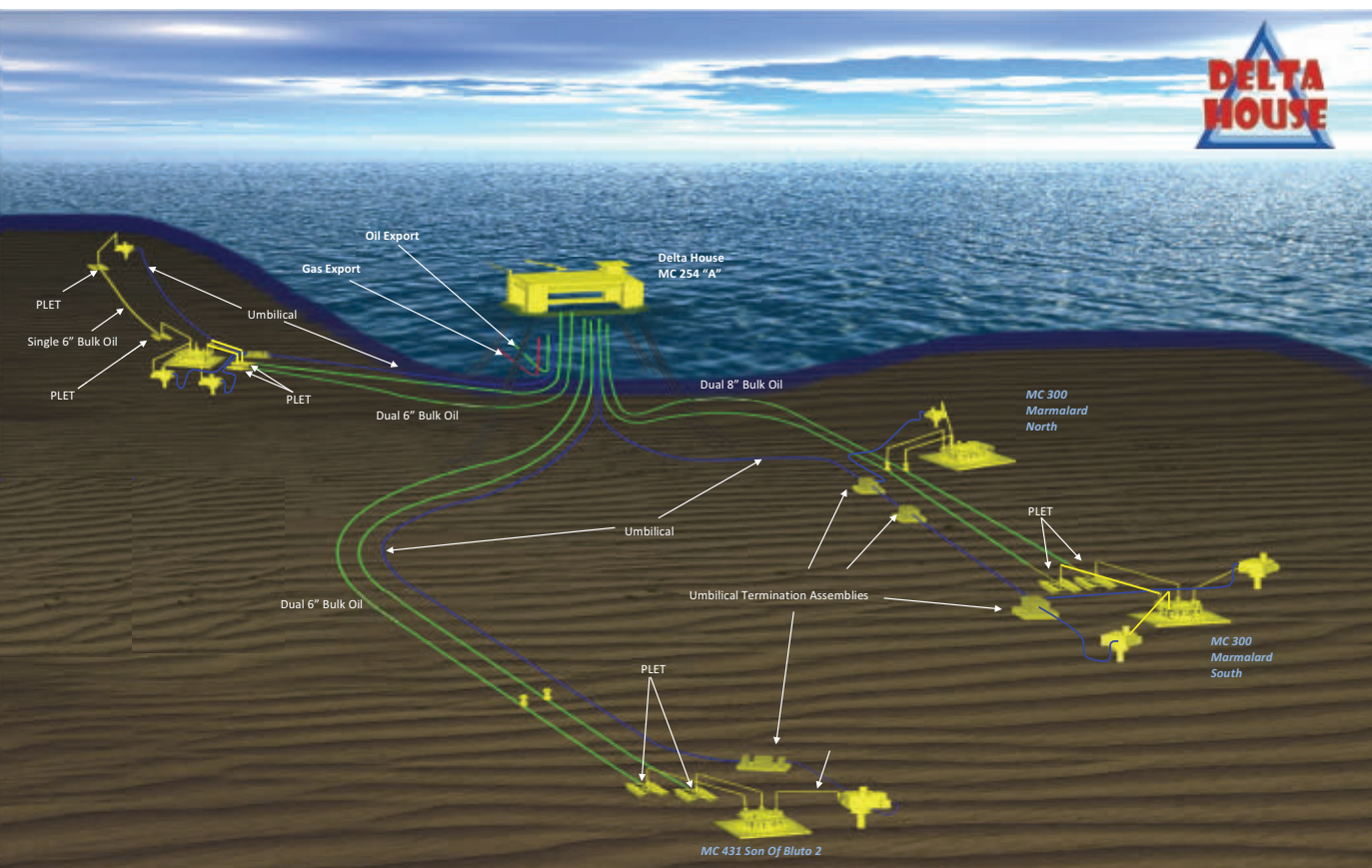
The problem was, the leases were about to expire. The longest of them had just three years remaining.

“We had to act fast,” Altobelli says. “We assembled our group of owners, which included LLOG and the companies in the Houston Energy partnership. Together we approached the Bureau of Safety and Environmental Enforcement (BSEE) and were successful in obtaining a five-block unit for one prospect and a separate two-block unit for a second prospect to advance our drilling program.”

“The lease expiration dates were staring us in the face. We had to get out there and drill wells.”



Rick Fowler,
LLOG vice president of
deepwater projects



Subsea layout of the Delta House Project.

The BSEE granted “Suspensions of Operation” to the partnership so drilling could proceed, but at least a few of the regulators had doubts that LLOG could drill the wells in time.

“We were very transparent in our presentations to the BSEE, and since then, we’ve done everything we said we were going to do,” Altobelli says. “It was a pretty dynamic time. I’ve never been involved in a project with that much going on in such a condensed period of time. The lease expiration dates were staring

us in the face. We had to get out there and drill wells.”

After the partnership’s first two discoveries came in, the same agency granted “Suspension of Production” permits to allow time to complete the development through initial production from the unit or lease. LLOG and its partners’ commitment to developing the fields was the basis for the granting of the Suspensions of Production.

Banking on the Bit

Visionary financing allows early sanctioning

Two separate groundbreaking deals—signed just days apart—are as much a part of the Delta House story as the field itself. It's likely that the agreement to fund the host platform is the first of its kind in the oil industry. Much of the credit for the Delta House development goes to ArcLight Capital Partners, majority owner of the host platform, and Blackstone,

“We could have put up the capital to build it ourselves, but that would have meant a large investment in the midstream side of the business.”



Philip LeJeune
LLOG chief financial
officer

partners in a LLOG joint venture, which is the largest working interest owner of the subsea wells.

Funding the FPS

The seven companies that own the leases do not own 100% of the Delta House floating production system (FPS). Instead, LLOG and its partners—owners of the fields—pay a processing fee to the owners of the FPS. While that is unusual, the arrangement is not unique within the industry. In the case of Delta House, it was a critical step that allowed the whole project to work. The commercial contract, which involved a total of eight companies, is quite complex. The final agreement runs more than 8,700 pages, yet it was completed in only six months.

“Delta House would have been difficult to execute without ArcLight,” says Philip LeJeune, LLOG’s chief financial officer. “Even though ArcLight is a private investment firm that focuses on North American energy assets, not many investment teams would have gone the extra mile to make this project work.”



When LLOG opened 2012 with two major discoveries in the Gulf’s hydrocarbon-rich Mississippi Canyon, its project team began evaluating ways to produce the reserves. One option was to pipe the oil and gas from subsea wells onto existing platforms owned by other operators, but the closest potential hosts were 26, 29 and 35 miles away. The distances raised flow assurance questions and other serious issues. Based on the volume of reserves they had found, building a new facility made more sense. The next question was, how best to pay for it?

“We could have put up the capital to build it ourselves,” LeJeune explains. “But that would have meant a large investment in the midstream side of the business. The other option was to have a third party build and own the FPS, then pay them fees over time to

process the oil and gas we produce. Since we prefer spending our money on exploration, the second option was a better fit.”

An interesting point is that ArcLight does not own any of the reserves, only the FPS and the export pipelines. If needed, ArcLight could sell the FPS, since the design is suitable for most deepwater developments in other parts of the world. That part of the agreement makes the investment more secure, because the FPS effectively serves as collateral.

Negotiations began in April 2012. By May, the companies had the basis of a deal: ArcLight would provide 51 percent of the \$860 million needed to build the FPS and export pipelines. A consortium of six exploration companies, including LLOG, would fund the rest.



● Angelo Acconcia, Blackstone's managing director.

"We've Got Something Here"

There was a turning point in the early meetings when it became clear just how valuable the location was relative to other producers in the area. Even if the volumes from LLOG's wells proved disappointing, it was likely that future Mississippi Canyon operators would want to use the Delta House FPS to process their oil and gas.

"When they studied the maps, our partners could see that infrastructure in this area was going to be valuable," LeJeune says. "Even before the project had been completed, one partner committed to route production from one of its recent discoveries to the FPS. Overall, the Delta House reserves have more than doubled since the time ArcLight underwrote the transaction. I'd say this project is a winner for everyone involved."

Early Sanctioning

One result of ArcLight's controlling interest in the Delta House FPS is that it allowed for early sanctioning of hull and topsides construction. Other companies typically wait for more wells to be drilled before they approve construction of the production facility. In this case, ArcLight has a controlling interest in Delta House, but

is not limited to processing oil it receives from the seven owners of the field. After the first five years, if production falls below the expected level, ArcLight is free to process oil from other producers.

"Companies typically drill more wells before they start building the production facilities," LeJeune explains. "In this case, however, ArcLight accepted some risk of the production on these fields and offset that by the fact that they could attract other fields if ours perform differently than projected. Because of that, we were able to sanction the FPS much sooner. When you compare the timing of this project to others of this scope, I think we'll come in about two years faster than average."

Funding the wells

Besides the floating production system, the original Delta House development plan called for at least three deepwater wells, plus the infrastructure to connect them to the FPS. Since then, the plan has grown to include seven



● Dan Revers, ArcLight's managing partner.



● ArcLight's controlling interest in the FPS allowed for early sanctioning of its construction.

wells during the startup period. The estimated cost of the seven wells was \$1.2 billion. That's where Blackstone and HSBC Bank stepped in.

"We began talking to the Blackstone Group in April, 2012, around the time of our second discovery," LeJeune says. "Our strategic partnership with Blackstone was the largest of its kind. The joint venture with Blackstone will enable LLOG to capture opportunities that we could not otherwise pursue. Within that arrangement, HSBC and three other banks provide the Reserve Base Loan (RBL) through the joint venture called LLOG Bluewater. Although the financial structure for the RBL had been used internationally, it was the first time for a U.S. operator."

Securing the Drilling Rigs

Based on the development plan, LLOG knew it would need at least two more drilling rigs on long-term contracts. A pair of three-year contracts would be ideal, but day rates for deepwater rigs are in the range of \$500,000. When you add supply boats, tugs and other support, the bill comes to about \$1 million per day. Blackstone's participation made it possible for LLOG to secure two deepwater

drilling rigs for three years each. It was a critical component of the Delta House development plan.

"If you look at that level of commitment to make a 3-year contract with a drilling rig contractor, it is \$1 billion times two," LeJeune says. "The Blackstone transaction made those rig contracts happen, which meant we could execute our projects and still do additional exploration. Blackstone and ArcLight were the keys, and the agreements all came together within a few days of each other in late November and early December 2012. We didn't get much sleep around that time."

For its part in funding the wells, Blackstone and LLOG Bluewater will get approximately 34 percent of the oil and gas (the working interests vary by field). The rest of the production in various percentages goes to the other partners: Red Willow Offshore, LLC, Calypso Exploration, LLC, Deep Gulf Energy, Houston Energy, and the entities managed by Ridgewood Energy (which includes Riverstone designated affiliates). That same group owns 49 percent of the FPS.

Drilling and Completions

Focused on Efficiency and Safety

The drill bit was still turning in the second exploration well when LLOG began ordering subsea trees. Nine of them, at roughly \$7 million each. The purchase took more than confidence. The development team was planning far ahead, not only with the trees, but the wellheads, casing and intelligent downhole systems. Everything had to be ordered long before it was needed in the field. It takes a tremendous amount of planning; safety is paramount, but beyond that, planning mistakes can quickly break the bank.



● To shorten the field development time, wellheads were ordered far in advance.

Standards Reduce Risk

LLOG's drilling team was sure it could use the equipment that was ordered for Delta House, mainly because the company has standardized its wells. Most LLOG deepwater developments, for example, use the same horizontal trees. Any trees that are not needed for Delta House can be used in other LLOG fields. Standardization adds flexibility, and it also makes it easier for suppliers to respond to urgent requests.

"Any benefit we may give up in terms of a perfect fit for one application, we gain back in terms of responsiveness from our suppliers and the ability to move a project forward," says Joe Leimkuhler, drilling vice president. "With a horizontal tree, I can get on a well with any riser and BOP stack combination of any deepwater rig in the Gulf of Mexico."

There are tradeoffs, of course. Horizontal trees are better for major well interventions because you can gain full access to the wellbore without pulling the tree, but if all you need is lighter diagnostic work, a vertical tree has some advantages. LLOG's subsea manifolds are also standardized. Instead of designing a new manifold for each field, LLOG uses a standard manifold that's good for four wells.



Seadrill's *West Neptune* drill ship is designed for water depths up to 12,000 feet and wells to 37,000 feet.



● Testing one of the subsea manifolds for Delta House.

If the development calls for more than four wells, a second manifold is bolted to the first. Everything is linkable.

The Organizational Model

LLOG has also built an organizational model for well engineering and operations. “For the initial drilling at Delta House we utilized a single experienced engineer per rig,” says Leimkuhler. Senior Deepwater Drilling Engineers Steve Stegeman and Bob McMann filled that role and did an excellent job.”

While the arrangement works for short periods of time, LLOG prefers the dual engineer model for sustained operations with multiyear rig contracts. The goal for each rig is to have one engineer planning the next well while the other engineer oversees the current one.



The lead engineer’s average level of experience is 20 to 30 years. With that level of seasoned talent on the rig, the lead engineer doubles as the operational superintendent. Under LLOG’s system, the engineer who plans the well is typically the one who drills the well.

“On the offshore operations side we have an excellent group of core foremen with substantial deepwater experience,” Leimkuhler says. “The lead engineer is the operational interface with the foreman offshore. It’s a tight package. I don’t have to worry about the handoff interfaces. I don’t have one engineer planning a well and another drilling it in conjunction with a field superintendent. Larger companies have a lot of interfaces that we don’t deal with here. Decisions can be made quickly, because all of the decision makers are involved right from the start.”

Safety and Environmental Management

LLOG, like every other producer on the Outer Continental Shelf, operates under a safety and environmental management system (SEMS) as required by U.S. law. LLOG Health, Safety and Environmental (HSE) professionals assist with and oversee the plan. Any changes must be approved by LLOG HSE and LLOG Drilling.

For emergency support, LLOG is also a member of the Helix Well Containment Group (HWCG), a nonprofit consortium of more than 60 mid-sized deepwater operators and most of the larger service companies. Depending on the nature of the spill event, HWCG can deploy its equipment and a full complement of well containment specialists within 48 hours. That response organization includes the technical and operational support of the HWCG member operators. LLOG’s technical staff is part of the network of HWCG experts on call, 24 hours a day.



● Joe Leimkuhler, LLOG's drilling vice president.

“We are trained to serve in various roles in all the well containment subgroups, including source control chief,” Leimkuhler says. “We train as a group of companies once a year. Every time we have an emergency drill, the messages go out to all the other member companies. Within three days, we can have the whole source control organization filled out by experienced people from our own organization as well as other HWCG member companies.”

People and vessels are deployed in the emergency drills. In May 2014, for example, LLOG alone sent nine staff members to a command center in Houston for an exercise in which Freeport McMoRan was the responsible party. The group included LLOG’s Chief Well Engineer, Darrell Herrington and several lead engineers.

“In a full deployment exercise, HWCG has run the exercise all the way to the point where they deployed a capping stack in 8000 feet of water, latched onto a wellhead on the seafloor, pressure tested the system and proved that they can execute the well containment plan,” Leimkuhler says. “These are not just exercises on paper.”

Drilling the Wells

By the end of 2014, six of the proposed 15 Delta House wells had been drilled. To handle the workload on Delta House and other projects, a good portion of LLOG's staff are professional engineers. As a result, all of the company's professional engineering work led by Chief Well Engineer Darryl Herrington is done in house, including certification.

"We have a sizeable drilling organization," Leimkuhler notes. "Many companies our size rely more on contract staff they bring in for specific projects, but we chose to gear up for the long haul. We've built a drilling and completions group, with engineering and operations staff sufficient to run three to four floaters on a continuous long-term basis. In that respect, our capability and capacity is similar to what some of the majors can do in the Gulf of Mexico."

Of the first six Delta House wells, two wells were drilled by the *Ensco 8502* in 2012-2013, two were drilled by the *Noble Amos Runner* in

2011-2012, and the *Ensco 8503* drilled the 6th Delta House well in late 2014, followed by the initial two subsea completions for the field. The Sevan *Louisiana* is scheduled to drill wells 7, 8 and 9 in 2015. The Sevan *Louisiana*, which uses an exceptionally stable cylindrical hull design, is a DP rig that has also proven to be fuel efficient, with enough storage capacity that it can be used as a temporary liquid mud depot if needed. A second vessel, Seadrill's *West Neptune* drill ship was delivered to the field in late 2014. The newly built *West Neptune* is designed for water depths up to 12,000 feet and drilling depths to 37,000 feet. The *West Neptune* is outfitted with dual BOP stacks to enable efficient completion of the remaining wells in the field. Both the Sevan *Louisiana* and the *West Neptune* are under three-year contracts with LLOG.

Each Well is Unique

"Even though our wells are in a similar geologic setting, each of them is unique," says Leimkuhler. "At the Marmalard field, for example, our delineation well was more than three miles from the exploration well. When you're that far away, you can't assume that pore pressures are the same, even if the rock is in the same trend." Experienced and capable engineers such as Steve Stegeman and Jason Brink work closely with the LLOG Petrophysical engineers and LLOG foreman on the rig. Together, they optimize operations and allow LLOG to determine quickly how best to develop the Delta House fields.

Stegeman, Brink and the rest of the drilling team were confident enough to make sure that even the first two exploration wells could



be completed as producers. “Every well we’ve drilled to date was designed to be a producer,” Brink says. “We don’t drill expendable wells. We might in the future, but not yet.”

Smart Completion Technology

The wells feeding into the Delta House FPS will have a variety of completions. In some cases, a typical wellbore intersects several pay zones that are anywhere from 50 to 100 feet thick. The gross interval between the upper hydrocarbon-bearing sand to the lower one might be as much as 600 feet.

“Reservoirs with shale breaks between pay zones will have multiple frac packs to maximize production, and smart well technology to manage it,” says Senior Deepwater Completion Engineer Barney Paternostro. “We generate a single wing to make sure we get past any near-wellbore damage from the drilling fluids, then open things up and pump our proppant. We use screens to keep that proppant from entering the wellbore during production. We could probably get by with gravel-packs, but frac-packs are better producers.”

Erik Hoffpauir, a completion engineer also working Delta House, notes that all of the wells are drilled directionally to reach individual sands, but none of the wells are horizontal. The formations themselves are very plastic, so proper placement of the proppant is important to enhance permeability around the wellbore.



● Tim Lindsey, LLOG's senior vice president for operations.

In for the Long Run

“Delta House is just one of several hub-class prospects in our portfolio,” says Tim Lindsey, senior vice president for operations. “We’re going to drill them, but to operate safely, you have to be realistic about how many rigs you can supervise and how many wells you can plan. We’re challenged enough to develop what we’ve found and explore what’s on the horizon. Generating the most net present value is a unique riddle sometimes, but that is what we do best. As folks here in Louisiana like to say, ‘Clean the fish you’ve caught and have the bait to catch more.’”

Even though Delta House has been a fast-paced development, its safety record has been very good across the board.

“We have outstanding, experienced supervisors on the rigs, and they are really our first line of defense for safety and safe drilling practices,” says Lindsey. “As a company, we don’t often have time to celebrate all the significant things that happen. The wells we drill, delineation of the field, construction of the hull and topsides, integration, transport, mooring and commissioning—each of those accomplishments are tremendous things. Sometimes things don’t go as well as we had planned, but how we react to those challenges is what makes LLOG the company that it is.”

Geology of Mississippi Canyon

Reading the reservoirs

From the geologist's viewpoint, the already difficult search for oil in the Gulf of Mexico is further complicated by a thick layer of salt that formed when the region was a shallow sea. Over millions of years, layer after layer of sediment deposited above the salt caused it to act in strange ways, forming huge domes and ledges that oozed toward the surface. In geologic

time the salt structures grew, shoving older sedimentary layers aside. Fresh sediment flowed around them. Throughout much of the Gulf of Mexico and inland for hundreds of miles, these massive salt formations also trapped hydrocarbons that would otherwise have leached to the surface long ago.

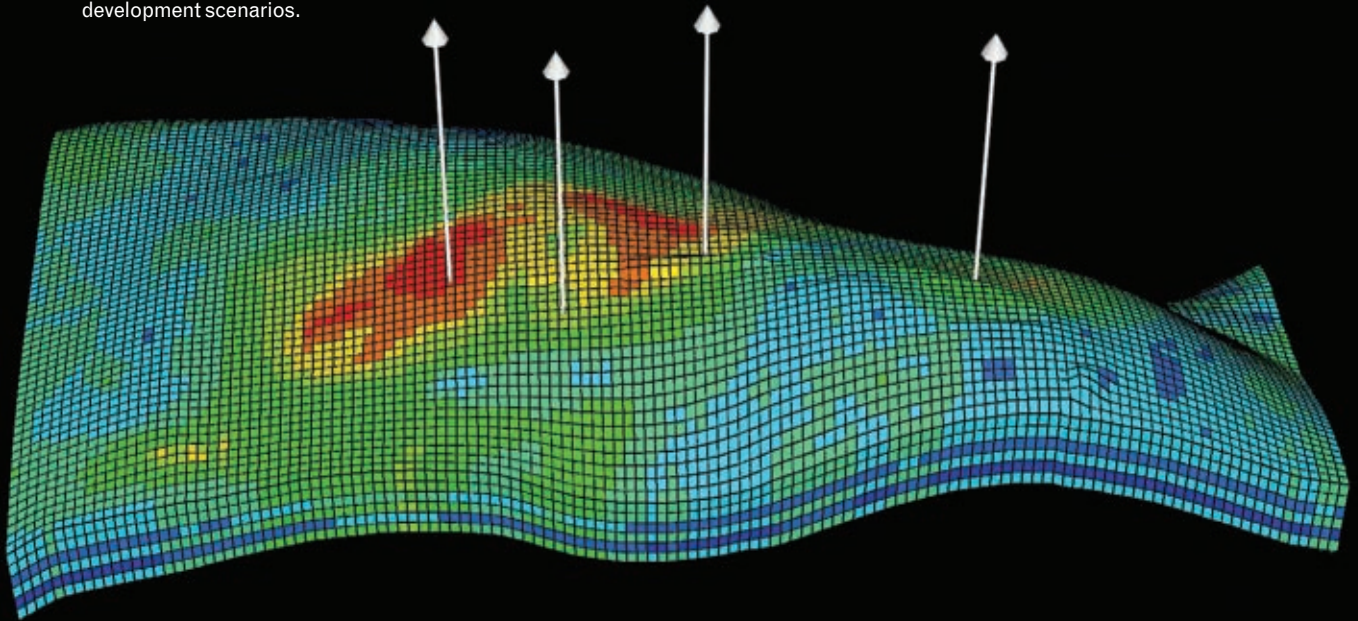
The roughly 400-square mile region known as the Mississippi Canyon is a dominant feature on subsea maps. Its central trenches and cliffs began taking their modern shapes some 20 million years ago, as snaking regional rivers carved through the land and dumped their organic-rich sediment into the sea. Today, the Mississippi Canyon is home to some of the largest deepwater developments in the Gulf of Mexico.

In 1979, Shell's Cognac project on Mississippi Canyon 194 became the first deepwater development in the area. Since then, most of the major oil companies have explored it with varying success.

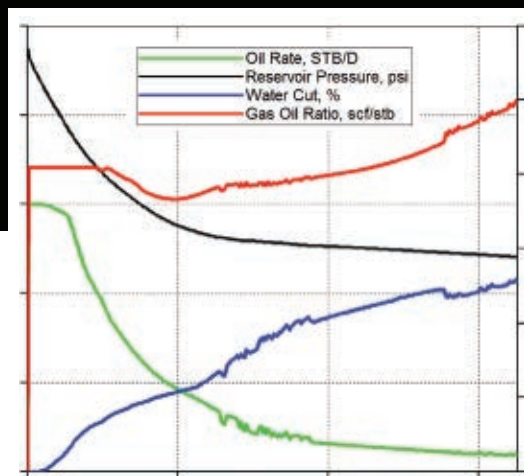


● John Doughtie, vice president, exploration, Houston.

LLOG reservoir
engineers use reservoir
simulation models like this
one to predict production
and reserves under various
development scenarios.



“Some of the majors looked at the area where we are today and thought that the reservoirs weren’t large enough to be commercial,” says LLOG’s John Doughtie, vice president exploration, Houston. “That was several years ago. Using the latest seismic technology, we were able to image the reservoirs with a clarity that wasn’t possible then. It has opened new opportunities for us. As we drill more wells in the Mississippi Canyon, we’re beginning to understand the basins much better.”



Home Team Wins

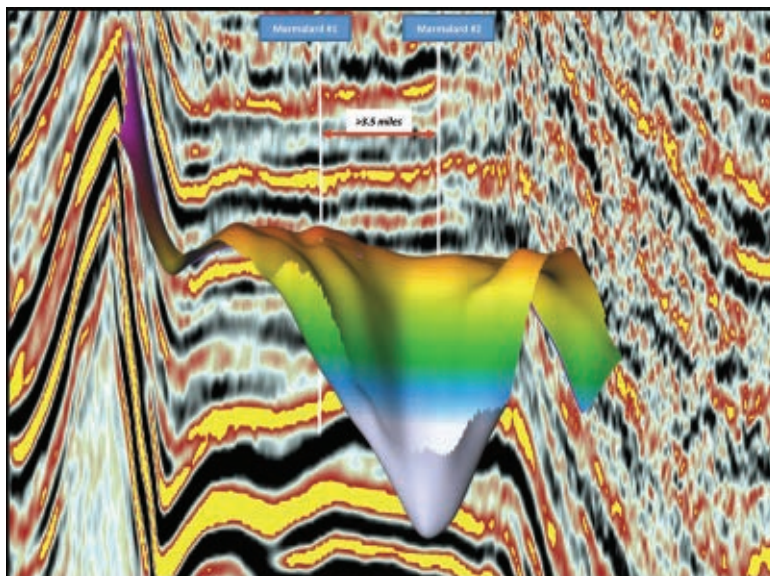
“We have an extraordinary number of people involved on the subsurface side,” says Eric Zimmermann, LLOG vice president geology. “Our partners at Houston Energy were on the front end of exploration as well. We have

some really good partners who know what they're looking for. They see things the way we do, but they've also added to the project. They have certainly kept us on track."

By any standard, Delta House is a world-class prospect. So is the geoscience team that found it. "Between our capabilities and those of our partners, no part of the puzzle is being outsourced," Zimmermann says. "Individuals within our organization are doing all of the specialized geoscience work. Carlos Guzman, an exploration geophysicist here in Covington, helped to identify key target areas. John Hollins, our seismic reprocessing coordinator in Houston, works on small-scale velocities and details on the geophysics side. Malloy



● Eric Zimmermann, vice president, geology.



Seismic image courtesy TGS.

● Seismic image of Marmalard Field.

French, Jay Cole and Stan Hewitt are all well respected in their fields in the industry. It is most unusual to have such talent in a private company our size."

Proving the Model

No matter how good the models look, explorers never know for sure if they've got oil until they find it with the bit. In February 2012, LLOG's Mississippi Canyon 431 Number 2—the one dubbed "Son of Bluto 2"—came in strong. A second high-profile well, Mississippi Canyon 300 Number 1, dubbed Marmalard, became the discovery well on the second of three Delta House fields when it reached total depth some four months later. So far, the Delta House field appears to have even more potential than the geoscience team first thought.

"The good fields tend to get better with time, and we're still drilling wells and learning more about the resource," Zimmermann adds. "We're still peeling back layers of the onion."







Building the FPS

Fifteen nations,
12,000 workers and
22 months to build

LLOG is known for efficiency, in part because it looks for ways to standardize even its offshore platforms. The Delta House FPS is a larger version of Exmar's very successful Opti-Ex® platform used in the Who Dat field. Exmar's design, customized to LLOG specifications, is the first in what LLOG sees as a series of floating production systems, all with the same basic Delta House plan. Early work has already begun on its twin.

"The Delta House program is the bigger story," says Rick Fowler, LLOG vice president deepwater projects. "In keeping with the effort to standardize our facilities, we've designed a semi-submersible platform that we can deploy in a wide range of conditions."

The Concept Evolved

Delta House is a four-column semi-submersible floating production system based on Exmar's Opti-Ex® design. It is similar to LLOG's successful Who Dat platform, but 40 percent larger. As the name implies, the hull is optimized to increase the amount of payload it can carry relative to the weight of the steel in its hull.

A prominent feature of the Opti-11,000® is that it reduces the cost and weight of the hull without sacrificing strength. Look closely and you'll see that the columns are square only on the outer corners, where structural loads are the greatest. To the inside, the faces of the columns are diagonal. That saves steel, which means the structure itself is lighter and more buoyant than conventional four-column hulls. Another weight saving feature is the way the risers attach to the FPS.



Construction of the hull began in March, 2013 and was completed in 12 months.

"The way the hull is designed, we swap off risers for ballast," says Craig Mullett, project manager for the hull and topsides. "If we tension the risers at the top of the hull, we sacrifice weight capacity. By fastening our risers to the bottom of the hull instead, we save the weight."

Delta House is larger than Who Dat, and it can support more topside weight. The payload went from 5,000 to 9,300 metric tons. While the Delta House hull is 55 percent heavier than Who Dat's hull, the payload nearly doubled. The hull-to-payload weight ratio for the Delta House FPS is nearly one-to-one.

The Opti-11,000® is suitable for water depths from 1,500 to 10,000 feet. The hull has a payload capacity of 11,000 tons, and it is relatively easy to build. To minimize the effects of ocean heave in shallower water, the FPS can be fitted with flexible risers. Even the shape of the hull makes it more stable than older designs.

"Heave—the tendency for a vessel to rise or fall in the water—is the enemy of four-column semi submersibles," Mullett explains. "But one feature of our design effectively resists much of the vertical inertia caused by heavy seas. We call it a 'ring pontoon.' Its outer edge extends beyond the columns, like a wide shelf sticking out below the water line. That extra drag in the water greatly dampens any vertical movement."

Selecting the Fabrication Yards

"We began looking at construction yards for the hull and topsides as soon as we acquired the leases, long before our first Delta House





● To save hull weight without losing strength, the interior sides of the columns are flat.

discovery,” says Bruce Cooley, vice president facilities. “We have a potential development scenario in mind for every deepwater lease we drill. For the Delta House FPS, we settled on Exmar’s basic design in November 2011 and began looking at preliminary layouts.”

By selecting the construction yards early—Hyundai Heavy Industries for the hull and Kiewit Offshore for the topsides and integration—LLOG could involve the yards early in the design process. It also meant that the capabilities of each yard could be

incorporated from the start. The Kiewit yard at Ingleside, for example, has a maximum lift capacity of 13,000 tons, so that became the upper weight limit for the Delta House topsides. Since the payload of the Opti-11,000* hull is 11,000 tons, there is excess capacity for future expansion.

Keeping to the Schedule

“There are always plenty of challenges on a project this size,” Cooley says. “One of the biggest was that other jobs in front of us in the Hyundai yard ran late. That meant we



● The Delta House single deck design allowed more flexibility in the delivery and installation of individual components.







● The Delta House hull left South Korea on March 24, 2014, just one year after construction began.



couldn't get into dry dock on schedule. Toward the end, it rushed the construction of our hull. Hyundai did a great job of getting it together, but I'm sure it caused them a lot of headaches."

● The subsea pipelines were pre-installed.

In keeping with LLOG's policy of developing solid, long-term relationships with its suppliers, Dockwise was contracted to deliver the hull from South Korea to Texas. "Dockwise does all of our transportation," Cooley says. "We made sure that our hull would fit on any of the six T-class vessels that Dockwise owns. We didn't want something so big that only one vessel in the world could move it."

The Opti-11,000* hull finally left the Hyundai yard aboard the Dockwise Treasure heavy transport vessel on March 25, 2014 for the two-month trip to Kiewit's yard at Ingleside, Texas. Once there, high winds forced crews to wait another two weeks until the hull could be safely offloaded. Even with the weather delay, the Delta House team maintained the overall project schedule.

"We pre-installed our pipelines," Cooley says. "We pre-set the mooring system. The idea was always to lay the pipe ahead of time, have the lay vessels go away, moor the FPS, then have the vessels return to tie it in. That flexibility allowed us to close the gap in the schedule."



■ Much of the topside equipment was skid mounted, which meant it could be built offsite.

Tweaking the Topsides

Delta House was designed to be extremely flexible in the variety of crude oil it could process. The acceptable API gravity range is 28 to 38, which includes the majority of crudes in the Gulf of Mexico. Even so, the project team had to make last-minute changes to accommodate some unusual properties of the gas.

"We found that the crude had a lot of light ends, and the gas had a lot of heavy ends," Cooley explains. "Normally you wouldn't have those two at the same time. That meant that we would be producing more propane and butane than we anticipated."

The fix was to add a condensate stabilization unit to the processing equipment. Fortunately, the Delta House production deck had plenty of extra room and weight capacity. Adding the stabilization unit allowed LLOG to inject the liquids into the sales gas pipeline, which transformed them and increased the richness of the gas.

The Advantage of a Single Main Deck

Most FPS designs use three decks, which means that during construction, everything that goes down below must be installed before the upper decks can be set on top. Using a single main deck design instead gave the LLOG team more freedom to make last-minute adjustments to the topsides construction without throwing the project off schedule. Later, the ability to mate the topsides to the hull in one lift at Kiewit's dock was also much safer and less expensive than trying to do the same job with heavy lift vessels offshore.





● Massive slings were attached to lift the 9,580 metric-ton Delta House topsides onto the hull.

“Having a single main deck made the FPS much easier to build,” Cooley explains. “With all of the production equipment on one elevation, we could build equipment off site, then integrate it onto the top deck. If something didn’t come in on time, we had the flexibility to add it later. We weren’t waiting on one piece of equipment so we could sandwich another deck on top of it.”

That flexible single-deck design enhanced safety for the construction crews and also shortened the project’s cycle time. “We were still designing some components while others were being built,” Cooley says. “Detail drawings were arriving just in time.”

From sanction of the project to installation took just 22 months, a near record for the industry. To help maintain the aggressive topsides construction schedule, Project Manager Craig Mullett spent most of his time at the Kiewit yard, overseeing work and answering questions on the spot. “That’s one of the benefits of a small project team,” he says. “We don’t have to go through layers of management to make decisions. We know what our boundaries are, so if we do have a question, we can run it up the ladder. Our management is always accessible, even the guys in the corner offices.”



● Bruce Cooley (left) and Craig Mullett.

LLOG's emphasis on safety paid off with a 12-month total recordable incident rate (TIRR) of just 0.34, about twice as good as the industry average of 0.66.

Topsides Integration

In December, 2012, as ink was still drying on the ArcLight and Blackstone contracts to fund the \$2 billion project, Kiewit crews began building the Delta House deck. Workers at Hyundai's yard in South Korea began cutting steel for the hull on March 4, 2013. The hull was offloaded at the Kiewit yard on May 29, 2014, and two weeks later, the integrated truss deck and topsides facility was added to the hull. At 9,580 metric tons it was the heaviest single lift the Kiewit yard had ever done. The operation was flawless. From the time the hull was positioned until the load was released took less than five hours.





● After three days of preparation, it took less than five hours to lift the topsides onto the hull.

Ceremony at Ingleside

On July 9th, 2014, hundreds of people gathered at Kiewit's windy 500-acre fabrication yard at Ingleside, Texas, about 15 miles from the city of Corpus Christi. Inside a huge white air-conditioned tent, crews taking a break from their jobs mingled with reporters, photographers, joint-venture partners, investment bankers and project executives. Outside, the nearly completed Delta House FPS towered over the yard, dwarfing nearly everything in sight. From its 2-acre footprint to the tip of its flare, the 18,600-ton vessel stood 296 feet tall.

While integration and commissioning work continued high above on the topsides deck, speakers at the christening ceremony expressed their appreciation for the work that

was done by the 12,000 people worldwide who had a hand in the Delta House project. At the appointed time, Sharon Speakes, a longtime employee of LLOG, officially named the vessel "*Delta House*" and released a champagne bottle that burst against the hull. Even though the FPS wouldn't leave the yard for another two months, every visitor that day could see that the Delta House FPS was well on its way.

Delta House is powered by three 4.8 Megawatt Solar Taurus 60 gas turbine generators. The electricity they deliver runs all the rest of the equipment and utilities, which increases reliability and reduces noise on the platform.

The entire topsides assembly consists of a single deck that was fitted to the hull in one lift.





Some 500 project people and guests came to the Kiewit yard on July 9th, 2014 for the Christening ceremony. Many stayed to bravely tour the Delta House main deck that was about 18 stories high.

Completing the package

The project prepares for first oil

By August 2014, the project team had completed nearly all of the topsides engineering work, but the work that remained was still daunting. The FPS was still in Kiewit's yard as technicians checked the critical systems required to earn the U.S. Coast Guard's approval to take the new vessel out to sea for the first time. As the FPS was nearing completion, a small fleet of ships and barges were busy in the field, installing the rest of the field's infrastructure.



● Bruce Cooley, vice president facilities.

Subsea Systems

Three separate subsea systems, each with the capacity to support eight wells, feed all of their produced fluids to the Delta House FPS. Equipment on the seabed is linked by a fiber-optic communication system, and each well has its own multiphase meter.

"Both of those are unique for us," says Bruce Cooley, who managed the subsea installations. "Using fiber-optics instead of copper wire greatly improves the equipment response time. Where the old system might take 30 seconds to transmit some data, the fiber-optic system is nearly instantaneous."

The use of multiphase meters gives reservoir engineers the chance to monitor what each well is producing. As fluids come from the well, engineers at LLOG offices can see how much of it is water, gas and oil. In addition, downhole pressure and temperature sensors in each well update their readings every few seconds.

One feature of the Delta House subsea system is that all of the production lines are looped. Looped lines give operators the ability, in the



● The remaining work and final commissioning of Delta House was done in the field.

case of a damaged line, to redirect the flow into another line.

“Looped lines also allow us to clean the loop train,” Cooley notes. “We can launch pigs from the topside and round-trip them through our flowlines. If we ever have to shut in for a hurricane, or any maintenance operation that requires pigging, we can do both lines simultaneously.”

Another advantage of looped flowlines is that the flow from stronger wells doesn’t have to be commingled with the flow from weaker wells.

“If you want to maximize recovery and have all your wells on a similar depletion plan, looped lines give you more flexibility,” Cooley says. “You can maximize the flow from lower pressure wells so they don’t have to compete with higher pressure wells.”

Likewise, it’s easier to dedicate one of the lines to gas wells and the other flowline to oil wells, if desired.

Mooring and Integration

Twelve mooring lines—each more than 1.5 miles long—keep the Delta House FPS on station. They’re anchored to a dozen



matching 16-foot diameter suction piles that weigh 150 tons each and reach some 80 feet into the seabed. LLOG'S Mark Farrow, offshore construction manager, directed the installation of the piles and later, the mooring operation itself.

"The mooring lines are a combination of polyester rope which is about 10 inches in diameter and steel chains with links that weigh nearly 500 pounds each," Farrow explains. "Lengths of chain attached to the upper ends of the polyester ropes allow each line to be tensioned independently."



Given the extreme weight of mooring lines, most companies use heavy lift vessels to install them. The Delta House team was able to economize by enlisting one of the anchor handling vessels already on contract with LLOG, and modifying it slightly to do the job.

By October 2014, the FPS was successfully moored in Mississippi Canyon 254, some 130 miles southeast of New Orleans in 4,500 feet of water. Once it was ballasted down to working depth, the underside of the main deck was 72 feet above the water line, with 98 feet of the hull below the waves.

Operations

Safety and operational integrity are key

About two dozen people live aboard the Delta House FPS for two weeks at a time between crew changes, but there is space for twice that many if extra workers are needed for special jobs. A supply boat trip to the Fourchon shore base near Grand Isle, Louisiana takes about six hours or a helicopter ride to the Galliano base takes about an hour.

The Delta House host platform receives all of the raw production from the wells and subsea gathering system that serves three separate fields. Onboard processing equipment uses mainly gravity and pressure reduction to separate the fluid's various components and to bring the natural gas and oil up to the specifications of the export pipelines.

Marketing

Delta House is designed to process a wide range of gravities and gas-oil ratios. Likewise, the FPS can deliver its oil and gas at a range of export pressures to suit any pipeline in the Gulf of Mexico.





Oil from Delta House flows through some 35 miles of newly-constructed 12-inch pipe that connects to the Shell-operated Odyssey oil pipeline. Gas from Delta House is delivered through 31 miles of new 16-inch line that links the FPS to the BP Pipelines-operated Destin Pipeline Company's 24 inch gas pipeline.

"We use a number of factors when selecting our export pipelines, including the capital cost, capacity, netback price, and reliability of each option," says Jack Boelte, director of marketing. "In the case of Delta House, we were fortunate to have a number of good options. Shell and BP have been great to work with on this project."

Storm Safe

The Gulf of Mexico is famous for its hurricanes, which keep offshore operators watching the skies from early June to late November. Even the threat of a big storm can shut down platforms days before the main event.



"If a hurricane is imminent, we follow a detailed evacuation plan," says Rick Bullock, production vice president. "The evacuation procedure for Delta House is much simpler and quicker than many similar facilities that require changes in draft or mooring tensions. The FPS is quite robust and is designed to withstand the impact of a thousand-year storm. After the storm passes and the weather is safe, the crew would return and restore production, following another detailed plan."

Other safety features are built into the Delta House design. The legs of the FPS, for example, are fitted with elevators and stairwells rather than ladders. There are also safety tunnels in the pontoons. Most of the topsides equipment is electric rather than being powered by diesel fuel or natural gas. The result is a working environment that is quieter, cleaner and more efficient than most offshore platforms, and it is more reliable.

Drilling Continues

In June 2014, the round-hull Sevan *Louisiana* rig began working in Mississippi Canyon block 79, just north of the first two Delta House wells. The plan was to finish that well, move the Sevan rig to complete a second Delta House well, then send it along to a third site. In early August, however, there were a series of delays in the Delta House drilling program. The Sevan *Louisiana* did not complete its work on MC 79 until late October. The good news is, the well was a significant new find.

The new well logged more than 70 feet of net hydrocarbons in a Miocene reservoir with a high yield of gas condensate. Part of the



Photo courtesy of Tim Burdick of Crowley Tugs

delay in moving the Sevan *Louisiana* was the time it took to drill an appraisal sidetrack, which confirmed the discovery. LLOG, which owns 70 percent of the field, is the operator. Ridgewood Energy managed entities (which includes Riverstone designated affiliates) is the non-operating partner. Delta House will likely be the host platform.

The West Neptune Moves In

One of LLOG's three deepwater drilling rigs is the newly built Seadrill *West Neptune*, which was delivered to the Gulf of Mexico in

December 2014. The *West Neptune* is LLOG's first dual-BOP deepwater drilling rig. U.S. law requires that a blowout preventer must be disassembled and tested after each use, a process that takes about two weeks. Having two BOPs on board means that one can be tested and recertified while the other one is in use. That saves at least 12 days off the time it takes to complete each new well.

Looking Ahead

In it for the long run

To our knowledge, Delta House and Who Dat are the only two privately-owned deepwater floating production systems in the world. They won't be the last.

"We've been fortunate to align ourselves with some very sound partners," says LLOG's Chief Executive Officer, Scott Gutterman. "As a private independent, our biggest challenge historically has been securing sufficient capital to underwrite our programs. Especially as we continue to grow our deepwater

business and are more frequently confronted with developments that require investment beyond our available conventional resources. In the case of Delta House, ArcLight and Blackstone have been extraordinarily strategic partners. By providing access to additional external sources of capital to expedite this development, they provide an ability to harvest the value we created without diminishing our focus on continued growth through our exploration program."

A Bright Future for Delta House

The FPS itself is designed for 25 years of continuous production. While the facility is nominally built to process 80,000 barrels of oil per day (bopd), 200 million standard cubic feet of gas (mmscfd) and 40,000 barrels of water per day (bwpd), the peak capacities are at least 20 percent more. By the end of 2015, we expect to have seven Delta House wells on production. The development plans for the known fields include 14 wells, as Rick Fowler, LLOG vice president deepwater projects, explains.

"Our plan is to continue our development and exploration activity in the area to get the facility full and keep it full as long as possible,"



● Scott Gutterman, LLOG's chief executive officer.





● LLOG plans to use the same hull and topsides design for future projects.

Fowler says. “If we do reach 100,000 barrels per day, we’ll look at debottlenecking the facility. The absolute production limit is the export pipeline, which can handle about 117,000 barrels per day. How close we get to that depends on our drilling success in the known fields and nearby prospects.”

Is there room to expand the Delta House FPS? “Yes,” says Delta House Project Manager Craig Mullett. “And there is even more weight capacity than deck space. We have 1,000 tons extra capacity, but it would be difficult to get 1,000 tons of equipment out there without building extensions on the deck.”

LLOG has a healthy prospect inventory in and around the Delta House development. In October 2014, LLOG and Ridgewood Energy announced test results from an exploration well at the Mississippi Canyon 79 “Otis” prospect. The well encountered more than 70 feet of net hydrocarbons. A subsequent appraisal sidetrack confirmed the discovery. LLOG, which owns 70 percent of the field (30% is owned by Ridgewood Energy managed entities which includes Riverstone designated affiliates), has been

evaluating development options and regional hosts, including the Delta House FPS.

A number of other projects are scheduled for testing, but even with the three deepwater drilling rigs LLOG has on long-term contracts, there aren’t enough rig days available to drill its entire inventory. For now, the contract rigs will focus on the Delta House development. As rigs become available, they will be redirected toward exploration. If all goes well, the Delta House FPS will eventually have a twin, and another after that. The FPS is optimized to be as flexible as possible in terms of where it can deploy and the types of production it can handle. Changes will likely be in the nature of equipment upgrades as new technology is available.

“The second FPS we build in the Delta House program will probably have minor differences from the first, but no substantial changes,” Mullett says. “We don’t need to touch our production module, where we have all our separation equipment. The third one, if we build it, will be extremely close to the second one. From here on, it’s all about fine tuning what we’ve got.”



COMPANY PROFILES

48 / Exmar Offshore Company

52 / ArcLight Capital Partners, LLC

54 / Blackstone

56 / Societe Generale

57 / Houston Energy, L.P.

58 / Ridgewood Energy

60 / Red Willow Production Co.

62 / Calypso Exploration, LLC

63 / Bexco NV-SA

64 / Audubon Companies

66 / Baker Hughes

68 / Cimation

69 / Civeo Corporation

70 / DNV GL



72 / Cyrus J. Guidry & Associates (CGA)

73 / FMC Technologies

74 / Gate, Inc.

75 / Intermoor

76 / Kiewit Offshore Services

77 / Oceaneering International, Inc.

78 / Pinnacle Engineering

79 / Seadrill Americas Inc.

80 / Perma-Pipe Oil & Gas and BASF Corporation

83 / Spitzer Industries

84 / Technip

85 / Wood Group PSN Offshore O&M Services

Exmar's Innovative FPS: Optimization and Efficiency by Design

Exmar Offshore Company (EOC) provides engineering services related to the marine industry with a special emphasis on the oil and gas segment. EOC's expertise encompasses ships and offshore units such as floating production systems, drilling rigs, accommodation units, floating production, storage and offloading units and floating storage units. EOC is a full life cycle maritime business with capabilities including concept development, basic and detailed design and engineering, construction, project management, start-up, commissioning and operations.

EOC's parent company is Exmar NV (Exmar) of Antwerp, Belgium, a diversified and independent shipping and offshore group. Exmar NV is a recognized leader in designing, owning and operating vessels that transport liquefied gases (LNG, LPG, ammonia) and floating LNG liquefaction and regasification facilities. Exmar's Caribbean FLNG® barge-based liquefaction facility is the first of its kind

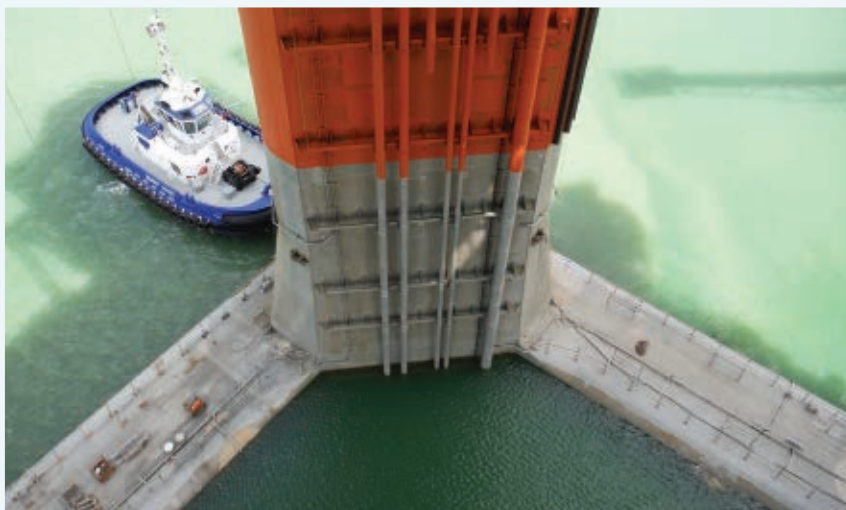


▲ The Exmar OPTI-11,000® single-deck lift set a record of 9,580 tons at Kiewit Offshore Services.

in the world, and will be installed near the coast of Colombia in 2015.

Exmar's primary business model in the offshore segment is to own and operate assets with the support of its engineering division, EOC. Within the

Exmar Group, EOC develops new concepts and design improvements to existing marine technology. This mandate for innovation led EOC to introduce a new design for a semisubmersible floating production system (FPS). In 2004, EOC created a unique hull design, named the OPTI®, optimized for minimal movement and efficient use of material. Market conditions at that time projected the demand for floating production facilities in the Gulf of Mexico and globally would be considerable. Exmar management was confident the OPTI® hull design had unique characteristics that would give it a market advantage in performance, constructability and operational flexibility. With a standard hull design and flexible topsides configuration for "typical" Gulf of Mexico production, detailed design and construction would be quicker, production of first oil would occur sooner, and returns



▲ The inside face of the optimized, multi-sided columns protect on-hull piping, I-tubes, and pump casings.

would be improved. Based on this assessment, Exmar made the decision to speculatively order an FPS named OPTI-EX® utilizing the OPTI® hull and unique topsides design concept. LLOG Exploration acquired the initial OPTI® FPS and made it central to the Who Dat project. The success of the project validated the Exmar approach. In 2011, the OPTI-EX® Who Dat FPS sailed to location less than 12 months after signing an agreement with LLOG.

While Who Dat achieved first production as planned and is efficiently producing oil today, the real proof of success is shown by LLOG's selection of the OPTI® hull design approach for their second deep water development, Delta House. EOC is proud to partner with LLOG and help them continue to achieve their business objectives.

Innovation Applied – Unique Characteristics of the OPTI®

The OPTI® innovation challenge was to design a production semisubmersible hull with better motions and an efficient structural design to achieve optimal hull-to-topsides weight ratio. The hull design needed to be flexible for variable operational requirements and fabricated as efficiently as possible. The OPTI® addressed these design drivers and is an economically attractive solution. The OPTI® is immediately recognizable from its proprietary column shape and ring-pontoon design. The combination of the unique pontoon and column shape delivers better performance in most offshore environments worldwide. Because the design was conceived to be scalable, the benefits of the design are preserved with different topsides load requirements. The OPTI-11,000® achieved a hull steel weight-to-topsides payload ratio of one-to-one.



▲ The Exmar proprietary riser porch and adapter arrangement on Delta House can connect 18 risers.

The flat truss deck allows for simple installation of topsides modules which, when completed, allows for a single-lift deck-to-hull integration. Building and installing modular equipment on the flat deck reduces schedule risk, simplifies interconnecting piping and electrical systems and allows for future modification should the production profile change or the FPS be redeployed. The OPTI® design premise also includes open deck space and spare load capacity for future expansion or process modification.

In addition to the hull design, EOC designed a proprietary riser porch / riser adapter connection that mates with any riser more quickly than conventional connectors. This design has unique, repeatable and proven efficiencies in installation that were employed in both the Who Dat and Delta House developments.

OPTI-11,000® for Delta House – What is New?

As with any design, the second implementation incorporated changes and improvements. Some were genuine applications of "lessons learned" while others were specific to LLOG and

the field, however, all the unique performance benefits of the design were preserved with an improvement in operability. For Delta House, reusing the OPTI® hull design allowed for an optimized schedule and the flexible single-level deck layout simplified the design for the topsides processing equipment. Combined with an accelerated project execution plan implemented by LLOG, the ambitious project schedule was achieved.

The Delta House overall production capacity needed to be considerably greater than Who Dat, with a peak daily rate of up to 100,000 barrels of oil and 240 million cubic feet of gas. EOC had already been considering the challenges to create more deck area and deal with the subsequent additional weight. One of the key aspects of the OPTI® series is to make the semisubmersible hull design as independent of the process equipment as possible. The proprietary ring-pontoon provides stability in most sea conditions and an open deck space entirely accessible for crane lifts. Version two of the OPTI® series, for Delta House, is designed for 4,679 square meters (50,357 square feet) of

deck space and can accommodate up to 9,300 metric tons of production facility modules and equipment. Essentially, the hull for Delta House is 50% larger and oil production capacity nearly doubles that of Who Dat. The table below shows the key changes from the OPTI-EX® to the larger OPTI-11,000® for the Delta House development.

The hull and topsides integration required close coordination with Audubon Engineering, the topsides design company for Delta House. EOC and Audubon held regular meetings to address the total weight of the topsides and center of gravity calculations. These

two design parameters were critical for the EOC design team to ensure the hull and topsides deck truss structure would meet the required operating service parameters. Unlike traditional ship hulls and SPAR designs which have multiple decks, complicated piping arrangements and access interactions, the deck on an OPTI® hull design is primarily based on a flat, single-level surface. The positioning of the process equipment is important for the deck's center of gravity calculations to ensure the heavy-lift crane can optimize its lifting capability during deck and hull mating operations. The Delta House and

Who Dat topsides were built onshore at Kiewit Offshore Services and integrated quayside with the hull in a single lift, completed within hours in both cases. This approach allows faster construction, integration, and commissioning time.

The Delta House design benefited from the experience of early direct operator involvement and the experience of the OPTI-EX® on Who Dat. EOC was pleased there were no major unforeseen changes, but acknowledges each design iteration will enhance the next. Some of the benefits in the second design in the series included:

- Column stairs and elevators for easier pontoon access
- Access tunnels between pontoon pump rooms and columns for improved operations and inspections
- Improvement in the proprietary riser attachment design
- Application of a new riser pull-in method for easier installation

OPTI® Vision – What is Next?

The market is receptive to an opportunity to get to first oil faster, and EOC is committed to continue to improve the offshore O&G business through innovation as demonstrated by the new OPTI® FPS design. LLOG achieved success with Who Dat and is now heading to another successful milestone with Delta House. With this validation, EOC continues to refine its vision for the OPTI® design beyond versions 1 and 2.

The hull and flexible topsides arrangement can allow redeployment of an OPTI® design to a new field. A smaller reserve base may have an expected life of 5 to 10 years, which in deeper water may not be commercially viable. However, with a flexible, standard con-

	OPTI-EX®	OPTI-11,000®
HULL		
PAYLOAD		
Topsides Nominal	6,000 metric tons	11,000 metric tons
HULL WEIGHT		
Displacement	25,000 metric tons	39,000 metric tons
HULL CONFIGURATION		
Deck Size	60.0 m x 60.0 m	68.4 m x 68.4 m
Pontoon Length	76.8 m	88.8 m
Top of Column ABL	42 m	52 m
Draft	26.0 m	30.0 m
Column Access	Ladders	Elevators and Stairs
Pontoon Access	No Tunnel	Tunnels Connect All 4 Pump Rooms
TOPSIDES		
PRODUCTION CAPACITIES		
Oil Production (Peak)	60,000 bopd @ 24° to 35° API Gravity	100,000 bopd @ 28° to 38° API Gravity
Total Fluids (Peak)	75,000 bpd	120,000 bpd
Gas Production (Peak)	150 MMscfd (SG 0.65 to 0.80)	240 MMscfd (SG 0.65 to 0.80)
GENERAL		
Water Depth Independent	Yes	Yes
Suitable for SCR / Flexible and Hybrid Risers	Yes	Yes
Prime Mover Power	Gas Engine	Turbine/Electric
Flaring	Vertical Tower	Inclined Boom
EXPANDABLE CAPACITY		
Slots Available for Production, Import, Export Risers	Up to 18	Up to 18
Future Loads	1,000 metric tons	1,000 metric tons
Additional Space	350 m²	900 m²



▲ Exmar's single-lift truss deck remains dry in a 1,000 year Gulf of Mexico hurricane.

figuration and shorter delivery time, EOC's proprietary design may help make smaller fields more economical.

The standard OPTI® hull design's flat deck for topsides process equipment can be more easily reconfigured for different compositions of oil and gas. This opens a new business approach for field developments and smaller fields in particular. Exmar's core business model is to own and operate marine assets. Therefore it could own the FPS and make it available to an operator for field development and production on agreeable commercial terms. It is a business model that may appeal to an operator preferring to focus its capital into expanding reserves rather than into fixed assets. For operators who prefer to own and operate their assets, EOC is fully committed to provide the OPTI® hull or complete FPS on a turnkey basis.

EOC's FPS design is a hull sized for weight, stability and operability independent of water depth. It provides flexible flat topsides space that is easier to integrate and re-configure. We anticipate additional designs in the series to accommodate as much as 600,000 b/d of oil and 1,000 MMscfd of



▲ The OPTI® semisubmersible hull is scalable to meet operator needs and is water depth independent. OPTI-EX® installed July 2011 (shown left), and Delta House installed September 2014 (shown right).

gas production. To provide more deck space and to handle additional weight, we are considering a six-column design in addition to our standard four. The additional space on deck will allow for more flexibility in equipment selection, layout and overall mission (drilling and production).

Thinking beyond the traditional FPS market, EOC is working on extending the application of the OPTI® hull design to support a drilling rig configuration. The deck space could also be

ideal for accommodation and work-over services. LNG processing, upgrading of heavy crude, or remote compression of gas are also well within the capabilities of the unit. Having two OPTI®-based facilities in deepwater Gulf of Mexico installed in the past 5 years allows us to take a proven design to new applications with a high degree of confidence.

LLOG and Exmar Offshore have partnered on two highly creative and exciting projects. The success of Who Dat and Delta House is thanks to the hard work and dedication of many people



and their respective companies. EOC is pleased to have the OPTI-11,000® be an essential part of the Delta House project.

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Efficient Sources of Capital

The success of any major project in energy depends on the smooth interplay of many processes and systems. Ranging from steel and pumps to computers and engineering talent, these systems

cover a wide spectrum. One system ties them all together, money. Good project management includes having the capital available when required. ArcLight Capital Partners ("ArcLight")

provides that capital to energy-focused companies to help make their projects successful. That is the role they served in the LLOG-operated Delta House Project in the Gulf of Mexico.



▲ ArcLight, LLOG, and Exmar staff on site at HHI's yard in Korea during construction.

The Investment

The Delta House Floating Production System (FPS), located in Mississippi Canyon 254, is designed to accommodate production from a number of nearby fields, including LLOG's previously announced discoveries in Mississippi Canyon 300 and Mississippi Canyon 431. Oil and gas export lines will connect the FPS to existing downstream pipeline infrastructure. The FPS will have daily processing capacity of 80,000 barrels of oil, 200 million cubic feet of gas, and 40,000 barrels of water with a daily peaking capability of up to 100,000 barrels of oil and 240 million cubic feet of gas. The FPS will have riser facilities to accommodate production from up to nine simulta-

THE ARCLIGHT STRATEGY

ArcLight invests across the entire energy industry value chain including coal, oil and gas production, midstream, power generation, gas and electric transmission and distribution as well as related service businesses. ArcLight bases its investments on fundamental asset values and execution of defined growth strategies with a focus on cash flow generating assets and service companies with conservative capital structures. The firm has consistently applied this philosophy and strategy by:

- » Employing a diversified, non-directional approach to energy investing;

- » Exploiting emerging trends, and identifying hard to find opportunities;
- » Investing in hard assets and service companies that produce significant cash flow;
- » Optimizing underutilized assets to maximize returns;
- » Pursuing private/public arbitrage opportunities;
- » Mitigating exposure to commodity risk to create long-term, stable cash flows;
- » Partnering with experienced operators and management teams to enhance value post-investment;
- » Applying risk management and asset

optimization techniques to capture incremental value and protect against downside risks; and

- » Maximizing exit alternatives by pursuing non-traditional means to investment exits, limiting reliance on public markets.

ArcLight believes this approach allows it to identify unique value creation opportunities throughout the energy industry. These investments generate attractive rates of return through a combination of strong current income and long-term capital appreciation while providing significant downside protection and high visibility of investment returns.



▲ **Delta House topsides under construction — financed by ArcLight.**

neously producing fields. The facilities are expected to process and transport production from six initial wells when commercial operations begin in 2015. Total capital required for the project is over \$2B.

ArcLight's Involvement

Affiliates of ArcLight are providing construction financing and will have a majority ownership interest in the entities that own the FPS and the oil and gas export pipelines. LLOG and its working interest partners (the "anchor producers") will pay fees to use these "infrastructure" assets. This frees up capital to focus on the exploration and extraction of the hydrocarbons which aligns with their core capabilities. The infrastructure owners will also collect fees

from other discoveries developed by the anchor producers and from potential third party tiebacks. The structure developed by ArcLight and LLOG for this transaction carefully allocated risks among the parties and provided a fair return for the capital employed in each aspect of the project. This capital efficiency enabled the anchor producers financial flexibility to bring reserves to market more quickly than a self-funded alternative.

Daniel Revers, ArcLight Managing Partner, commented, "LLOG has a long and successful track record. The deep-water Gulf of Mexico is an attractive and growing domestic production basin, and we are pleased to be partnering with one of the premier operators on this critical piece of infrastructure. We believe that the independent ownership of infrastructure in the deepwater is a

win-win model for producers and infrastructure owners that will facilitate the continued development and growth of this prolific supply basin."

Formed in 2001, ArcLight has demonstrated the ability to aggregate funds to invest broadly and profitably across the entire energy industry. It currently manages over \$10 billion in capital commitments across five private equity funds.



ARCLIGHT CAPITAL PARTNERS, LLC

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Blackstone Provides Financial Flexibility for LLOG's Delta House Project

Blackstone Energy Partners is pleased to be part of LLOG's Delta House Floating Production System (FPS) located in the Mississippi Canyon in the Gulf of Mexico. Blackstone has built a leading private equity investing franchise with an extensive, successful track record of investing in partnership with exceptional management teams seeking to capitalize on their growth opportunities and realize the full potential of their assets. In the past 10 years, Blackstone has committed and invested more than \$7.5 billion of equity in 25 energy transactions, throughout the energy value-chain on a global basis. Oil and gas companies represent a significant share of Blackstone's capital commitments to the energy sector and remain a key focus area for new investments.

Energy is a global, high technology business. Angelo Acconia, the Managing Director of Blackstone Energy Partners who oversees their oil and gas investments, commented on the LLOG partnership, "Critical to the success of



▲ Blackstone site visit.

an oil and gas company is having the right technical, operational and health, safety and environmental ("HSE") teams in place with a strong track record of success, coupled with the right access to capital and ability to effectuate opportunistic acquisitions. LLOG is a best in class organization on the technical,

operational and HSE front and recognized that a strategic partner and funding source helps achieve their business goals more quickly. Financing for the investments and operations is often not at the front of the discussion, but is no less important. LLOG's core skills are the technical and safety issues and recognized a funding partner would help achieve their business goals more quickly." Blackstone Energy Partners and LLOG developed a relationship before the Delta House Project was sanctioned. Delta House is the first joint investment under the partnership.

In November 2012, LLOG Exploration Company L.L.C. and Blackstone formed a long-term, strategic partnership to expand and accelerate LLOG's offshore operations in the Gulf of Mexico. LLOG had made four deep water dis-



◀ Delta House FPS headed for service in Gulf of Mexico.



▲ LLOG Bluewater (jointly owned by Blackstone and LLOG) have executed a three year contract with the SeaDrill West Neptune Drilling Rig which will perform much of the completion work for the Delta House wells.

coveries and was considering appraisal of its extensive prospect inventory of more than 110 offshore leases. Accorcia, further commented, “We are very excited to form this long-term partnership with LLOG to accelerate the growth and development of LLOG’s attractive and extensive portfolio of discoveries and prospects. LLOG has a very talented and experienced technical and operations team, one of the best we have seen in the GOM and the Company has an incredible track record of exploration and development success, operational excellence and strong safety and en-

vironmental practices. To complement this, LLOG is a highly efficient deepwater operator, with the history and ability to accelerate development, minimizing the timeframe to first production and significantly increasing project returns.”

The partnership is designed to leverage the combined operational and financial resources of LLOG and private equity funds managed by Blackstone to expedite development of LLOG’s assets. In addition, the partnership will assist LLOG grow its Gulf of Mexico asset base through federal lease sale participation, farm-ins and acquisitions. LLOG wants to build on its position as one of the largest private companies in the basin. This strategic partnership is the largest private equity financing executed in the Gulf of Mexico to date. Scott Gutterman, LLOG’s CEO, commented, “We are very

excited to form this unique, significant, and long-term strategic partnership with Blackstone. This is the first time that we have joined forces with an equity partner on a Company wide basis, and we cannot imagine a more suitable partner to mark this significant inflection point for LLOG.” This strategic partnership is one of the largest deepwater private equity financings executed in the Gulf of Mexico to date.



BLACKSTONE

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Societe Generale, a key partner in the Delta House financing

Societe Generale (SG) is a Joint Lead Arranger of LLOG's Delta House FPS's (Delta House) debt financing.

SG facilitated a unique financing structure whereby a major offshore floating infrastructure vessel is financed on the basis of projected cash flows coming from the underlying anchor oil fields. This structure does not require an investment grade leasing counterparty in contrast to traditional financings of offshore assets.

The Delta House financing required expertise from two different areas of SG, Shipping & Offshore and Reserve Based Finance. By combining financial and technical expertise of these two teams, SG delivered the first financing of this kind in the US Gulf of Mexico.

This transaction highlights the global nature of SG's commitment and expertise in natural resources and offshore financing. The US Deepwater GOM is a very active area with a number of new large field discoveries and SG is committed to meeting the growing advisory and financial needs of our clients operating in this region.

Societe Generale, your global partner in Oil & Gas and Shipping & Offshore advice and financial solutions

SG is committed to long-term relationships with our clients built on trust. We work to help them succeed in their most important projects. Taking managed risks for them is both our role and our responsibility as a global bank.

SG's global presence brings many financial skills to its customers. Natural Resources & Energy Financing and



Photo courtesy Crowley Solutions; Photographer: Tim Burdick

▲ Delta House FPS – financially supported by Societe Generale.

Shipping & Offshore Financing are two key pillars of the bank designed to deliver the best advice and financial solutions to our client base. With our unique global Reserve Based Finance platform under the Natural Resources & Energy Financing Group, our professionals are best positioned to provide advisory and financial services on a world-wide basis for upstream oil & gas. Clients may select single field development finance or a borrowing facility based on multiple producing fields.

SG's Shipping & Offshore Finance provides dedicated global expertise to clients looking to fund construction, purchase or development of vessels and offshore projects. Underlining SG's position as a leading global energy bank, we have specialist teams dedicated to the LNG and Offshore sectors which include deepwater drillships and FPSO vessels.



SOCIETE GENERALE

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Houston Energy's Deepwater Exploration Success Supports Delta House

Houston Energy congratulates LLOG on the successful deployment of the Delta House FPS.

Exploration geoscientists at Houston Energy made initial identification of two of the fields, SOB II (MC 431) and Marmalard (MC 300), which will be produced through the Delta House FPS at startup. Houston Energy supported exploration for the third field in the Delta House area with additional seismic data and analysis.

Based on advanced 3D seismic interpretation, Houston Energy purchased 26 Deepwater blocks from ConocoPhillips in 2008 to secure the three prospects for drilling and development. These prospects were in the same channel levee turbidite system as Houston Energy's earlier Santa Cruz-Santiago discovery, now a prolific oil producer at MC 519.

Marmalard Field is a turbidite sheet sand draped over a four-way structure with stratigraphic edges. Son of Bluto II Field is a stratigraphic trap on regional dip and is in the eastern portion of the Ariel Field depo-system. Marmalard and SOB II were subtle features recognized

by Houston Energy after additional proprietary 3D seismic processing. The third field, like Marmalard, is a turbidite sand over a four-way structure.

Houston Energy has made a total of 9 discoveries in 10 attempts in the Deepwater Gulf of Mexico. The Santa Cruz-Santiago Field has produced more than 22.6 MM bbls oil. Elsewhere in the Deepwater, Houston Energy has made recent oil discoveries at Big Bend (MC 698) and Taggart (MC 816). Big Bend is scheduled to begin production in the third quarter 2015. The Taggart discovery, operated by LLOG, was made in 2013 and is scheduled for completion and hookup in 2016.

Houston Energy and its partners have acreage on 25 undrilled prospects with a resource potential of 1,610 MMBO and 1.6 TCF. The blocks include high quality Miocene and Lower Tertiary age oil prospects in the Mississippi Canyon, Atwater, Green Canyon, and Walker Ridge Areas.

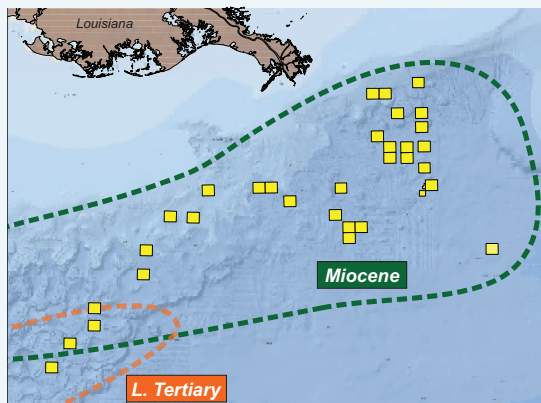
Houston Energy is a privately held independent oil and gas company exploring the Off-shore Gulf of Mexico, South Louisiana, Texas Gulf Coast. The company was formed in March, 1988 by Ronald E. Neal and Frank W. Harrison, III. The mission of Houston Energy is to economically find and develop oil and gas reserves for its partners.

Houston Energy uses an extensive inventory of



▲ Houston Energy's Santiago Field discovery.

3D seismic data to develop drilling opportunities across a range of depths, potential reserve sizes and risk levels. This exploration approach produces a diversified prospect portfolio to match varied investment strategies.



▲ Houston Energy Deepwater Prospects.



HOUSTON ENERGY, L.P.

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Ridgewood Energy: Technology. Expertise. Discipline.

As an energy-focused private equity firm and active investor in Gulf of Mexico exploration and production projects for over two decades, Ridgewood Energy has partnered with many of the most successful and pioneering energy companies in the Gulf. Since 2008, Ridgewood Energy's activities have been primarily focused in the deepwater Gulf of Mexico, where it has participated in a series of major oil discoveries—including the three Delta House fields—and built a leasehold inventory of oil prospects. Ridgewood Energy is also a proud partner in the development of the Delta House Floating Production System. Today, Ridgewood Energy is participating in deepwater projects that have discovered estimated gross

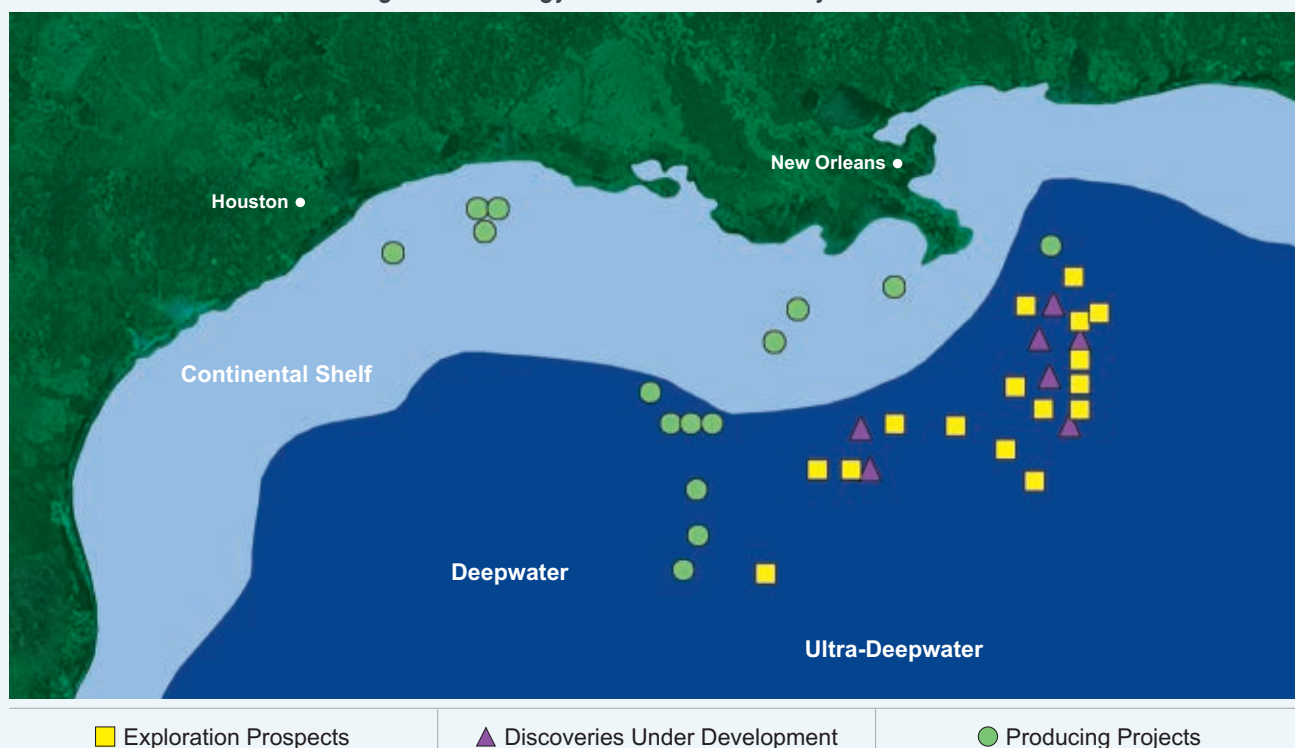
reserves in excess of 450 million barrels of oil equivalent (proven plus probable), and holds interests in Gulf of Mexico leases with additional gross resource estimated to exceed 600 million barrels of oil equivalent.

Ridgewood Energy remains committed to being a value-adding, non-operating partner to leading exploration and production companies. Its Houston-based team is comprised of seasoned industry professionals with dedicated geoscience, production and reservoir engineering, land, marketing, and commercial expertise. The Ridgewood Energy team is highly skilled and accomplished in all areas related to successful oil and gas exploration, development, and production, and brings deep, basin-specific knowledge to the

evaluation, execution, and management of projects.

With a strategic focus on projects located in the Central Gulf of Mexico, Ridgewood Energy has concentrated the majority of its deepwater investment activity in the Mississippi Canyon, Green Canyon, Ewing Bank, and Atwater Valley, where Ridgewood Energy, either directly or through its joint venture partnerships, has access to state-of-the-art seismic data coverage. Bidding alongside key joint venture partners, Ridgewood Energy was the seventh largest overall participant in the 2014 Central Gulf of Mexico Lease Sale 231. In addition to direct participation at the Lease Sale, Ridgewood Energy also acquires leasehold interests from other energy companies, and

Ridgewood Energy's Gulf of Mexico Project Portfolio





▲ While Ridgewood Energy's strategy is to be a non-operating partner in major deepwater oil projects, the firm brings enormous technical expertise and validation to the projects in which it participates.

participates in attractive drill-ready projects. This multi-channel approach allows Ridgewood Energy to participate in a broad range of projects, and to partner with many of the Gulf's leading exploration and production companies.

Ridgewood Energy currently manages a strategically focused deepwater Gulf of Mexico investment program of capital commitments totaling approximately \$2.5 billion. This program includes a significant investment that Ridgewood Energy manages on behalf of affiliates of Riverstone Holdings LLC, which is one of largest energy-focused private equity firms in the world. Since its inception in mid-2010, Ridgewood Energy's joint venture with Riverstone has participated in six significant oil discoveries (including the three Delta House fields). Through its joint venture with Ridgewood Energy, Riverstone affiliates are also partners in the Delta House Floating Production System, and continue to progress

additional deepwater Gulf of Mexico exploration and development opportunities.

In 2014, Ridgewood Energy made more than \$500 million of capital expenditures related to deepwater Gulf of Mexico drilling and development activities. Over the next several years, Ridgewood Energy's level of investment in high-value deepwater Gulf of Mexico projects is expected to increase significantly.

In addition to development work related to existing discoveries, Ridgewood Energy's current inventory of exploration prospects creates visibility to its participation in the drilling of a significant number of exploration wells during 2015 and beyond. In the meantime, Ridgewood Energy's technical in-house team will continue its active origination work, reviewing opportunities from industry partners, and generating new high-potential prospects.

In the months and years ahead, the team at Ridgewood Energy looks forward to building on its existing relationships—and to forging new partnerships—to develop America's vital deepwater Gulf of Mexico oil and gas resources. In this pursuit, Ridgewood Energy will remain dedicated to preserving its reputation as a reliable, professional, and value-adding partner to leading energy companies in the Gulf of Mexico.

Ridgewood Energy wishes to thank LLOG Exploration and all of its industry partners who are contributing to the safe and successful development, deployment, and operation of Delta House.



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What's an Indian Tribe doing in the Gulf?

Indian reservations in the western US often have natural resources which can be a source of value. The Southern Ute Indian Tribe has leveraged the natural gas resources on the reservation in the San Juan Basin into a group of successful businesses under an organization called the Southern Ute Growth Fund. Red Willow Production Company is an E & P company and the largest company in the Tribe's portfolio.

In 2000, the Growth Fund was charged by the Tribal Council with finding quality investments off the reservation. As part of that effort, Red Willow entered into a number of exploration agreements with Houston Energy (HE), including a deepwater exploration agreement in 2004. This deepwater exploration program has been very successful, yielding a number of discoveries. In fact, nine of the group's first ten wells are discoveries. Ed Zinni and James Hart of HE have been the primary oil finders. The partnership has an extensive inventory of leased prospects throughout Mississippi Canyon.

The exploration partnership was fortunate to partner with LLOG on a number of these discoveries, and a group of these discoveries are the reserve base



▲ Red Willow fracking a Niobrara well on the Western edge of the reservation.

for Delta House. Red Willow generally retains between 20% and 25% of the working interest in a prospect developed by the partnership.

LLOG's team on Delta House has developed a world class facility quickly and at a reasonable cost, greatly improving the economics of the group's deepwater investments in the area.

The Southern Ute Indian Tribe and the Energy Business

The Southern Ute Indian Tribe has a unique philosophy guided by long-held

values and wisdom. It requires Red Willow to ask, "What will future generations think of us?" LLOG's record as an operator meets Red Willow's tough standard

The planning and strategy that resulted in Red Willow's participation in Delta House is a unique story in Indian Country. The Southern Ute Tribe is a leader in self-determination. They began actively developing their extraordinary natural resource base on the reservation during the 1980s and 1990s. The Tribe's energy business portfolio

▼ Red Cedar's Coyote Gulch gas plant on Southern Ute reservation in San Juan basin.



originated with the formation of Red Willow Production Company in 1992 and the purchase of Red Cedar Gathering Company in 1994.

Red Willow was originally formed to buy back natural gas leases and to upgrade the performance of gas wells on the Reservation. Its success required increased capacity to transport new volumes of gas to the interstate pipelines. The Tribe partnered with the Stephens Group in 1994, and purchased Red Cedar to gather, process and transport natural gas from the Reservation. Kinder Morgan bought out Stephen's successor in 1998 and has been a great partner for the Tribe.

Tribal Council adopted an official Financial Plan in 1999 that separated its core government Permanent Fund from its business enterprises, initially energy, and related investment activities. In accordance with the Financial Plan, the Tribal Council enacted the Growth Fund Implementation Plan in 2000. This plan defined the goals, systems of operation, and consolidated the management of the Tribe's business activities. The Growth Fund's business portfolio initially contained only Red Willow, Red Cedar and a few small Tribal Organizations.

Southern Ute Indian Tribe Growth Fund (SUGF) - "Our mission is to provide economic prosperity for the Southern Ute Indian Tribe by managing the Tribe's businesses effectively, building new businesses prudently, and investing its money wisely. We provide analysis and advice to the Tribal Council on the Tribe's businesses and financial affairs, and we provide the day to day executive management of the Tribe's business enterprises."

The Tribe realized that its energy resources on the Reservation were finite, so the Tribal Council instructed the Growth Fund to diversify operations off of the Reservation and into other ventures and investments. Since 2001, Red Willow has participated in energy projects in nine states, Alberta, and the Gulf of Mexico. Red Willow Production Company has net production of 120 mmscfd of gas and 10 mbd of oil. These figures will increase with the new production from Delta House. It has interests in more than 1900 wells in 10 basins on over 290,000 acres across the U.S.

The Southern Ute Indian reservation is located in southwestern Colorado on 700,000 acres in the northern half of the San Juan Basin. Production is primarily coal bed methane from the Fruitland Coal, with conventional production from the Mesa Verde, Pictured Cliffs and Dakota formations. The company partners with major operators, including BP, ConocoPhillips and Energen in the San Juan Basin. It has an interest in more than 1300 producing wells on over 148,000 acres of leasehold. Red Willow operates more than 400 wells on the reservation.

The financial success of the energy businesses has allowed the Growth Fund to diversify its portfolio. This diversification includes substantial real estate investments across the US. The GF Properties Group has expertise operating companies in all aspects of real estate; planning, development, investment and project/asset/property management. Investments consist of residential and mixed use land for sale and property in retail, office, industrial, apartments and condominiums. As the company's portfolio continues to grow, the focus is on acquiring income-producing properties, providing asset

management services for the properties in the portfolio, and divesting assets as appropriate to optimize investment returns.



▲ The Tribe's real estate group is majority owner of the Spire condo project in Denver.

The Southern Ute Indian Tribe has created an energy, real estate, and private equity portfolio of investments which provide financial security for the Tribe and its members. A huge part of this success comes from working with excellent partners. LLOG is one of the best.



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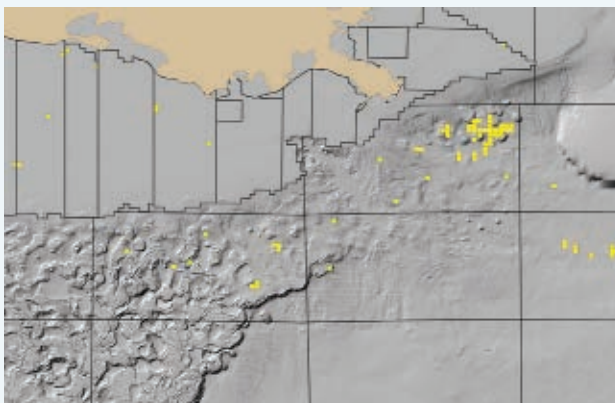
Calypso Exploration – Economically Strong, Technically Savvy, Timely

Calypso Exploration, LLC (CXL) is an independent oil and gas company incorporated in 2000 and was created to find drilling opportunities offshore as a non-operator. CXL is privately owned and works out of cash flow.

The CXL story is one of success in that the company has two employees who are responsible for finding exploration/exploitation opportunities in the Gulf of Mexico on both the Shelf and in Deep Water. Since inception CXL has partnered with many notable operators including Shell, ENI, Noble, Murphy, Anadarko, LLOG, Deep Gulf, and GoMex.

The business model employed in deep water is simple: (1) drill seismically driven prospects with amplitude and structure that are supported by attributes and stratigraphic ties, and (2) look for oil. CXL takes care in selecting great partners and Delta House is replete with those. First of all, Houston Energy, Inc. (HEI) was the play generator and because of the great amount of detail that went into the geophysical interpretation, the project has been void of costly surprises. Secondly with LLOG as operator, the project drilling and the FPS design and construction has been very smooth, cost efficient, and on time.

Many wonder how such a small independent can thrive in Deepwa-



▲ Calypso Exploration Leasehold interests in Gulf of Mexico.



▲ (l) Charles C. Barnes, Vice President Land & Business Development and (r) Dave Barrett, President.

ter GOM? Well the answer to that is wise investing and great industry relationships. We also have great internal trust relationships within our company and that is a strategic advantage in that our decision making can take place in a very short time frame. Delta House is an example. Because of the quality of work that HEI put into the Delta House play, after an hour and a half of review and discussion, CXL was able to commit to taking a WI in 4 prospects

with just one quick phone call. Not all small companies are alike, and Calypso distinguishes itself with economic strength, technical expertise, very quick analysis, and timely decision making.

The President is Dave Barrett with 40 years of Geo-

science experience and a graduate of the University of Houston, and the Vice President Land/Business Development is Charlie Barnes with 40 years experience and a graduate of the University of Texas. In addition to the Delta House prospects of Marmalard, Son of Bluto 2, Son of Bluto 3 and one other field, other projects producing or capable of producing include Noble's Raton South MC 292, Deep Gulf's Odd Job MC 214/215, and GoMex's Redevelopment Project VR 282/EC 272, all of which are oil projects with CXL's WI ranging from 10.125% to 37.5%.



CALYPSO EXPLORATION, LLC

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Delta House DeepRope® project delivery milestone achieved on schedule

Bexco is a leading European manufacturer of precision engineered fibre rope solutions. From its main production facility located within close proximity to the port of Antwerp, Bexco's experienced craftsmen and engineers have established the company as a reliable provider of sturdy mooring, towing and lifting rope, made-to-measure for offshore oil and gas, marine and industrial applications.

Bexco designed, manufactured, tested and successfully delivered twenty six reels of DeepRope® with sixteen inserts for the permanent deepwater offshore mooring of LLOG's Delta House Floating Production Semisubmersible. DeepRope® is a class-certified product. Its production process has been type-approved and certified according to latest API RP 2SM and ISO 9001 standards. In addition, the DeepRope® supplied to Delta House was one of the first of its kind to be delivered with the new DNV OSE303 certification on such a large rope size for deployment in the Gulf of Mexico.

Each rope for Delta House measures 1000 metres in length, and is configured to handle a Maximum Break Load (MBL) of 1700 tons. Rope production commenced in mid-May of 2013, with everything completed two weeks ahead of schedule by mid-November and expedited from the rope production facility on 11th December 2013.

Given the harsh environment for mooring as well as strict regulatory requirements stipulated by the Bureau of Safety and Environmental Enforcement (BSEE), Bexco produced a sample DeepRope® for seabed pre-lay

testing purposes in the Gulf of Mexico for in the summer of 2012. Several days of testing at sea were carried out with a senior Bexco engineer on-site. This included dragging and resting



▲ Loading Bexco DeepRope® reels at Port of Antwerp for Delta House.

the DeepRope® sample on the seabed, leaving it on the seabed for 24 hours and cycling through boat motions. The posterior DNV visual inspection proved positive and in November 2012 Bexco received seabed pre-lay BSEE approval. The engineered installation processes for DeepRope® were also subjected to the Intermoor mooring installation procedure, and subsequent comprehensive DNV testing was carried out on the sub-rope to perfectly forecast rope behavioural response during installation.

In order to produce DeepRope® consistently to specification for Delta



▲ Close-up of DeepRope® for Delta House.

House and for all its projects, Bexco builds a simulation model that is validated by actual sub-rope testing, using its state-of-the-art R&D test bench at its production facility in Belgium. This new test bench is equipped with 5 metre dual cylinders which allow for precise, digitized stress tests of extended duration for large diameter synthetic rope of up to 25 metres in length.

Bexco is proud of its role in this unique project, and aspires to continue to innovate in developing state-of-the-art, durable deepwater mooring solutions for LLOG Exploration with its DeepRope® range.

BEXCO
OUR ROPE. YOUR SOLUTION

BEXCO NV-SA

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Audubon Engineering Solutions – Integrated Topsides Design Required Management and Flexibility

Project Design Scope

Audubon Engineering Solutions was selected by LLOG Exploration Company (LLOG) as the topsides engineering contractor for the Delta House floating production system (FPS) project. Straightforward and reliable design principles as well as a “one size fits most” modular design philosophy set the foundation for this project. LLOG’s goal was to design, fabricate and install the platform in approximately 30 months. For the Delta House project, the proven EXMAR OPTI™ hull design was scaled-up to meet the new design criteria of a production rate of 80,000 BOPD, 200 MMSCFD and 40,000 BWPD.

The topsides deck for Delta House consists of a two-level structure with most of the processing and utilities equipment/systems located on the upper level for ease of fabrication, operation and maintenance. The FPS was designed to have extra capacity and an expandable control system designed to support future production.

The “one size fits most” design philosophy was used in the Delta House equipment layout while considering future platforms. Subsequent floating production systems will use Delta House as a basis for design with minimal

changes necessitated by the PVT data. Utility systems and marine systems will not be modified unless new sizing criteria dictates a change in size or location. Production, treating, utility and control systems were designed for ease of operation while meeting the regulatory requirements of the Bureau of Safety and Environmental Enforcement (BSEE) and U.S. Coast Guard; the class-

semisubmersible hull and confirm topsides compliance with U.S. Coast Guard regulations.

Integrated Design and Project Management Capabilities

As with any topsides designs for an offshore production facility, proper communication and coordination protocol among key contractors in the design

phase was critical. Audubon Engineering Solutions supported LLOG by providing this important interface management. Key contractors that worked on Delta House included EXMAR Offshore, the hull design company; Kiewit Offshore Services (KOS), the topsides integration and lift contractor; Pinnacle Engineering, the subsea engineering company. The interface management scope included procurement services, expediting services, cost control management, construction management support, integrated scheduling, topsides engineering, commissioning, and Plant Design Management System (PDMS) for design and fabrication support. Audubon Engineering Solutions periodically



▲ Delta House FPS receives the topsides production systems.

ing requirements of Det Norske Veritas (DNV); and sales specifications of the receiving pipeline companies. LLOG selected DNV to class the OPTI-11,000™

cally exchanged PDMS models with EXMAR to check for design accuracy and performed numerous internal model walkthroughs as well as reviews with



▲ Delta House Topsides Fabrication / Integration being completed at Kiewit Offshore Services.

LLOG, KOS and other firms involved in the project.

Initial topsides engineering consisted of confirming that the selected OPTI-11,000™ semisubmersible hull design would meet the expected payload requirements of the processing and utility equipment as well as the additional 500-tonne payload required for future equipment (in actuality, over 900 tonnes of future payload was achieved). Tracking weight and platform center of gravity (CG) during the design process was a key metric to ensure the design remained within allowable tolerances.

A single lift of the integrated structural deck and topsides facility to be set on the hull was required to achieve LLOG's accelerated project schedule. Audubon Engineering Solutions' topsides design team worked diligently to keep the topsides deck within the stringent lifting requirements of the Heavy Lifting Device (HLD), which had a planned 10,000 short ton lifting configuration for Delta House to account for the weight of rigging and

safety factors. Holding the topsides CG within close tolerances allowed for the lifting of the deck without overloading either of KOS's HLD booms.

During the project, Audubon Engineering Solutions' experience in design flexibility was tested when new pressure-volume-temperature (PVT) data was received during the topsides detail design phase, requiring the addition of new processing equipment. Due to an unexpected large volume of Natural Gas Liquids (NGLs), a Condensate Stabilization System was necessary to meet the oil sales pipeline RVP requirements. An aggressive weight management plan and effective communication between contractors made this significant design change possible without affecting the delivery schedule or preventing the FPS from achieving its futures payload goals.

Audubon Engineering Solutions consistently collaborated with all of the project design firms, fabricators and vendors during the design of this project to deliver on schedule. Additional

coordination and expedition of vendors and fabricators ensured equipment construction was completed in accordance with specifications and delivered on time.

About Audubon Companies

Audubon Companies' affiliates provide integrated engineering, procurement, construction, project management, and automation to the global oil and gas industry. For almost 20 years, Audubon has provided exceptional engineering services in the oil & gas sector.

We understand the client's needs and solve dynamic project challenges with a flexible approach while delivering unsurpassed quality. Audubon takes pride in providing cost-efficient solutions that offer immediate value and long-term returns.

Our company is dedicated to the safety of our employees and upholds the highest standards. We are committed to practicing rigorous safety standards and maintaining an incident-free, work environment.

Audubon is comprised of four affiliates – Audubon Engineering Solutions, Audubon Field Services, Cimation and Affinity Management Group – and between them we tackle some of the industry's most complex engineering, technical and operational challenges. Find out how Audubon can help you achieve quality, efficiency and safety.



AUDUBON COMPANIES

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Formation Evaluation Technology Highlights the Baker Hughes Contribution to Delta House

Baker Hughes has contributed to LLOG Exploration Offshore's innovative Delta House project by providing drilling and evaluation services for the subsea wells that will tap reservoirs in four Mississippi Canyon blocks. Baker Hughes also will supply products and services for upper and lower completions for the project's nine wells.

To begin the project, five subsea wells were drilled, evaluated, and temporarily abandoned to await future completion and the arrival of the Floating Production System (FPS). Baker Hughes provided directional drilling services with its AutoTrak™ rotary steerable system. Because the wells would serve the dual purposes of field appraisal and development, LLOG called for a comprehensive program that included a full suite of formation evaluation measurements provided by logging while drilling (LWD) and wireline services.

Seismic While Drilling

The newest and most advanced evaluation technology applied on the Delta House project was the Baker Hughes SeismicTrak™ seismic-while-drilling service, which was used on one of the Delta House wells.

The SeismicTrak service combines use of a downhole sub with redundant sensors and a seismic source on surface to enable operators to update surface seismic models without impeding drilling operations. The SeismicTrak service captures check shot measurements during connections, and transmits the data to surface using mud-pulse telemetry. As an operator adds pipe, seismic operations from surface



▲ The Baker Hughes *Blue Dolphin* technology vessel.

engage, and the SeismicTrak downhole receiver acquires formation velocity data with no slowdown to the operation. In addition, the system collects check shot data and full vertical seismic profile data in memory for processing after drilling.

The SeismicTrak service acquires data just ahead of the bit so operators can see and estimate distances to bed boundaries, as well as hazardous faults and pore-pressure regions, in real time.

SeismicTrak on Delta House

To improve the depth positioning of surface seismic data, LLOG wanted to obtain a zero-offset checkshot survey of its exploratory well, while minimizing nonproductive time (NPT).

To help LLOG achieve its goals, Baker Hughes used the SeismicTrak service to drill and record check shots in the final section of the well.

The resulting borehole seismic data was transmitted in real time to experienced geophysicists through the Baker

Hughes WellLink™ RT internet-based, WITSML-compliant service.

The exploratory well surveyed with the SeismicTrak service had an elongated S-shaped profile, terminating in a near-vertical section where the check shots would be taken. Because of the well's configuration, a "zero offset" could be achieved by hanging the air guns from the rig.

At each check shot, the data were transmitted to town, where Borehole Seismic Group processed the data and delivered first arrival results within 30 minutes, followed by wavelet processing display 15 minutes later.

Because the SeismicTrak system could collect data ahead of the bit, its readings showed that the reservoir sand was located 200 ft shallower than the depth indicated by the surface seismic. The shallower depth was confirmed when the bit reached the sand layer ahead of the original prognosis.

After the well reached total depth, the SeismicTrak service acquired more

fill-in check shots, recorded in memory at 45-ft intervals, while tripping out to complete the data set. The final memory processing successfully delivered a vertical seismic profile (VSP) image. LLOG used the resulting time/depth information to update the time/depth conversion of the surface seismic model, reducing uncertainty in surface seismic interpretation.

TesTrak Service Used in Two Applications

LLOG employed the TesTrak™ LWD formation pressure testing service to periodically measure sand pressures as the well was being drilled, and enable engineers to adjust mud weights and other param-



▲ **The Baker Hughes TesTrak LWD pressure testing service measured sand pressures and enabled LLOG to adjust mud weight to ensure hole integrity.**

ters to ensure hole integrity, prevent BHA sticking, and keep the well under control.

In addition, the TesTrak system was used in the target sand to measure pressure gradients, reservoir fluid pressures,

and fluid viscosities. Geologists also could use TesTrak answers to update their models in real time with respect to reservoir connectivity, compartmentalization and sealing fault identification.

LWD Imaging Helps Map Reservoir Structures

The LithoTrak™ density-porosity LWD system was used as a wireline replacement tool, taking bulk density measurements and creating bulk density images to visualize the downhole geology. The LithoTrak system delivers reliable neutron porosity and formation bulk density logs at rapid sampling rates using an innovative downhole acquisition process. The LithoTrak service's 16-sector borehole image provides detailed information about the structural orientation of bed boundaries crossed by the well. Gamma Ray image logs, acquired with the OnTrak LWD system, also were used to determine formation dip angles.

The density and Gamma Ray image logs were used to further refine the Delta House earth model by more accurately mapping faults and formation dipping patterns.

Array Processing Improves Resistivity Answers

Baker Hughes employed an advanced method of processing resistivity logging data to help LLOG evaluate the Delta House pay zones.

Data were acquired using the OnTrak service, which provides dual gamma ray measurements and four resistivity measurements with variable depths of investigation.

MPRTEQ™ array processing considers all four resistivity measurements to accurately determine horizontal resistivity. The method also corrects for anisotropy and calculates a qualitative vertical

resistivity value to better understand interbedded sand/shale sequences, particularly in high relative dip angles.

Advanced Completions Ready for Deployment

All lower completions will be proven Baker Hughes sand control systems, featuring Excluder™ screens, CMP™ fluid loss control valves, SC-2™ sand control packers, and CK System™ frac extensions. Frac pack treatments will be pumped by a Baker Hughes technology vessel, either the *Blue Dolphin*™, *Blue Tarpon*™ or StimFORCE™ vessel.

Delta House wells completed in 9 $\frac{7}{8}$ -in casing with single zones that include Premier™ packers with Striker™ remote actuation, SAF-1™ fluid loss devices and non-sealing telescoping space out joints (TSOJ's) to facilitate connection with the lower completion. Wells completed in multiple zones will include quick connects, SAF-1™ fluid loss devices and sealing TSOJ's.

One Delta House well will be completed in 11 $\frac{7}{8}$ -in. casing using an intelligent well system. For this unique application, Baker Hughes developed an 11 $\frac{7}{8}$ -in Premier packer with feedthrough lines and an 11 $\frac{7}{8}$ -in SC-2 packer for the sand control portion of the well. The completion also will include a quick connect and a TSOJ.

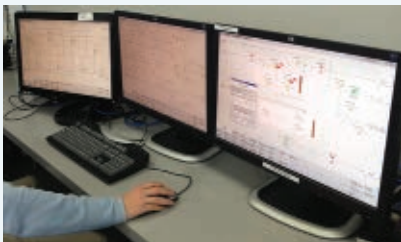


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Cimation – Automation and IT Support from Specification to Commissioning

In 2012, Cimation was awarded Delta House's automation and IT scope of work, which included the design, execution, startup, and commissioning of the facility's Programmable Automation Controller (PAC) and Human Machine Interface (HMI) control systems, architecture and configuration of the IT infrastructure, telecommunications engineering, and safety instrumented systems.

Cimation developed automation and IT specifications for Delta House, including HMI designs, network configurations, and standards documentation for use by all third-party vendors. These project-wide standards helped reduce the number of spares LLOG required, increased safety thanks to common communication protocols and fewer points of failure, and simplified system management through design consistency. Due to their in-depth knowledge of the project's technology requirements, Cimation also served as a witness during factory acceptance tests (FATs) conducted by other vendors.



▲ Cimation created HMI standards for LLOG Delta House.

One of Cimation's key objectives was to create efficient, reliable automation and IT systems that met the demands of a complex deepwater platform. To meet these requirements, Cimation opted for a PAC/HMI-based solution that was

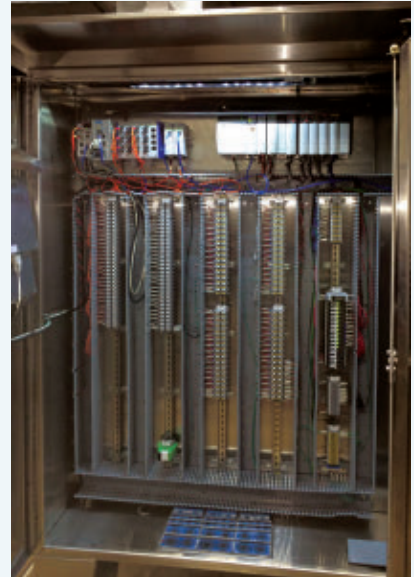
both cost effective and relatively quick to deploy. Cimation also developed and implemented a virtualized infrastructure for HMI, historian, and other server functions, reducing the space required to support the hardware by allowing three servers to run twenty virtual machines. The virtualized infrastructure resulted in a more robust system with more effectively separated functions, additional redundancy, reduced energy requirements, and less weight. Dedicated Ethernet/IP networks on a redundant ring topology were designed and implemented for remote I/O and Motor Control Center (MCC) integration. This type of network has a very low failure rate, making it a robust option for projects of this magnitude.

Cimation's Enterprise Data Solutions (EDS) team also provided solutions that allowed LLOG's operations, engineering, accounting, and management teams to use data from multiple offshore facilities through integration into onshore systems including a consolidated process historian, remote operations center, SCADA system, and accounting systems.

Using their skills and expertise as an industry leader in industrial control systems security, Cimation built cyber security best practices into every aspect of automation and IT design, from network security appliances and firewalls to access controls and password protection.

About Cimation

Cimation, an affiliate of Audubon Companies, is an operations consulting company successfully delivering secure



▲ Streamlined panel design by Cimation.

technology solutions to the global energy industry by combining automation, industrial IT, cyber security, and enterprise data solutions.

Cimation was proud to provide excellence in integrated automation and IT services on LLOG's prestigious Delta House project. By developing a valued and trusted relationship with LLOG and the other project vendors, they provided best-in-class solutions for safety, reliability and efficiency through all stages of operations.



CIMATION

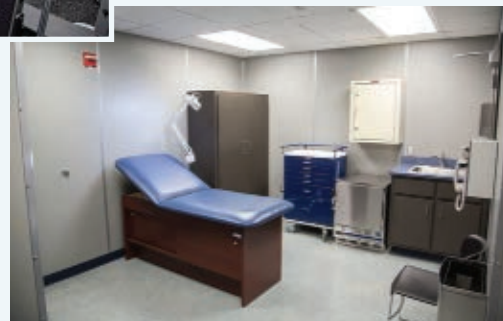
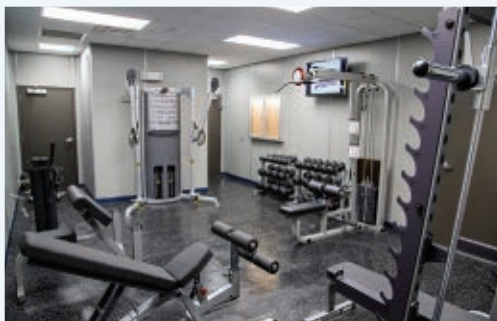
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Civeo Completes Comprehensive Crew Quarters Package

Civeo Corporation is a global work-force accommodations specialist dedicated to helping people maintain healthy, productive lives while working away from home. Civeo offers comprehensive solutions for housing hundreds or thousands of workers with its long-term and temporary accommodations and provides catering, facility management, water systems and logistics services. Civeo builds forward-thinking solutions to our clients' offshore accommodation needs. We offer seaworthy solutions, including custom designs and a diverse rental fleet consisting of 400 portable modules for installation and use on offshore platforms, vessels, salvage/dredging barges and ships.

"Civeo was extremely excited and proud to be included in this project", said Billy Derenbecker, Vice President of Offshore Operations. "The Delta House project marks the beginning of a new chapter, as we continue to expand our product and service offerings into custom designed offshore accommodation solutions."

Civeo completed the Delta House Crew Quarters package in January 2014. This comprehensive 16-month project included the design and fabrication of a 38-person living quarters package, complete with an attached helipad, life boats and an emergency generator. The helipad can handle 12,000 pounds and used for transporting people to and from the shore base. The schedule included a three-month design period in which all structural and architectural plans were completed.



▲ The Delta House Crew Quarters package was packed with amenities, including: A weight room, conference room, full-service kitchen and dining room and medical bay.

The 570-ton unit was constructed at Civeo's fabrication yard in Belle Chasse, LA (just south of New Orleans) and was transported to Kiewit Offshore's fabrication yard at Ingleside, Texas. There it was integrated with the Delta House topsides.

The Crew Quarters Package is designed for safety with fire suppression and access to life boats. It complies with US Coast Guard and other regulations and certifications for offshore operation. In addition, it is packed with amenities, including: bunk-style quarters for the general workforce and private in-suite quarters for management; a conference room, medical bay, laundry facilities, weight room and a full-service kitchen and dining room.

Civeo also provided temporary quarters on the topsides to support installation and commissioning activities.

LLOG ran an efficient project and encouraged cooperation among all the contractors. Civeo worked closely with Audubon, the topside engineering design firm, to ensure the Crew Quarters Package was on specification for size and weight. That cooperation combined with the experience and expertise of the entire Civeo staff made this first-time endeavor finish ahead of schedule. Civeo's team was proud to contribute its part to this successful LLOG project.



CIVEO CORPORATION

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DNV GL Classification and Regulatory Approval for Delta House

Proving the US market has options to choose among classification partners in US waters, DNV GL provided classification and verification services to LLOG's Delta House project for the US Coast Guard (USCG) and BSEE, respectively. Put simply: Making sure LLOG as well as the USCG and BSEE were confident in Delta House meeting all regulatory requirements.

"Being a part of the success that is Delta House is something we are proud of," says DNV GL's project manager Raja Roy. "In 2008 we did class the first FPSO in the Gulf of Mexico, BW Offshore Pioneer for the Chinook field. We wanted to make Delta House another reference project in the Gulf of Mexico. Now everyone knows that you can choose DNV GL and be confident of regulatory approval," he says.

To meet with all the USCG requirements for the Delta House project, a design basis agreement was developed using the DNV offshore rules. For two years, from early design to sail away, ten people, in the US, Norway and Ko-

rea, worked on the classification scope: Making sure the design and construction effectively met the US Coast Guard requirements.



"This was the first project following an explicit statement from the USCG accepting plan review and inspection functions conducted by DNV GL for a floater in the Gulf of Mexico as part of the unit's certification under Title 33, Code of Federal Regulations," says DNV GL's Houston based project manager Raja Roy.

The USCG has confirmed that DNV GL's competence, communication, and attention to detail made oversight straight forward.

At the same time, another DNV GL team was working in its capacity as Certified Verification Agent (CVA) for BSEE (Bureau of Safety and Environmental Enforcement). Their scope was the structure, mooring and riser. The CVA group had to work independently of the class group, yet at the same time have the necessary overview to capture synergies.

Numerous suppliers and manufacturers were involved in this project and some had not previously worked with DNV GL. DNV GL helped familiarize them with the process. "This went well, and expanded the number of engineering units and major vendors who now know our rules and processes," says Pari Natarajan, the project manager in the field.

With the Exmar designed hull being built in Korea, and the Audubon Engineering Company designed topside being built in the Kiewit Offshore Services Yard in Ingleside, Texas, the integration of these two parts had to work smoothly. Through effective knowledge sharing processes and interactions, the handover from Korea to Ingleside went without a hitch.

"Owners have expressed a strong desire for choice of classification society for floating offshore installations in American waters and we know there



▲ Delta House deck set safely on the hull.



▲ Delta House hull ready for sail away from Korea.

are many owners, designers, operators and yards who would prefer to work with DNV GL. This successful project is further proof that they can do so, confident of legal and regulatory approval,” says Paal Johansen, DNV GL’s Director of Operations for Maritime in North America.

“With local capabilities and expertise DNV GL is a well established alternative and experienced partner for classing floaters and complex projects in the Gulf of Mexico. We now look forward to address the industry’s needs and desires for increased safety, reliability, cutting edge technology and, of course, reduced downtime. We are confident that both owners and regulatory agencies will benefit from this,” he said.

DNV GL has carried out extensive verification and independent analysis for many GoM floaters throughout the past 20 years, including many high pro-

file failure and accident investigations. DNV GL has a wide portfolio of CVA and development projects for the oil and gas industry in the GoM.

About DNV GL

Driven by our purpose of safeguarding life, property and the environment, DNV GL enables organizations to advance the safety and sustainability of their business. We provide classification and technical assurance along with software and independent expert advisory services to the maritime, oil and gas, and energy industries. We also provide certification services to customers across a wide range of industries. Operating in more than 100 countries, our 16,000 professionals are dedicated to helping our customers make the world safer, smarter and greener.

In the oil and gas industry, DNV GL is the leading technical advisor to the

global oil and gas industry. We provide consistent, integrated services within technical and marine assurance and advisory, risk management and offshore classification, to enable safe, reliable and enhanced performance in projects and operations. Together with our partners, we drive the industry forward by developing best practices and standards. Our people combine industry expertise, multi-disciplinary skills and innovation to solve complex challenges for our customers.



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Delta House: Project management with a personal touch

Long before welders cut the first piece of Delta House steel, Cyrus J. Guidry & Associates (CGA) was part of the project management team. Thousands of talented people contributed to the finished product, but we were there from the start. Back in May 2012, when the Gulf's newest deepwater platform was little more than spreadsheets and a spot on a map, we were helping to estimate costs, prepare bid packages and lists of bidders. After the bids came in, we helped expedite procurement and made sure that LLOG was getting all the value it expected.

For two years, a dozen of our most experienced Construction Managers and inspectors worked full time at the Kiewit Offshore Services yard at Ingleside. Another 18 CGA people traveled regularly to 134

vendor sites around the United States and Canada, ensuring that the components for Delta House were delivered on time, on spec and fit for purpose. At Ingleside, around the country and offshore, CGA construction managers oversaw every aspect of the job, from safety and environmental care, to fabrication, inspections, transport, installation, commissioning and startup.

"We're a close-knit company with little turnover in staff," says CGA owner and president Cyrus Guidry. "Our project engineers and inspectors are sea-



▲ Delta House being set on top of hull.



▲ Typical testing stall at Cyrus J. Guidry & Associates' Welder Testing Facility.



▲ Delta House hull in the shipyard.

soned problem solvers who average nearly 25 years each in the business. Our people are well respected for their integrity and record of safe operations."

Cyrus J. Guidry & Associates, established in 2004, has a number of high-profile Gulf of Mexico projects under its belt, including the Who Dat platform, Garden Banks 72, Lucius, and a number of BP Projects. (i.e. Thunder Horse, Holstein, etc.). The projects it accepts can be as big as Delta House, with a full time on-site team, or small enough so that one person working part time can manage the job.

"Our goal is to always assign the right

personnel for the job," Guidry says. "We'll turn down a project before we send someone who does not have the experience to handle it."

Welder Testing and Procedure Qualification

In 2014, CGA expanded its capability by opening its Welder Testing Laboratory in Houma, Louisiana. Here, companies can send welders to become certified in difficult procedures and techniques. Typically, welders spend several days at the facility, first reviewing the procedure, then dem-

onstrating their ability. The welds are then mechanically tested in our laboratory to confirm the quality of the work. All of our testing staff are AWS certified themselves, and welders are certified to AWS, API, ASME and ABS standards. Cyrus J. Guidry & Associates is also becoming ISO 9000 certified. The process should be complete by early 2015.



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Leader in Subsea Technology

Since the establishment of a Subsea Alliance in 2008, LLOG and FMC Technologies have continued to successfully deliver subsea systems. The goal of the Alliance is to develop deep-water assets by fostering a collaborative partnership that is flexible and adaptive to market needs. LLOG, the largest private E&P company in the Gulf of Mexico, continues to lead by leveraging standardization of equipment and the latest subsea technology.



▲ Delta House Manifold.

Subsea On Demand

A key element of the partnership between the two companies involves FMC Technologies' Subsea On Demand program, which promotes fast-track development of the field and offers pre-engineered and field-proven equipment that allows subsea tiebacks and revenue streams to have a safe and healthy head start. Subsea On Demand also reduces field development time by maintaining an inventory of standard configurations, including deepwater wellheads, subsea trees, control systems, manifolds, and tie-ins, and the experienced personnel to install them. FMC Technologies goal is

to design and produce subsea systems available for quick delivery and installation, reducing the time to first oil.

Enhanced Horizontal Subsea Tree (EHXT)

For Delta House, LLOG's second floating production system, FMC Technologies installed the 5" Enhanced Horizontal Subsea Tree. Available in 5-inch by 2-inch for 10,000 psi and 15,000 psi applications, the award winning EHXT has the best uptime performance in the industry.



▲ Enhanced Horizontal Subsea Tree (EHXT)

Manifolds and Tie-In Systems

The LLOG STANDARD 4 SLOT, DUAL HEADER, pigable design utilizes mud mat foundations that can be stand alone or daisy chained as required. The hydraulic valves and sensors on the manifolds are controlled and monitored from corresponding trees and Subsea Control Modules (SCM).

Control Systems

Designed to meet challenging controls environment, FMC Technologies controls systems offer flexibility and reliability. For Delta House, FMC Technologies provided the enhanced Subsea Router Module, 620 SCM and Subsea Distribution System.

FMC Technologies

FMC TECHNOLOGIES

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GATE and LLOG Commission an Environment for Success

Gibson Applied Technology & Engineering, Inc. (GATE) provides technical support and commissioning services to the upstream oil and gas industry. The principal strength of the company is a systems engineering approach to field design and operation that combines technical, commissioning and project management expertise. This takes personnel with a broad knowledge of production systems and an in-depth understanding of detail design, construction, commissioning and operations. The GATE philosophy is to start with the end result in mind and to make sure that all activities remain aligned to the common goal of safety and timely project delivery, startup and operation.

GATE's scope of work for LLOG's Delta House project was commissioning the hull and topsides in preparation for first oil. The key for success is the right people. GATE had approximately 50 personnel with a strong mix of project management, commissioning, engineering and technical skills assigned to the project. This team represented the GATE core philosophy of using a multi-discipline team to provide seamless technical and project management services to Clients.

GATE appreciates LLOG management and staff promoting an environment where best practices were shared and implemented across multiple contractors, teams and disciplines. This was instrumental in the success of the project.

The first milestone for the project was commissioning quay-side to achieve a Temporary Certificate of Inspection (TCOI) from the US Coast Guard. The main activities at this stage includ-



▲ GATE's Systems Approach helped to streamline the Systems Completions Process.



▲ GATE lead pre-commissioning activities of topsides prior to integration with the hull.

ed the mating of the topside and hull; ensuring that all hull and topsides equipment was secure and ready for float-out to the offshore location.

The second major milestone was the offshore commissioning of the topsides process equipment in preparation for start-up and first oil. This part of commissioning included the major rotating equipment, power generation and separation vessels. GATE also created and validated standard operating and start-up procedures for Delta House.

The GATE team included a Commissioning Regulatory Lead, whose focus was to ensure all systems were ready for the regulator's testing and inspection to

obtain necessary operating permits. GATE believes this is a "best practice" for successful commissioning.

GATE was pleased to be part of the LLOG team for the Delta House Project. An organized and decisive operator in LLOG, combined with GATE's approach of engineering-

driven project delivery, helped achieve first oil on time and with no safety incidents during commissioning.

Steven Guy, GATE Vice President – Commissioning: "We are very pleased to work with an Operator such as LLOG. When we sign on to a project, GATE delivers full client attention and dedication to ensure the final outcome of steady state operations is achieved safely and professionally. We are an employee minded Company that believes employees' satisfaction ultimately builds to Client satisfaction."

GATE specializes in Materials & Corrosion, Subsea Engineering, Marine Services/ Marine Construction, Chemical Systems Engineering, Water Injection, Flow Assurance, Operations Readiness, Commissioning & Startup



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InterMoor provided design, fabrication, installation and hook-up of complete mooring system

InterMoor, an Acteon company, provided suction pile design, fabrication and installation, followed by pre-set mooring installation and pre-set mooring hook-up of the Delta House Floating Production System (FPS). Delta House was moored in 4,500 ft. of water and is LLOG's second Exmar-designed OPTI® deep-draft, semi-submersible production system in the Gulf of Mexico.

InterMoor's contract was to design, fabricate and install 12 suction pile anchors, to install 12 pre-set chain/polyester mooring lines, and hook up the FPS.

Fabrication of the suction piles took place at InterMoor's 30,000 square-foot facility in Morgan City, Louisiana. The 12 piles were 85 ft. long and 16 ft. in diameter, weighing about 165t each. The piles were designed to be used as permanent anchors for the project.

The installation of the mooring system took place in Q2 2014 in the Mississippi Canyon 254 block, while the hook-up took place in Q3 2014.

One of the challenges of this deep-water installation was the use of a prescribed anchor handling vessel. Because the mooring system was procured early on in the design process, it was necessary to find a solution that would utilize the selected vessel and extend the vessel capabilities beyond what has previously been done with this class of vessel in terms of mooring component size.

Standard design practices were utilized to develop the installation procedures for the suction piles, preset



optimized for the application assured success on this project.

The Delta House mooring system was deployed and installed safely and on time, without major incident. The hookup system was successfully connected under high loads. Close attention to tolerances and connection interfac-

es was paramount to the accomplishment of this project. Technical innovations stretched the capabilities of the prescribed anchor handling vessel, minimized chain twist, and ensured cost effectiveness that would not have been possible with another vessel. High strength synthetic ropes were an enabling technology that allowed the installation vessel to be

◀ Lift Test for one of the 12 pile anchors.

▼ Installation of the piles from an AHV.



mooring layout, and hookup. A vessel survey was completed well before the installation and the large size of the mooring system components required modifications to the vessel. The length, size, and weight of the lowering line were also optimized. Fixing two points in the design (i.e. vessel and mooring components) independently of one another created challenging circumstances but closely working with suppliers and manufacturers in an iterative process to ensure that the equipment was

more efficient, effective, and reliable.



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Early Contractor Involvement enables safety and success

Early Contractor Involvement for the Delta House FPS Project between Kiewit Offshore Services, Ltd., Exmar Offshore Company, Audubon Engineering Company and LLOG set the team up for success from the beginning. This early involvement among all parties allowed Kiewit to provide input for a safer and more productive design which helped allow efficient construction and timely completion.

Since Kiewit had previously constructed and installed the topsides for LLOG's deep-water Who Dat Project, LLOG sought Kiewit's fabrication experience once again for the larger Delta House Project to ensure a safe, high quality, on-time project.

Kiewit fabricated the Delta House topsides structure at its 555 acre yard in Ingleside, Texas. The topsides included several major sub-assemblies including

a 5,000 short ton deck truss, topsides modules and equipment with individual components weighing as much as 600 short tons each. These major substructures were comprised of five pipe racks, a Production Module (PM), a Compression Module (CM), and a Generation Module (GM), all of which were all fabricated onsite at Kiewit. The fabrication also included 57,000 linear feet (LF) of process piping and 275,000 LF of cable.

Using Kiewit's Heavy Lifting Device (HLD), which is capable of lifting up to 13,000 short tons, Kiewit lifted, set, and integrated the 9,850 ton topsides onto the OPTI® design semisubmersible hull. To facilitate lifting the topsides with the HLD, Kiewit designed and fabricated two 115-foot long spreader bars with each one having a 5,000 short ton capacity.

Kiewit's scope of work involved 1.8 million man-hours and employed 640 craftsmen at the peak of the project. Work started December 2012, and the Delta House Floating Production System (FPS) was ready for transport to location September 2014. The single-level Exmar OPTI-EX topsides design facilitated simpler construction and equipment integration and allowed Kiewit to compress the schedule and deliver on time.



▲ The Delta House topsides are set on to the hull using Kiewit's Heavy Lifting Device (HLD), which has a capacity of 13,000 short tons.



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Oceaneering Delivers Power and Control for Seabed Operations

Since it began in 1964, Oceaneering International, Inc. has transformed from a small regional diving company into a global provider of engineered products and services. Oceaneering now employs over 13,000 people in 25 countries.

Oceaneering develops products and services for use throughout the lifecycle of an offshore oilfield, from drilling to decommissioning. It is the world's largest manufacturer and operator of Remotely Operated Vehicles (ROVs), with over 300 systems operating worldwide. The company is also a leader in offshore oilfield maintenance services, workover control systems, umbilicals, subsea hardware and tooling.

This comprehensive life of field approach to projects provides customers with a single, accountable field services contractor that delivers results in accordance with clients' specifications and high Oceaneering standards.

LLOG and Oceaneering have been working together for over 10 years. Oceaneering has performed jobs for LLOG ranging from routine Inspection, Maintenance and Repair (IMR) to suction piles, light construction duties and complex pipeline repair solutions requiring extensive engineering and intervention support.

LLOG selected Oceaneering for the umbilical installation on the Delta House project. This work includes four (4) umbilical tiebacks from Marmalard North, Marmalard South, Son of Bluto 2 and one other field to the Delta House floating production system (FPS). Each tieback includes installation of a control umbilical along with other distribu-



▲ The Oceaneering vessel *Olympic Intervention IV* was used extensively on the project.



◀ The Millennium ROV system was used to ensure safe touchdown of field equipment.

tion hardware such as flying leads and Umbilical Termination Assemblies (UTA).

The umbilicals provide power, data and fluids to the well equipment and are an integral part of production operations. Expert engineering teams carefully planned the installation to ensure there were no problems.

The well manifolds are in approximately 6,500 feet of water and required four (4) control umbilicals. One key challenge for this project was installing via the lazy-S flotation method to secure the connection of the umbilicals between the Delta House FPS and the seabed. The engineering for using the

lazy-S method was important so the cables touched down in the proper locations and did not interfere with any other subsea infrastructure.

Oceaneering work scope included installation services and ROV services. Oceaneering provided assets such as the *Olympic Intervention IV* multi-service vessel, other sub-contracted vessels, Millennium® Work Class ROVs, intervention tooling and other assistance.

Oceaneering will continue to supply a wide range of engineered services and products required to safely support the deepwater efforts of its customers in 2015 and beyond. From developing customized ROV technology to support drilling and vessel-based projects to strengthening subsea products for tooling and installation, Oceaneering will continuously improve and expand its deepwater portfolio.



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Pinnacle Engineering – Subsea Systems and Export Pipelines for Delta House

Pinnacle Engineering Inc. and sister company, Pinnacle Project Services, supply complete engineering, procurement, inspection and commissioning services to the offshore oil and gas industry. Our company specializes in cradle to grave solutions for projects ranging from single to complex multi-well fields in any water depth. Pinnacle understands the importance of managing costs, schedules and risks, as well as being committed to providing a valued partner and trusted resource for economical, safe offshore project development.

Since opening our doors in 1993, Pinnacle has remained focused on providing multidiscipline engineering on scopes ranging from thousands to hundreds of millions of dollars; and locations from shallow marsh to the deepwater Gulf of Mexico. With the installation of more than 100 platforms, 250 pipelines and 100 subsea tiebacks behind us; our understanding of how to get a project completed on time and on budget is unmatched. Pinnacle prides itself on innovation, holding over five pending patents related to subsea hardware design.

LLOG Exploration and Pinnacle began their successful relationship in 2000 with the development of their first deepwater tieback in 1425' wd. The well was brought online (including planning, purchasing, permitting, installation and commissioning) in under five months. From there, the LLOG projects quickly

expanded into more complex fields in deeper water. Some of the more notable include: subsea tiebacks to Shell's Brutus TLP (1st non-Shell tieback to a Shell floater), W&T's Matterhorn TLP, and BP's Pompano structure. Most recently the LLOG Who Dat field, a floating production semisubmersible platform (FPS) with three separate subsea fields tied back and capacity to expand.

Early 2012 brought about the start of the latest challenge in the LLOG/Pinnacle partnership with the kickoff of the Delta House project. Following the success of Who Dat, LLOG stuck with the concept of a central FPS (Delta House, MC 254 "A") with multiple remote subsea fields tied back: Marmalard (MC 300), SOB2 (MC 431), and the third field.

The location and water depth of the subsea fields (>6500ft) and FPS (>4500ft), presented a unique challenge to field routing due to the presence of multiple salt domes, steep inclines, heavy faulting and multiple high potential chemosynthetic areas. Routes were carefully selected to provide predominantly uphill flow to mitigate hydrate potential, avoidance of natural hazards and optimize constructability.

Working hand in hand with LLOG management and flow assurance engineers, the concept of dual, insulated, piggable flowlines connected to mid and end of line manifolds was selected. For the controls, an Ethernet/fiber op-

tic system was selected to better support the large amount of data expected from multiphase flowmeters and well sensors. Umbilical and chemical injection system designs address early and midlife needs and is also designed to be easily expandable for future discoveries.

Pinnacle selected a purchasing and contracting strategy of breaking up awards into smaller pieces that maximize use of a contractor's core business. The purpose is twofold: it allows the subcontractors to accelerate deliverables and also gives LLOG flexibility to create compacted installation schedules that utilize multiple contractor fleet availabilities rather than one single SURF type contractor.

Over 50 different vendors and service providers were coordinated by Pinnacle in the execution of this project. Timely and clear communications in the sharing of interphase details and schedules was critical, with Pinnacle providing the central hub of information. The end result is a world class deepwater subsea development on par with any of its kind.



PINNACLE ENGINEERING

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Seadrill Commissions New Drillship, *West Neptune*, for Delta House Project

Seadrill is a leading offshore deepwater drilling company. Seadrill operates a versatile fleet of 69 rigs that comprises drillships, jack-up, semi-submersibles and tender rigs for operations in shallow to ultra-deepwater areas in both harsh and be-

nign environments. With the most modern fleet in the industry, combined with experienced and skilled people, Seadrill provides safe efficient operations, and is a preferred provider of offshore drilling services.

In 2013, Seadrill signed a long-term contract with LLOG for the brand new drillship *West Neptune*. The *West Neptune* will go to work on the Delta House project. The initial focus will be on the completion of eight wells followed by the drilling of five additional wells.

The *West Neptune* is a 6th Generation drillship of the Samsung 12,000 design. Equipped with a DP3 dynamic positioning system and outfitted to work in up to 10,000' of water. The *West Neptune* is capable of operating in water depths of up to 12,000' and drilling depths up to 37,000'. As one of the most modern drillships in Seadrill's fleet, it has numerous high-end features including the latest in safety and control technologies. To illustrate, the *West Neptune* includes:

- Multi-Machine Control which automates drillfloor processes to simplify workflow for the operator: i.e. racking of tubulars, stand building,



and picking up tubulars. These automated systems create a safer work environment as they reduce the dependence on crewmembers to perform those tasks.

- A 165,000-ton Active Heave Compensated Knuckle Boom crane for simultaneous subsea operations during drilling activities; such as, running and retrieval of Intervention/ Workover Control Systems (IWOCs) and Xmas Trees. This crane allows operations in sea states that could otherwise interfere with progressing work, increasing efficiency for LLOG.
- Outfitted with two complete 7 cavity 15,000 PSI NOV Shaffer NXT Blowout Preventer (BOP) systems. This capability allows the rig to retrieve the operating BOP on the well, and then run the second one, resulting in increased efficiency as it mitigates downtime associated with performing maintenance and repair when there is only one BOP.

LLOG's and Seadrill collaborated on a number of changes to enhance the *West Neptune*'s ability to support the Delta House project. These upgrades

targeted completion activities, as this will be the principal focus of the work for LLOG. Examples include:

- 15,000 PSI dedicated well fracture pipe system for increased efficiency and safety of operations, avoiding the need for temporary rig up of surface lines.
- Launch and Recovery System (LARS) for subsea deployment of the IWOCs, providing increased operational flexibility.
- Optimization of well test deck space for improved deck load capacity and area.
- Installation of a Remote Operated Vehicle (ROV) cursor rail system for heavy weather deployment of the ROV to increase operational windows.

The planning and resulting outcomes of the customization of the *West Neptune* is a testimony to the cooperative teamwork between LLOG and Seadrill and a commitment to find and implement creative solutions for the specific needs of the Delta House field development. The result is a better-equipped drillship with an improved design: setting the standard by providing LLOG with superior efficiency and safer drilling and completion operations.



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Perma-Pipe provides Auto-Therm® GSPU insulation for the LLOG Delta House project using BASF Elastoshore mercury free polyurethane

Winning Team

Perma-Pipe and BASF are industry leaders supplying thermal insulations for flow assurance for offshore and onshore pipelines and equipment. Auto-Therm® GSPU (Glass Syntactic Polyurethane), Perma-Pipe's most popular thermal insulation product for offshore applications, was used extensively for LLOG's Delta House and prior offshore projects.



Perma-Pipe New Iberia plant with Auto-Therm® GSPU pipe storage.

Auto-Therm® GSPU was developed in partnership with BASF, a world leader in polyurethane chemistry and the development and manufacture of polyurethanes and other specialty materials. Perma-Pipe and BASF have a long history of working together to provide insulation technology solutions for many different industries and applications; BASF on material development, and Perma-Pipe on material application processes. Together they have the expertise and capabilities to provide GSPU insulation for subsea pipelines and equipment to meet critical project requirements

safely and economically. Their combined expertise resulted in the highly thermal efficient and cost effective Auto-Therm® GSPU, the product used for Delta House.

Perma-Pipe's Auto-Therm® GSPU, has been used on deepwater subsea pipeline projects since 2005. Backed by years of testing from independent third party organizations including Heriot-Watt University, Edinburgh, Scotland; Stress Engineering, Houston, TX, and the Joint Industry Project (SWIS JIP) managed by Chevron, to name a few. The SWIS JIP members include major oil and gas operators, pipeline lay contractors, subsea



equipment manufacturers and thermal insulation applicators. In addition to the independent testing, Perma-Pipe and BASF have conducted extensive in house R&D, testing and application trials.

Perma-Pipe is the leading supplier of GSPU insulation to independent and major oil and gas operators in the Gulf of Mexico. Auto-Therm® GSPU has been supplied to over 30 projects, totaling over 1,350,000 feet (411 km) and holds

the world's record for the deepest insulated flowline for Shell Perdido at 9,627 feet (2,934m) water depth, in service since 2009.

Perma-Pipe also insulates the subsea equipment including; jumpers, PLETs, PLEM's, manifolds, trees, goose-necks, connector covers / doghouses and other equipment for many offshore projects.

BASF's Unique Mercury Free Chemistry

Working closely together, Perma-Pipe and BASF were the first to develop and offer mercury free GSPU insulation for the offshore industry in 2004. Perma-Pipe and BASF continue to improve the overall performance, thermal and mechanical properties, and processing methods for Auto-Therm® GSPU.

Auto-Therm® GSPU was developed to provide a combination of excellent material flexibility, low thermal conductivity and optimum temperature performance required for offshore pipelines and subsea equipment. Auto-Therm® GSPU is;

- Extremely flexible to meet the stringent requirements for insulated pipeline installation using the reeling method. Auto-Therm® has been reeled to a radius as low as 13 feet (4 m) and has successfully undergone low temperature bending trials at 10°F (-12°C).
- The lowest thermal conductivity GSPU insulation available, resulting in less insulation thickness than other products to meet project

thermal performance specifications.

- Proven successful in simulated service conditions for one year at 228°F (109°C) by the SWIS JIP.

With over 35 polyurethane manufacturing locations around the world, BASF is well positioned to supply the global subsea insulation market. With over 110,000 employees and over 1,500 patents filed yearly worldwide, BASF is the world's largest chemical company and the leader in polyurethane technology.

Perma-Pipe's Strong Relationship with LLOG

Perma-Pipe has been LLOG's insulation supplier for their offshore projects including Who Dat, Who Dat extension, Goose, Mandy, GC 141 and others. Working closely with LLOG's subsea engineering partner, Pinnacle Engineering, LLOG selected Auto-Therm® GSPU to insulate all the flowlines, risers and subsea equipment for Delta House.

Delta House is the largest single project using Auto-Therm® GSPU, consisting of approximately 318,000 feet (97 km) of flowline and riser pipe, and subsea equipment including; 16 jumpers, 8 PLETs, and 4 In-line sleds.

Delta House's tight schedule required Perma-Pipe to insulate a large quantity of pipe in coordination with the lay contractor's schedule for spool base welding, reeling and installation. To meet this demanding schedule, Perma-Pipe worked multiple shifts, 24 hours a day for most of the project and coordinated very closely with BASF to ensure on time material deliveries to supply Perma-Pipe without interruption.

BASF manufacturing facilities in Houston, TX and Geismar, LA delivered the polyurethane materials to support this schedule while meeting all materi-

al and quality standards and specifications. Through this close coordination, Perma-Pipe and BASF completed the GSPU insulation of the flowline and riser pipe to support the installation contractor's spool base welding and installation schedule without any disruptions or delays.



▲ Custom Designed Auto-Therm® GSPU Connector Shrouds for LLOG.

Perma-Pipe's Patented Production Process

Perma-Pipe's patented production process was critical for meeting the Delta House schedule. The Auto-Therm® GSPU process is a continuous molding process where the GSPU insulation is applied as the pipe travels through a short stationary mold sized to provide the required insulation thickness. As the pipe travels through the mold the

GSPU material is injected into the annular space and cures rapidly before exiting the mold. This method has significant advantages over other GSPU processes including lower tooling costs, higher production, and was very important for the successful execution of the Delta House project.

Perma-Pipe's continuous molding process is unique in that it allows 80 foot (24m) nominal length pipe to be insulated for quad and hex lay installation methods reducing the number of field joints in half resulting in significant cost savings and installation time by the offshore lay contractor.

In addition, Perma-Pipe's New Iberia, LA facility is strategically located near lay contractor spool bases along the Gulf Coast and with access to the Intercoastal waterway, allowing for quick and convenient delivery of insulated pipe to lay barges in the Gulf of Mexico. This location has also competitively served the West Africa and Brazil markets.

Subsea Equipment Insulation

Perma-Pipe also provides Auto-Therm® GSPU for subsea equipment. In addition to Auto-Therm® GSPU, Perma-Pipe offers Auto-Therm® Si, a silicone insulation suitable for higher temperatures,



◀ GSPU insulating 80 foot (24m) double joined pipe.

up to 320°F (160°C). For these specialized services, portable processing equipment is mobilized to the equipment fabricator's yards all along the Gulf coast states.

Perma-Pipe's multiple portable equipment units, responsive and experienced field crews, ability to mobilize on short notice and close proximity to equipment fabricator's yards enables tight insulation schedules to be met.

About Perma-Pipe

Perma-Pipe, Inc. is a leading supplier of preinsulated and prefabricated piping system products and solutions for industrial and commercial markets around the world. Perma-Pipe is known worldwide for innovation and the ability to provide solutions for the most difficult applications.

In addition to the offshore oil and gas products supplied to the Delta House project, Perma-Pipe's other products include;

- District heating and cooling (DHC) piping systems for efficient energy distribution from central energy plants
- Industrial piping systems for efficient and safe transport of hot and cold fluids
- Industrial secondary containment piping systems for transporting chemicals, hazardous fluids and petroleum products
- Piping systems for cryogenic applications including LNG, ammonia, propane and butane
- Onshore insulated long lines for oil,



▲ Jumper with Auto-Therm® GSPU Insulation.

- gas and mineral transportation
- Heat trace systems for temperature maintenance and to enable viscous fluids such as heavy crude oil, sulfur and asphalt to flow efficiently
- Leak detection products for piping systems and sensitive areas such as data centers

Perma-Pipe's global manufacturing footprint consists of 7 facilities;

- New Iberia, LA USA
- Lebanon, TN USA
- Camrose, Alberta, Canada
- Fujairah, United Arab Emirates (UAE)
- Dammam, Saudi Arabia
- Gujarat, India
- Santa Marta, Colombia (opens 2015)

Perma-Pipe also mobilizes portable insulation equipment for projects anywhere in the world where large savings in transportation and logistics costs can be realized by locating the insulation facility near the project.



Perma-Pipe is a division of MFRI, Inc. a public company listed on the NASDAQ exchange. MFRI has two divisions; Perma-Pipe, Inc. and Midwesco Filter Resources, Inc. Midwesco manufactures fabric bag and cartridge filter elements for a variety of industrial end use markets.

Perma-Pipe and BASF are proud to have been selected by LLOG to be a part of the overall success of the Delta House project.



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Integrity Built In—Fabrication Solutions for the Global Energy Industry

A leading custom-steel fabricator, Spitzer Industries delivers a broad range of steel fabrication solutions for its energy industry customers. When FMC engaged Spitzer Industries to fabricate manifolds for the Delta House project, Spitzer Industries called upon its experienced workforce to deliver high-quality, custom-designed manifolds. The project was achieved with a zero-incident safety record. In addition to manifolds, Spitzer's Heavy Fabrication Division provides the offshore oil and gas industry with custom-fabricated sub-sea tiebacks and top-side modules, along with structural weldments, piping, manifolds, PLETs and PLEMs, jumpers, suction piles and other large modular components.

Within multiple fabricating disciplines, Spitzer Industries' engineered package offerings include glycol dehydration, crude oil stabilizer, amine treatment plant, heavy vessels, columns, towers and structural steel to the production, midstream and petrochemical sectors. Behind this diverse fabrication ability are robust project management capabilities for providing engineering, design and support on every order from start to finish.

The company has built a consistent track record of on-time delivery based on a highly skilled workforce. All Spitzer craftsmen are full-time employees, enabling more effective train-



▲ Spitzer Industries manufactures manifolds and other custom-fabricated heavy components at its Waterfront facility.



▲ This 150-ft demethanizing tower exceeding 300 tons is an example of Spitzer's complex manufacturing capabilities.

ing, competency management and operational continuity. And with a 77-acre footprint in Houston and 535,000 sq. ft. under roof, Spitzer has the space and equipment to tackle even the largest, most complex fabrication projects. Each of its three facilities offers convenient access to major highway, rail and air transportation links. And the Spitzer Waterfront facility on Greens Bayou provides a direct link to the Houston Ship Channel, enabling worldwide shipment of large components while reducing transportation costs to customers.

Spitzer Industries' materials tracking program meets regulatory and customer requirements of traceability from raw material to finished product. Our workforce follows rigid quality control processes to produce high-quality welding on stainless

steel and high alloys, and is certified to build Section VII, Division 1 and 2 pressure vessels. And with a comprehensive, fully-staffed HS&E management system, Spitzer Industries instills a "safety-first" attitude in all employees in the drive to prevent accidents and achieve a zero-incident safety record.

Over the years, Spitzer has achieved an enviable record of delivering turn-key products of impeccable quality safely and on schedule. The Spitzer advantage? Reproducible results on every job—with competent people, documented processes and robust project controls.



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Technip Plays Leading Role in the Delta House Subsea Development Project

Technip is a world leader in project management, engineering and construction for the energy industry.

From the deepest subsea oil and gas developments to the largest and most complex offshore and onshore infrastructures, our 40,000 people are constantly offering the best solutions and most innovative technologies to meet the world's energy challenges.

On the Subsea side, Technip provides a complete range of world class solutions for deepwater facilities and subsea systems, field development planning to EPCI, including pipeline construction (S-Lay, J-Lay and Reeled pipeline), Subsea Umbilicals, Risers and Flowlines (SURF) and heavy lift services, utilizing the largest and most advanced fleet for construction asset management.

LLOG awarded Technip a substantial contract for the development of the



▲ Technip's spoolbase, Mobile, Alabama.

Delta House project, located in the Mississippi Canyon area of the US Gulf of Mexico, in water depths varying from 100 to 2,000 meters (360 to 6,500 feet).

The scope of work included the project management, engineering, installation and pre-commissioning of more than 200 kilometers (124 miles) of infield and export flowlines and risers. The scope also included fabrication of (26) twenty-six subsea devices including Pipeline End Termination structures (PLETS), In-Line Structures (ILS), and rigid jumpers.

Technip's operating center in Houston, Texas performed the overall project management and engineering for the project. The infield flowlines and risers (over 60 miles)

were fabricated at the Group's spoolbase in Mobile, Alabama.

The offshore installation began in Q2 2014. Technip prepared the field with almost 500 concrete mattresses in anticipation of twenty-one pipeline/umbilical crossings along the lay route to Delta House. The Global 1200, Technip's state of the art S-Lay vessel, was used for fabrication and installation of over 60 miles of export flowlines. The Deep Blue, one of the most advanced pipelay and construction vessels in the subsea industry, was mobilized in the second half of 2014 to install the deepwater infield flowlines and structures.



▲ Technip's G1200 (top) and Deep Blue (bottom).

Technip

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Wood Group PSN Partners with LLOG on Delta House Startup and Operation a Success

Wood Group PSN employs more than 30,000 people in 40 countries, making us an industry leader in providing contract labor for pre- and post-production operations. In the U.S. Gulf of Mexico, we have more than 3,000 employees performing services and managing operations on over 1,200 Continental Shelf and Deepwater facilities.

A Close LLOG Partnership

Wood Group PSN has been a trusted partner on LLOG offshore facilities since 1995. For nearly two-decades, we have provided a variety of services on numerous offshore LLOG Exploration properties. One of the most notable is supporting production operations for *Who Dat* redeployable deep-draft semi-submersible floating production unit (FPU), the industry's first such facility and predecessor to the larger, more-complex *Delta House* FPU. We have been operating *Who Dat* since its first production, in 2011, and will provide similar services to *Delta House* after startup.



Wood Group PSN's Roles in Commissioning Ramp Up

Wood Group PSN's offshore operations & maintenance (O&M) group along with multiple specialty services teams have worked closely with LLOG on the *Delta House* project for over a year. Throughout the early design phases, we offered expert feedback on the practicalities of the initial design concepts. Each of

our primary skillsets came into play – mechanical, electrical, instrumentation, safety, planning, O&M and administrative – all contributing to planning and readiness strategies for the facility's future production operations.

Operator training was an important step completed during the ramp up toward commissioning and startup. We provided the staffing for future facility operations, assembling an experienced team of project management to craft-level positions. A proven work planning system was specifically created to be implemented at multiple stages from FEED through construction, to hookup, commissioning and startup. Our personnel also collaborated with LLOG to understand the new, sophisticated systems and equipment that will be at the heart of the *Delta House* operations.

The integrity of inspection packages for submission to regulators is critical and thoroughly scrutinized. In the post-Macondo era, it is imperative that every facet and component on the facility be correctly fabricated, properly assembled, non-destructively examined and meticulously tested. We worked closely with LLOG's safety and compliance departments to assemble a complete inspection package. Once verified, we conducted a final review to ensure its veracity and handled its submission to the United States Coast Guard and Det Norske Veritas.

Safety: A Wood Group Priority

The safety of our personnel and those working around us is our top priority and underscores everything we do.

Recently, we introduced the Wood Group PSN Safety Cocoon, comprised of four protective layers – Aristos, Hazard Awareness, Life Saving Rules and Behavioral Standard. These layers are focal points within our work culture to ensure everyone, everywhere, every day – safe home. Our company-wide safety initiatives distinguish us and are reflected in a 15-year, industry-low Total Recordable Incident Rate (TRIR).

Hookup, Commissioning and Startup Support

Wood Group PSN's experience in Deepwater operations is unparalleled. We adhere to a sophisticated ramp-up plan used for seamlessly moving the project from construction to startup. Our goals are to provide operational readiness, making stage transitions that are both cost effective and safe. As *Delta House* sails out to its final deepwater destination, Wood Group PSN-trained personnel will be on board to oversee the facility's final hookup and commissioning.

Once first production is reached, our personnel will safely manage the facility continuously through its project lifecycle.



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