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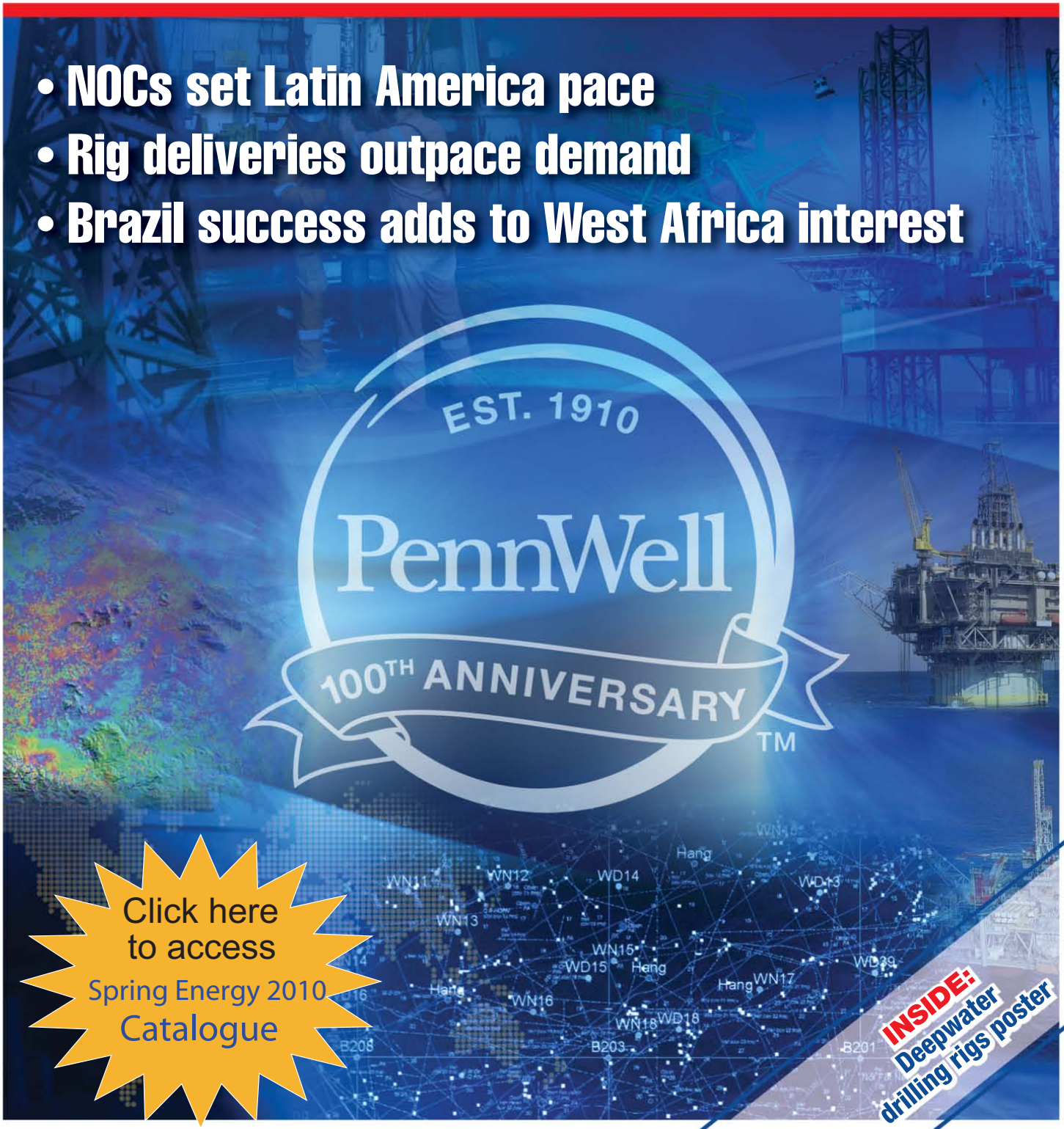
# Offshore®

July 2010

World Trends and Technology for Offshore Oil and Gas Operations

- NOCs set Latin America pace
- Rig deliveries outpace demand
- Brazil success adds to West Africa interest



# REMEMBRANCE and HONOR

Jason Christopher Anderson

Aaron Dale Burkeen

Donald Neal Clark

Stephen Ray Curtis

Gordon Lewis Jones

## We Will Never Forget

On April 20, 2010, a fire and explosion occurred onboard the *Deepwater Horizon*, working approximately 41 miles offshore Louisiana on Mississippi Canyon Block 252. Of the 126-member crew, 115 were safely evacuated. Despite exhaustive rescue efforts, eleven crew members lost their lives. It is with deepest sorrow that we send our condolences to all of the family and friends affected by this tragedy. Today, and always, we honor your loved ones.

Roy Wyatt Kemp

Karl Dale Kleppinger

Keith Blair Manuel

Dewey Allen Revette

Shane Michael Roshto

Adam Taylor Weise

50 Offshore

# Offshore

Celebrating Over 50 Years of Trends, Tools, and Technology

International Edition
Volume 70, Number 7
July 2010

## CONTENTS

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**COVER:** This year PennWell celebrates its 100th Year Anniversary. One of the oldest and largest family-owned publishing companies in the world, PennWell reaches more than 1.5 million professionals with 75 print and online magazines and newsletters, 60 global conferences and exhibitions, and an unrivalled line of books, maps, websites, research, and database services. Cover created by Chris Jones.

## SUBSEA



## FLOWLINES & PIPELINES



## SWEDEN



## DEPARTMENTS

# Control Change

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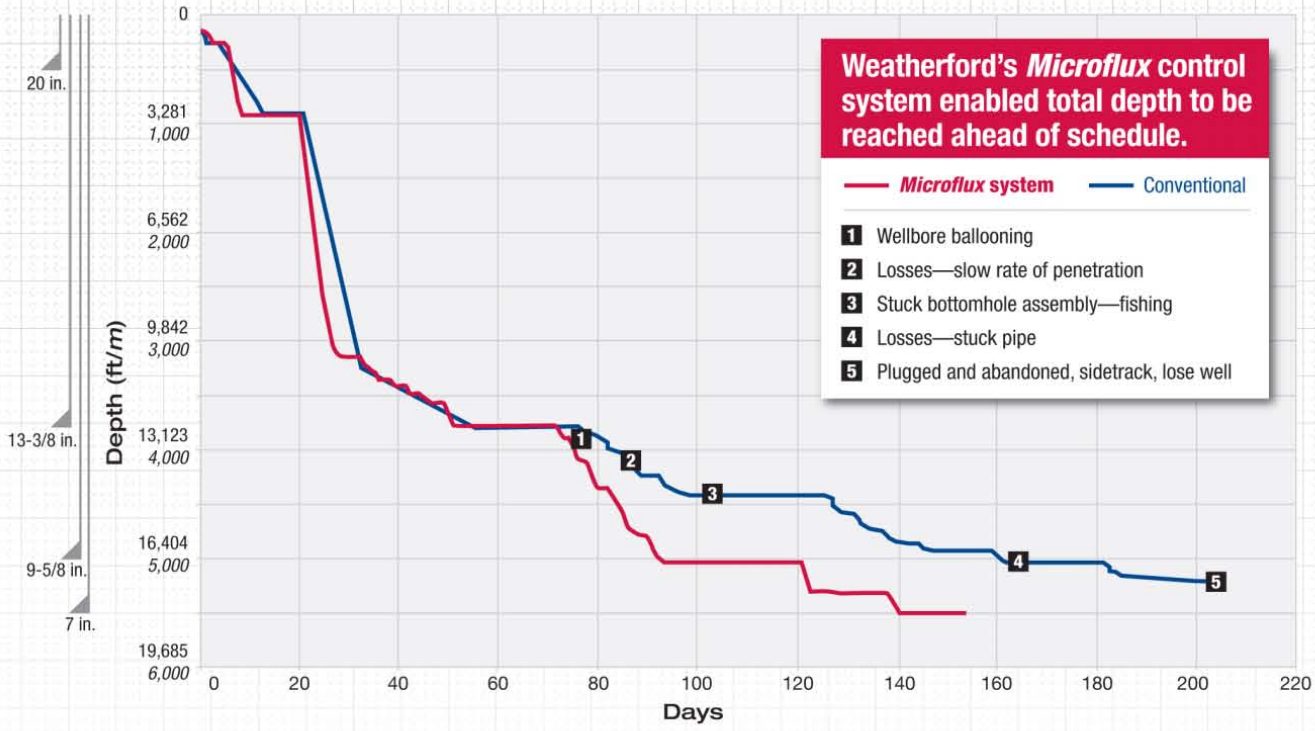


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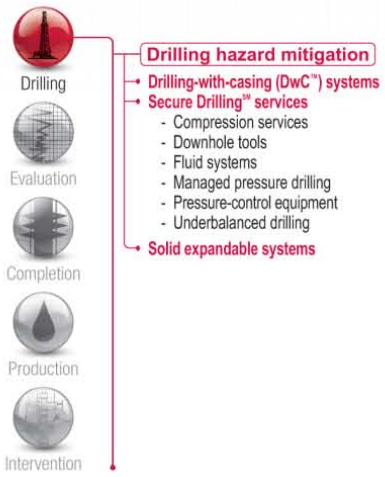


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## *Deepwater Horizon* incident

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Richard D'Souza, VP, Granherne Global Operations, KBR, addresses the challenge of choosing the floating platform that best matches reservoir and site characteristics while optimally satisfying an operator's commercial and strategic drivers.

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InterMoor President Tom Fulton and Technical Development Lead Kent Longridge discuss recent innovations in mooring technology. Topics include innovation in fiber rope, anchoring and connection, and mooring integrity services.

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- 2010 worldwide survey of FPSO units

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

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PUBLISHER'S COMMENT

*Mark Peters • Houston*

# Editorial lineup changes

Ball

Paganie

This month's issue marks the beginning of some editorial changes at *Offshore*.

Eldon Ball, who is the associate publisher, editor of *Offshore*, and conference director will become the editor emeritus of the Offshore Group and with responsibility for the Deepwater Operations, Subsea Tieback & Forum (SSTB), our new Topsides Conference & Exhibition, and future US conferences, as well as new print and online editorial features, including drilling technology reporting and analysis.

David Paganie, who has been the managing editor of *Offshore* is stepping up to be the chief editor and editorial director for *Offshore* and conference director for Offshore events. His new role will allow him to focus on making sure that *Offshore* continues to be the leading publication and conference/events group in the world. Under the tutelage and direction of Eldon Ball over the last five years, David has exemplified the strong work ethic, intellectual curiosity, and ability to multi-task that is essential in producing a monthly magazine, website, and eight e-newsletters. David has over 12 years of experience in the offshore oil and gas industry. Added to his background and overall responsibilities now for the global conferences and events, this increase in editorial responsibilities will give him greater insight and knowledge of the global industry.

We are also pleased to announce the appointment of Bruce A. Beaubouef to the position of managing editor of *Offshore*. Bruce has a PhD in US history and over 10 years of publishing experience in the oil and gas industry, including offshore pipeline design, engineering, construction, and operations. His previous position as the editor of a pipeline and gas publication will bring a new perspective to the coverage we currently provide.

These editorial changes will allow PennWell's Offshore Group to expand and enhance its industry-leading global coverage in print, digital, and conferences. As always, we welcome communications from our readers and subscribers on how we are fulfilling our obligation to you and what we might do better.

**Mark Peters**
*Vice President and Offshore Group Publisher*

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

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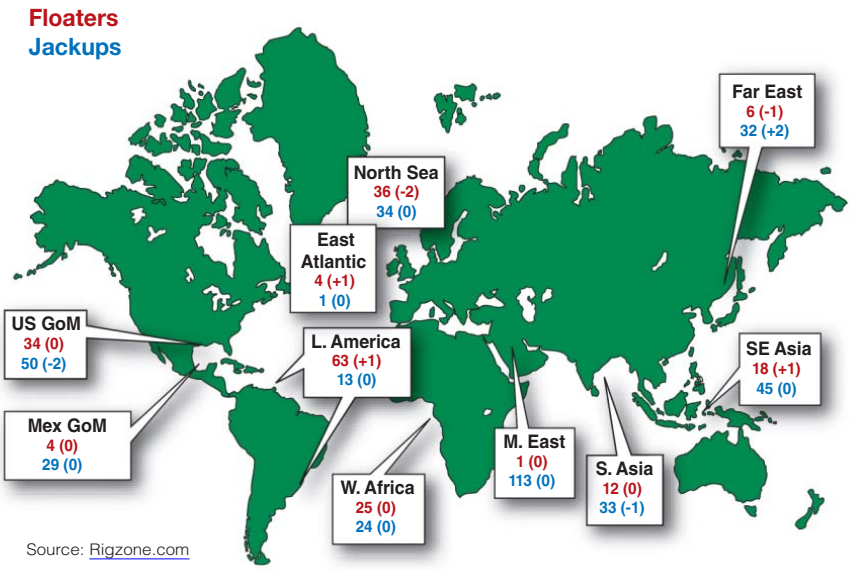
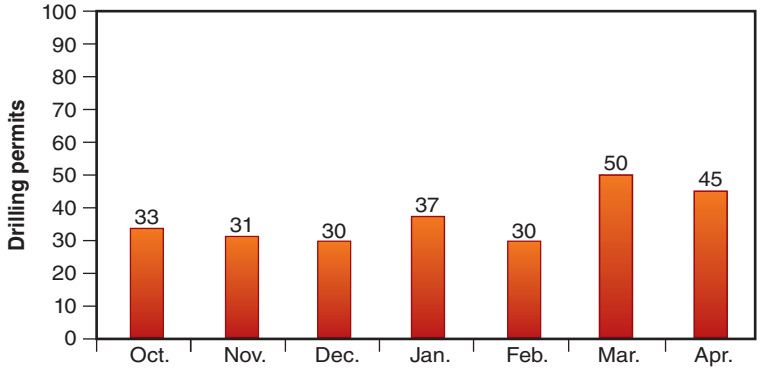
## Active rig fleet, June 2010




Source: Rigzone.com

## GoM drilling permits issued



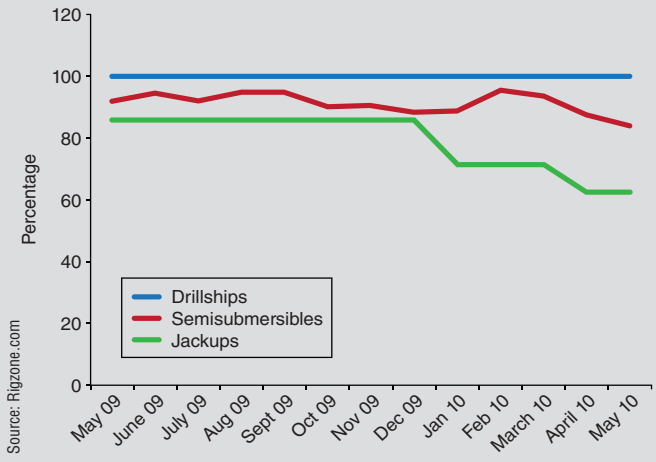

Source: US Minerals Management Service

## Worldwide day rates

| Year/Month | Minimum | Average | Maximum |
|---|---|---|---|
| **Drillship** | | | |
| 2009 June | $125,000 | $369,903 | $594,000 |
| 2009 July | $125,000 | $367,674 | $594,000 |
| 2009 Aug | $125,000 | $377,134 | $600,000 |
| 2009 Sept | $125,000 | $380,193 | $600,000 |
| 2009 Oct | $125,000 | $380,790 | $600,000 |
| 2009 Nov | $125,000 | $385,260 | $600,000 |
| 2009 Dec | $125,000 | $386,672 | $600,000 |
| 2010 Jan | $125,000 | $387,297 | $630,000 |
| 2010 Feb | $125,000 | $388,423 | $630,000 |
| 2010 Mar | $125,000 | $388,592 | $594,000 |
| 2010 April | $125,000 | $392,859 | $594,000 |
| 2010 May | $125,000 | $388,224 | $594,000 |
| **Jackup** | | | |
| 2009 June | $27,000 | $146,703 | $330,000 |
| 2009 July | $27,000 | $145,009 | $330,000 |
| 2009 Aug | $27,000 | $140,494 | $330,000 |
| 2009 Sept | $28,000 | $139,498 | $330,000 |
| 2009 Oct | $28,000 | $136,543 | $360,000 |
| 2009 Nov | $28,000 | $133,761 | $360,000 |
| 2009 Dec | $28,000 | $131,960 | $375,000 |
| 2010 Jan | $28,000 | $128,988 | $375,000 |
| 2010 Feb | $28,000 | $126,629 | $398,000 |
| 2010 Mar | $28,000 | $122,994 | $398,000 |
| 2010 April | $28,000 | $118,667 | $398,000 |
| 2010 May | $28,000 | $115,976 | $398,000 |
| **Semi** | | | |
| 2009 June | $38,400 | $343,515 | $647,000 |
| 2009 July | $80,000 | $349,205 | $650,000 |
| 2009 Aug | $80,000 | $352,291 | $650,000 |
| 2009 Sept | $80,000 | $353,274 | $650,000 |
| 2009 Oct | $80,000 | $352,439 | $647,000 |
| 2009 Nov | $80,000 | $357,694 | $647,000 |
| 2009 Dec | $80,000 | $364,363 | $647,000 |
| 2010 Jan | $83,000 | $368,806 | $647,000 |
| 2010 Feb | $83,000 | $365,114 | $647,000 |
| 2010 Mar | $83,000 | $366,767 | $647,000 |
| 2010 April | $83,000 | $362,626 | $647,000 |
| 2010 May | $83,000 | $360,027 | $647,000 |

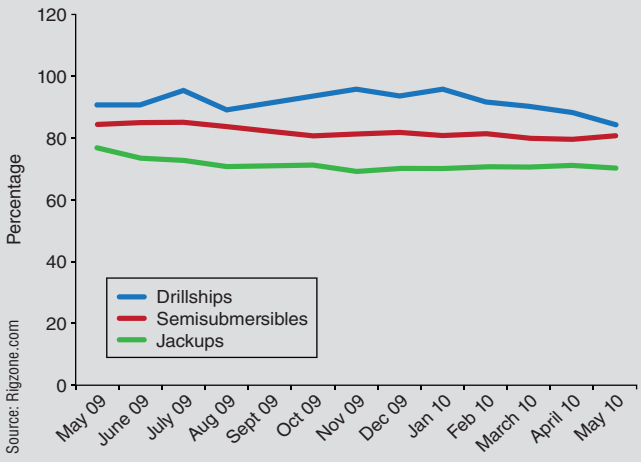
Source: Rigzone.com

## Brazil offshore rig utilization




Source: Rigzone.com

## Worldwide offshore rig utilization




Source: Rigzone.com

*Jeremy Beckman • London*

## Bright future ahead for floating production

Worldwide spending on floating production systems will total $44.8 billion over the next five years, according to a new study by analysts Douglas-Westwood. *The World Floating Production Report* 2010-2014 suggests that the sector is set for strong long-term growth, reflecting the continuing expansion into deeper waters, the need to exploit marginal fields, and increased demand for fast-track and phased developments. Latin America will account for almost a third of global capex in the forecast period, the analysts say, followed by Africa and Western Europe.

Elsewhere, Douglas-Westwood's Steve Robertson maintains that the ban on deepwater drilling in the Gulf of Mexico following the *Deepwater Horizon* incident should not impact floating production projects planned for this region.

## Americas

Oil has started flowing from the North Amethyst field 350 km (217 mi) offshore Newfoundland & Labrador. This is the first satellite development at Husky Energy's White Rose project, and also Canada's first subsea tieback. North Amethyst, with reserves of 90 MMbbl, is connected to the *Sea Rose* FPSO 6 km (3.7 mi) away via flexible flowlines. Output should peak at 37,000 b/d as more wells come online.

•••

Staatsolie has signed a Heads of Agreement with Tullow Oil for a deepwater exploration license offshore Suriname. Tullow plans to start acquiring seismic next year over the 2,369-sq km (915-sq mi) block 47. It has other interests off neighboring Guyana and French Guiane which it intends to start drilling later this year.

•••

Petrobras reports two further light oil finds in the deepwater Campos basin. Well 6-MRL-199D-RJS in 648 m (2,126 ft) water depth found oil in pre-salt carbonatic reservoirs in the Aptian section, with recoverable reserves estimated at 380 MMboe. These could be developed via the P-27 platform. Another well on the Carimbe structure in 1,027 m (3,369 ft) of water revealed 105 MMbbl of recoverable oil in an Albian post-salt carbonate reservoir. The *P-48* platform is a possible host.

In the pre-salt region of the Santos basin, Petrobras has signed a Letter of Intent with SBM Offshore and Queiroz Galvao Oleo e Gas for an FPSO for the second pilot program on the Tupi field in block BM-S-11. The vessel will be installed on the northeast of the field, in 2,130 m (6,988 ft) water depth, and will be able to produce 120,000 b/d of light crude and up to 5 MMcm/d (1.3 tcf/d) of gas. Delivery is due in the first half of 2013.

•••

Diamond Offshore's semisub *Ocean Guardian* continues its campaign of exploratory wells offshore the Falkland Islands. The latest effort has been probing the Toroa prospect off the East Falklands basin for BHP/Falklands Oil & Gas. Earlier wells brought gas/condensate and oil discoveries (Liz and Sea Lion) for respectively Desire Petroleum and Rockhopper Exploration. Results from Sea Lion have persuaded Desire to use its next slot to test the Rachel structure on the eastern flank of the North Falklands basin.

## West Africa

Maersk Oil has completed its first appraisal well on the deepwater Chissonga field in Angola block 16. The location was 2 km (1.2 mi) downdip of the discovery well, in 1,355 m (4,445 ft) water depth. A production test flowed 6,650 b/d of oil from Oligocene turbidites. Further wells will be needed to determine commerciality, Maersk points out.

•••

Namibia's government has awarded three contiguous offshore blocks to HRT, in partnership with Universal Power and Acarus Investments. The blocks cover a total area of 15,382 sq km (5,939 sq mi) west/southwest of the undeveloped Kudu gas field off southern Namibia. The initial four-year work program includes interpreting existing 2D and 3D seismic data and the acquisition of new data.

•••

Dana Petroleum and Petronas Carigali have contracted a newbuild semi from Maersk to drill structures offshore Mauritania this fall. Dana will use the rig for a well on Cormorant, a 2-3-tcf prospect in block 7. Petronas' program is in adjacent block 6.

The deck for Nexen's new Buzzard platform.

## Europe/Mediterranean Sea

Nexen Petroleum UK has completed installation of the 6,500-metric ton (7,165-ton) deck and bridge structures for a new production-sweetening platform at the Buzzard field complex in the UK central North Sea. Heerema Hartlepool was responsible for fabrication – the jacket, delivered last year, was built by Heerema Fabrication Group at Vlissingen, the Netherlands.

•••

Petrobras has signed for further deepwater exploration acreage offshore Portugal. It is taking 50% operating interests in the Gamba, Lavagante, and Santola blocks in the Alentejo basin. The combined acreage, covering around 9,000 sq km (3,475 sq mi) is in water depths of 200-3,000 m (656-9,842 ft). Petrobras operates a further four offshore blocks in Portugal's Peniche basin.

•••

Noble Energy has identified a further potential giant gas prospect offshore Israel in the Rachel and Amit licenses, according to partners Delek Drilling and Avner Oil & Gas Exploration. During a presentation earlier this year, Noble said that the tertiary Leviathan structure could hold recoverable reserves of 16 tcf (453 bcm), and had recommended drilling an exploration well late this year. Noble also identified further tertiary prospects on the Ratio Yam licenses which could yield around 3 tcf (85 bcm).

## Black Sea

Petrom has successfully applied multi-stage hydraulic fracturing to boost flow from two wells on its Lebada Est field in the offshore Histria block in the Romanian sector. The wells had been in service since 1998, but production had fallen due to the reservoir rock's low permeability. Strong results led the company to transfer this technique to a new well on the Lebada Vest field. The measures should lift Petrom's offshore production this year by over 300,000 boe.

•••

Calgary-based Stratic Energy has agreed to sell its interests offshore Turkey to a Turkish consortium. Stratic was one of the founder partners in the shallow water Akcakoca gas development, operated by TPAO.

## Middle East

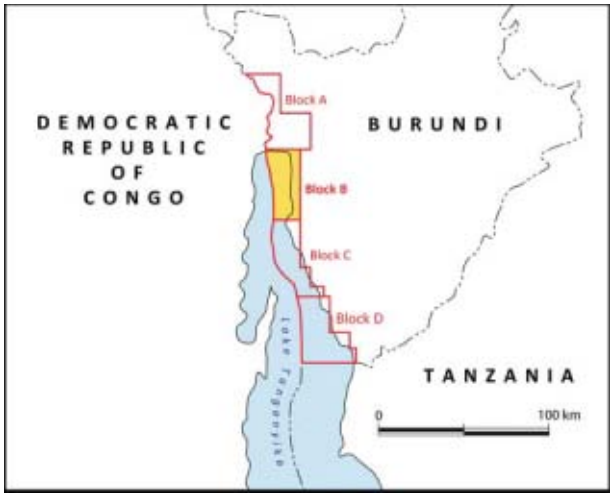
ADMA-OPCO has contracted NPCC for brownfield engineering and a new accommodation platform for the Zakum Central Super Complex offshore Abu Dhabi. The program involves re-activating and re-commissioning production facilities at the complex which had been mothballed since the 1980s. Under the $350-million EPC project, NPCC will install the new 3,500-metric ton (3,858-ton) platform via the floatover method. Work should be completed by late 2012.

•••

Shell and PetroChina have signed a 30-year PSC for block D offshore/onshore Qatar with Qatar Petroleum. The partners, led by Shell, will explore for natural gas in the 8,089 sq km (3,123 sq mi) concession, part of which extends beneath the North field in the overlying Khuff horizon. The first five-year phase includes seismic acquisition and drilling of a well to the pre-Khuff formation.

•••

RAK Petroleum has applied for approval from Oman's government to drill further production wells on the offshore Bukha and West Bukha oil and gas fields. The company took this decision following reservoir studies and well monitoring last year. West Bukha came onstream early in 2009 via a newly installed platform.




Surestream's concessions in Lake Tanganyika.

## East Africa/Indian Sub-Continent

Tanzania's government has approved BG Group's request to farm into 60% of blocks 1, 3 and 4, operated by Ophir Energy. The blocks span a total area of over 27,000 sq km (10,425 sq mi) in the Mafia Deep Offshore basin and the northern part of the Rovuma basin, in water depths of 100-3,000 m (328-9,842 ft). BG will pay 85% of costs of an initial exploration work program.

•••

UK consultancy WGP Exploration is performing a feasibility study for Surestream Petroleum for a 2D survey on Lake Tanganyika. The program relates to offshore blocks B and D. WGP has been investigating the type of vessels that could handle this program, and also local infrastructure/logistics capability.

•••

Cairn Energy and Santos have completed 3D surveys over the producing Sangu gas field in the Bay of Bengal, the South Sangu discovery, and the Magnama discovery in block 16. The partnership will assess the data to identify exploration and production drilling targets for a potential campaign late in 2010 through early 2011.

## Asia-Pacific

Korex has signed a 10-year PSC with North Korea's state-owned Korea Oil Exploration Co. (KOEC) covering exploration rights in the Korean East Sea. The 50,681 sq km (19,568 sq mi) concession comprises deep and shallow water areas off North Korea's east coast. Early commitments include completing work on existing data and acquiring new 2D seismic. Korex is co-owned by London-based Aminex and Chosun Energy of Singapore.

• • •

Primeline Energy Holdings has completed a drillstem test program for its LS 35-3-1- discovery well in the East China Sea. Logging indicated over 20 m (65.6 ft) cumulative hydrocarbon pay in two zones. The find could be tied back 14.5 km (9 mi) to a planned production facility on the LS 36-1 gas field. It is also significant, Primeline claims, as the first proven surface flow of gas from a low-permeability reservoir in the southern part of the East China Sea.

• • •

In the South China Sea, Husky Oil China has tested gas at 55 MMcf/d from its first appraisal well on the Liuhua 29-1 discovery. The well was drilled by the *West Hercules* rig in 765 m (2,510 ft) of water. Liuhua 29-1 is part of a proposed three-field development in the area, with first gas targeted in 2013.

• • •

Lundin Petroleum has signed a PSC with Petronas Carigali for blocks SB307 and SB308 offshore Sabah, Malaysia. The permit includes an oil discovery which will be evaluated to determine its development potential. The partners also plan to acquire 2D and 3D seismic data and to drill at least one exploration well.

• • •

Last month, Salamander Energy spudded the first of a series of planned wells in the little-explored Vinh Chau Graben system offshore southern Vietnam. The shallow water Tom Su Lua-1X well, drilled by the jackup *PVD-1*, was targeting around 60 MMbbl of oil in block DBSCL-01. The rig was then due to transfer to block 31 to work on the Tom Hum Xanh prospect.

• • •

Nido Petroleum has produced first oil from its shallow water Tindalo development in the NW Palawan basin off the Philippines. Drillstem testing of the Tindalo-1 well achieved unassisted (natural) oil flow of 18,689 b/d. An extended well test is currently under way – cashflow generated will be used to fund Nido's planned five-well campaign elsewhere in the basin.

## Australia/New Zealand

Apache Energy has contracted JP Kenny for subsea FEED for its Julimar project in the Carnarvon basin offshore Western Australia. Development takes in the Julimar, Brunello, and Grange gas fields with combined reserves of 2.1 tcf, in water depths of up to 250 m (820 ft). They will be produced via up to 18 subsea wells connected to the new Wheatstone central processing platform.

• • •

Petrobras has taken a 100% operating interest in block 2 in the Raukumara basin offshore New Zealand. The three-stage work program involves acquiring 2D and 3D seismic data, and drilling of one exploratory well.

• • •

ROC Oil Tasman has farmed into the AWE-operated PEP38524 permit in the southern Taranaki basin. Pending approval from New Zealand's government, the partners planned to drill the Tuatara-1 well this month in 50 m (164 ft) of water, targeting around 80 MMbbl of recoverable oil. ROC and its joint venture partners have also secured another permit offshore Taranaki – PEP52181 – which includes the Kaheru oil and gas/condensate prospect.

*Jeremy Beckman • London*

## Norway, UK address drilling risks

Norway will move ahead with its 21st offshore licensing round, but will not sanction drilling on any deepwater permits until a clearer picture emerges over events leading up to the *Deepwater Horizon* incident in the US Gulf. "The precautionary principle combined with a predictable framework have to be the foundation for our petroleum politics," said Petroleum and Energy Minister Terje Riis-Johansen.

Early last month, the UK's new coalition government reacted by announcing that it would double mandatory rig inspections on the UK shelf from eight at present to 16 per year. In a separate development, industry body Oil & Gas UK set up an oil spill prevention and response advisory group (OSPRAG) to review general practice on the shelf, focussing on a range of issues including pan-North Sea regulations and response mechanisms.

## Downward drift for Norwegian investment

With offshore Norway oil production (including NGLS and condensates) set to drop 4.5% this year to 2.2 MMb/d, the country needs to strike a balance in opening up its waters if it is to continue to attract fresh investment. Terje Riis-Johansen has acknowledged the importance of increased recovery from producing fields, and access to new acreage, to both the sector's long-term development and the Norwegian economy. The government foresees total expenditure on the Norwegian shelf, including exploration costs, declining by 2.5% this year to $20.7 billion.

Exploratory drilling continues to focus on relatively low-risk targets. Among the latest successes, BP proved further reserves close to its current Skarv/Idun development in the Norwegian Sea. A well drilled by the semisub *Borgland Dolphin* on the Snadd North structure, 2 km (1.2 mi) west of Skarv, encountered gas in the Upper Cretaceous Lysing formation. Recoverable volumes look to be in the range 57-100 MMboe.

In the North Sea, Det norske oljeselskap found oil and gas in the Storlakken prospect, 20 km (12.4 mi) northwest of the decommissioned Froy field. Det norske remains committed to a re-development of Froy, in license PL 364, and aims to start issuing contracts this fall, assuming government approval for its soon-to-be-submitted plan.

**The *Seven Atlantic*, Subsea 7's new diving support vessel, has completed its first project for Shell in the UK southern gas basin. The program involved 80 saturation dives and 10 surface (air) dives. The dynamically positioned vessel is designed for at least 60 days at-sea endurance, and according to Subsea 7, can work faster than comparable DSVs. It has capacity for 24 divers using a twin bell system, and can accommodate up to 174 personnel.**

## BP launches subsea projects

Despite its troubles in the Gulf of Mexico, BP appears committed to production on the UK shelf. One of its imminent projects is the long-delayed $724-million Devenick gas/condensate development in 114 m (374 ft) water depth in blocks 9/24b and 9/29a in the northern UK North Sea.

At a recent briefing in London, German partner RWE Dea revealed that the field will be produced through one existing well and one new producer, linked via a four-slot subsea manifold and a 34-km (21-mi) pipeline to Marathon's East Brae platform. According to Rene Pawel, RWE Dea UK managing director, the relatively high pressure and high temperature of the Upper Jurassic reservoir should not complicate the platform modifications program. Development drilling should start later this year, leading to first production in summer 2012.

BP is issuing contracts for its Andrew Area project in the central North Sea. Subsea 7 will engineer and install a 28-km (17.4-mi) bundle system, comprising pipelines for production, gas-lift, and methanol transport, to connect the Kinnoul and Arundel fields to the Andrew platform. Offshore installations should start next year.

Also in this area, Serica Energy is working on a multi-field development which would involve a new minimal facilities platform bridge-linked to BG's Lomond platform, formerly operated by BP. The new installation would produce Serica's Columbus gas discovery in blocks 23/16f; Dana's Barbara and Phyllis gas fields; and potentially a Forties formation accumulation drilled by BG last year in adjacent block 23/21. FEED studies could lead to submission of an overall development plan later this year.

## Access to UK infrastructure

Britain's Department of Energy and Climate Change looks to widen access to North Sea production infrastructure in an attempt to galvanize development of third-party marginal or technically complex fields.

Deloitte's energy, infrastructure, and utilities division welcomed the move – greater access was critical, said division head Carl Hughes, for Britain's to maximize the value and recovery of its reserves. He also suggested a review of the current voluntary infrastructure code of practice, including compulsory arbitration, to promote greater use of new and aging offshore facilities.

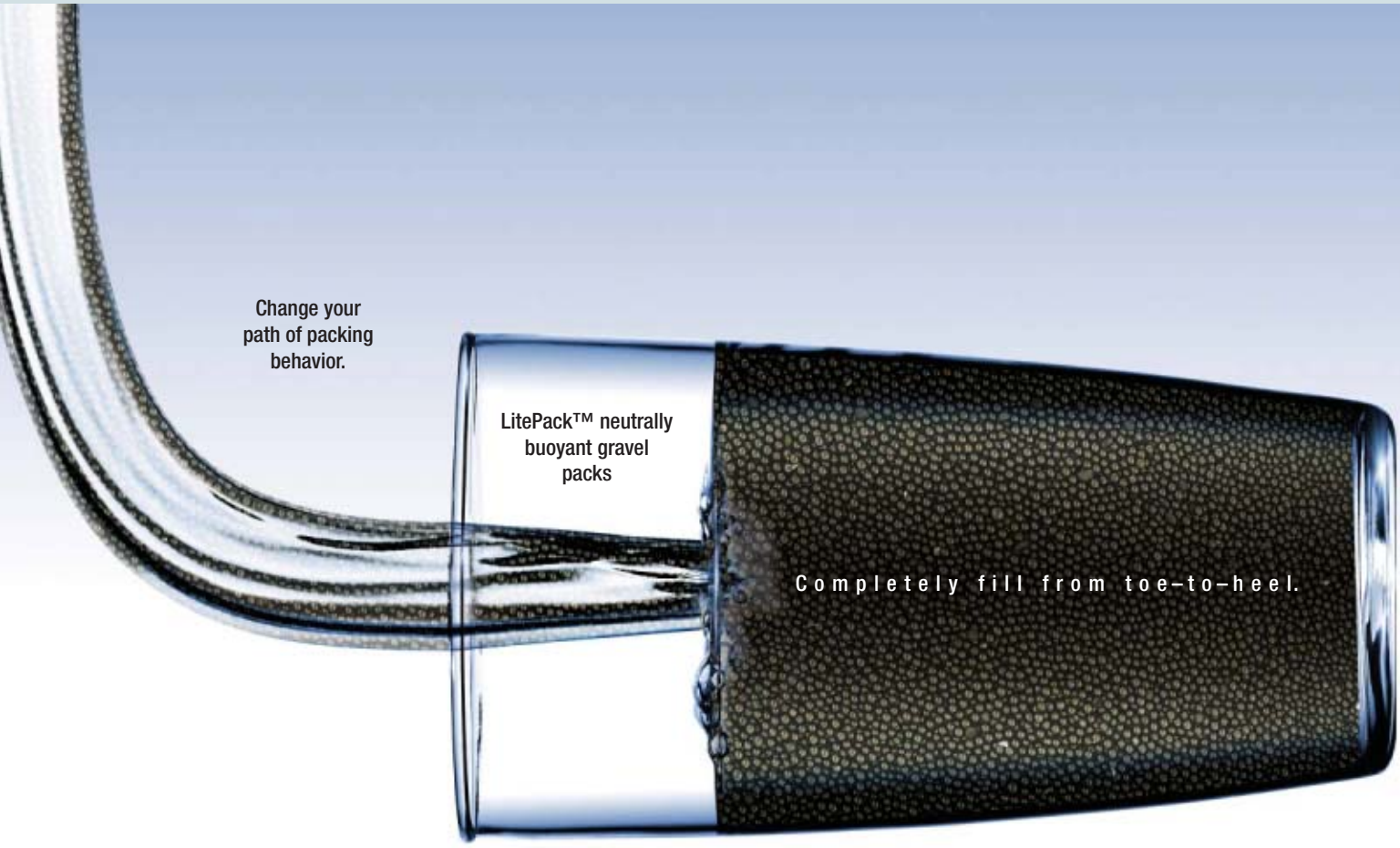
"In addition, thought needs to be given to the extent to which the infrastructure owners are required to operate and maintain that infrastructure well beyond the lives of the fields to which it originally related. Incentives to encourage the sale and purchase of infrastructure … could facilitate this process."

## Scotland's $CO_2$ options

A pan-industry project is under way to assess the suitability of carbon dioxide ($CO_2$) storage in sandstones beneath the Moray Firth, 30 mi (48 km) from northeast Scotland. The program is funded by Shell, BG, and Schlumberger, among others, in partnership with Scotland's government.

The Scottish Centre for Carbon Storage (SCCS) is assessing the technical and commercial viability of the Captain sandstone in this region as a $CO_2$ store. According to SCCS, this is one of various sandstones filled with salt water that provide over 95% of potential $CO_2$ storage capacity in the UK northern North Sea.

The program includes geological mapping and modeling to appraise the targeted rock's thickness, extent and fluid flow properties. It will also address $CO_2$ injection and monitoring issues. In time, SCCS says $CO_2$ emitted from industrial sources could be transported to the region either via existing or newly installed subsea pipelines, potentially forming a $CO_2$ pipeline network.




## BJ Services' sand control technologies improve horizontal well gravel packs.

BJ Services sand control experts are eliminating the risks associated with incomplete gravel packs in horizontal wells with proprietary products and services like the LitePack™ gravel pack, which is pumped at a lower rate and pressure to provide safer operations and reduce the risk of fracturing the formation. The neutrally buoyant fluid/proppant system can greatly reduce or even eliminate the alpha wave sand buildup so the annulus is completely filled from toe-to-heel.

To ensure optimal placement in your well, the pump rate required to place the LiteProp™ proppant is modeled with BJ Services' PowerSand™ software. For beta-only pack placement, the minimum pump rate is determined to eliminate the alpha wave and the job is performed at a rate slightly exceeding this rate. This technique has been successfully demonstrated in our horizontal wellbore simulator and confirmed in jobs performed across the globe.

BJ Services sand control experts have the products and technologies to make conventional sand control methods a wave of the past.

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*David Paganie • Houston*

## BP outlines containment plans

At press time, BP had outline a detailed plan for building additional capacity and redundancy for the containment of oil from the *Deepwater Horizon* incident. This was in response to pressure from US authorities to step up containment efforts amid reports of increasing estimated rates of oil flow from the damaged well. In a letter to Coast Guard Read Admiral James A. Watson, BP outlined the following steps:

1. A 25,000 b/d oil capacity FPSO would be mobilized from South America as a backup to the *Toisa Pisces* and *Helix Producer I*.
2. Two more lightering tankers were en route from Europe.
3. An added 3,800 ft (1,158 m) of 6-in. flexible hose was on its way from Brazil to backup subsea hoses.
4. Work continued to retrieve and repair the blue pod from the *Deepwater Horizon* BOP and to create added redundancy.
5. Work was under way to enable the *Discoverer Enterprise* or *Discoverer Clear Leader* to connect to either permanent riser system.
6. Additional heat capacity was being organized for the *Discoverer Clear Leader* test equipment to expand its installed capacity.

According to the letter, by mid to late July, BP planned to have a new LMRP cap with more seal integrity to ensure a relief well kill operations, and expanded recovery capacity for 60,000 to 80,000 b/d of oil. The recovery system would employ four vessels: *Toisa Pisces* and *Helix Producer I* would attach to the choke and kill lines with permanent risers; and *Discoverer Enterprise* and *Discoverer Clear Leader* would connect to the new cap with drill pipe and a suction pile, which is more hurricane efficient than using a riser, according to BP.

## Deepwater moratorium

At the time of this writing, US District Court Judge Martin Feldman granted a preliminary injunction blocking the US Department of Interior's moratorium on deepwater drilling. The US Court ruled in favor of Hornbeck Offshore Services vs. US Interior Secretary Ken Salazar, citing the US government failed to justify the six-month deepwater drilling moratorium.

On May 30, the MMS, in a Notice to Lessees and Operators (NTL), activated the moratorium on the drilling of new wells in 500 ft (152 m) of water or greater. The NTL also directed operators to cease drilling wells covered by the moratorium.

According to the NTL, activities not affected include:

- Intervention or relief wells for emergency purposes, including the two relief wells by BP
- Operations that are necessary to sustain reservoir pressure from production wells
- Workover operations
- Waterflood, gas injection, or disposal wells
- Driling operations or other activities that are necessary to safely close or abandon a well, or to complete a well under CFR 250.500.

If the moratorium stands, it is too early to know how it will ultimately impact the industry, but with an estimated 33 deepwater rigs active at the time of the effective date, analysts predict that at least 50,000 jobs associated with those rigs could be at risk. At press time, a number of operators active in deepwater had declared force majeure on its drilling contracts, which likely would force those contracts to be canceled if the claims are deemed legitimate.

It also has been estimated that the drilling ban could represent a GDP loss of $12 billion, assuming the moratorium lasts for 12 months.

## Exmar semi bound for GoM

LLOG Deepwater Development Co. LLC has agreed in principle to acquire the OPTI-EX semisubmersible production platform from EXMAR for use in the Gulf of Mexico. LLOG looks to install the facility in its Mississippi Canyon area development and initiate production in 2011. The platform will provide processing capacity of 60,000 b/d of oil and 150 MMcf/d of gas.

**Ships and drilling rigs surround the *Discoverer Enterprise* as it continues to recover oil from the *Deepwater Horizon* drill site. Photo by US Coast Guard Chief Petty Officer Bob Laura. For continuous news, videos, and analysis on the incident, visit: offshore-mag.com/index/deepwater-horizon-oil-spill-2010.html.**

*Gene Kliewer • Houston*

## Asia-Pacific
### Eni contracts Kitan subsea installation

Eni has contracted Technip to install subsea equipment at Kitan field in the Timor Sea in 350 m (1,148 ft) water depth. The area, jointly administered by Timor-Leste and Australia, is 500 km (310 mi) from the northern Australian coast and 250 km (155 mi) south of the Timor-Leste capital, Dili.

Technip contracted for project management and engineering; the supply and installation of 23 km (14 mi) of flowlines and risers; and installation of Kitan's umbilical system. Work is to be done in Perth, Western Australia. Pipelines will be manufactured at the group's plant in Le Trait, northern France, with the construction vessel *Venturer* starting offshore installation during the first half of 2011.

## Europe
### Trym gets subsea template

The subsea template and manifold for DONG Energy's North Sea Trym field development are in place.

Trym is in the Norwegian sector, just north of the Norwegian/Danish offshore median line. Norway's authorities recently authorized development on the Norwegian side.

The subsea production system will be tied back 6 km (3.7 mi) to the Maersk-operated Harald platform in the Danish sector.

Both the template and manifold were manufactured by Aker Solutions in Egersund, Norway.

FMC Technologies has contracted with Statoil ASA to manufacture and supply subsea production equipment for Marulk field. The award is a call-off from FMC's existing frame agreement with Statoil.

Marulk is in the Norwegian Sea, approximately 18 mi (30 km) southwest of the Norne field in a water depth of 1,200 ft (365 m).

Initial development will be two wells tied back to the Norne FPSO.

Eni Norge AS is the operator and partners include Statoil Petroleum AS and DONG E&P Norge. Statoil will assist Eni Norge with subsea installations and the tieback to the Norne FPSO.

Grenland Group, as a supplier to FMC Technologies, is to deliver a one-off integrated template structure and a one-off manifold. Total weight for the delivered structures will be approximately 340 metric tons (375 tons).

Most of the work will be at Grenland's sites in Langesund and Røra.

Contract value for Grenland Group will be around NOK 32 million ($5 million) and deliveries are scheduled to begin next May.

Aker Solutions has won a contract from Noble Energy Inc. for NOK 150 million ($23.5 million) in subsea control equipment.

Scope covers engineering, manufacturing, and delivery of a subsea controls distribution system, umbilical termination assemblies (UTA), and related equipment for the Tamar project in the Mediterranean Sea.

This contract complements the recently award for delivery of 240 km (149 mi) of subsea umbilicals for the same project. Aker Solutions also will supply a complete monoethylene glycol (MEG) reclamation unit to Noble Energy.

Estimated delivery date is 1Q 2011.

### Malaysia to get first Kongsberg Maritime HUGIN 1000 AUV

**Offshore Geo-Surveys Sdn Bhd has ordered a HUGIN 1000 AUV from Kongsberg Maritime. The vehicle, due for delivery in 2Q 2010, is rated for 3,000 m (9,842 ft) and runs on rechargeable lithium polymer batteries. Its geophysical and oceanographic sensor suite can operate at the same time to secure high-resolution seabed data. The AUV is scheduled to be stationed in Labuan, Malaysia. The unit is delivered in a transportable container system that includes launch and recovery using a stinger system over the stern.**

**Ashtead Technology has two new Reson SeaBat 7125 multi-beam echo-sounders for ROV use. The sonar is designed with variable swath width, roll stabilization, high ping rate, and excellent data quality, says Ashtead. "As deep-water projects are on the increase there is demands for multibeam systems with a depth rating up to 6,000 m (19,685 ft) like the SeaBat 7125," says Christian Blinkenberg, sales and business development director. "This is our latest step in capital investment to keep up with customer demand."**

## Africa
### Acergy to work off Africa

Acergy S.A. has won a $120-million contract to remove existing risers and to install 15 km (9 mi) of new pipelines and associated risers, together with associated diving and hook-up activities, offshore Nigeria in shallow water. Construction engineering will begin immediately, with offshore installation due to start in 1Q 2011.

*David Paganie • Houston*

**Malaysian engineering and construction contractor SapuraAcergy has issued an LOI to TSmarine to provide an ROV support vessel to assist the *Sapura 3000* pipelay installation vessel during the Shell Gumusut - Kakap deepwater campaign. TSmarine plans to mobilize the DP-2 vessel *Havila Harmony* in July for the work. The vessel is equipped with two deepwater ROVs and a 150-metric ton (165-ton) active heave compensated crane.**

## NPCC orders derrick laybarge

National Petroleum Construction Co. (NPCC) has contracted the Chinese shipyard Zhenhua Heavy Industries to build the *DLS 4200* derrick laybarge.

The vessel concept, developed by Ulstein Sea of Solutions (USOS) based in Vlaardingen, the Netherlands, combines double joint S-lay capabilities with a 4,200-ton (3,810-metric ton) lifting capacity.

The *DLS 4200* is to be equipped with a 10-point mooring system to operate in the Arabian Gulf and offshore India, although the vessel is designed to work worldwide.

The 197-m (646-ft) long vessel features a center double joint firing line to optimize pipelay operations. This and the double joint fabrication areas are on the freeboard deck, covered by the main deck. According to USOS, this provides a clean, dry environment for the pipelay equipment, and an unobstructed main deck for lifting operations.

Its Amclyde Model 80 main crane can handle lifts of up to 4,200 tons at a 125-ft (38-m) radius over the stern in tieback mode, and 4,200 tons at 95 ft (29 m) without tieback. In full revolving mode the crane can lift 3,635 tons (3,300 metric tons) with an outreach of 130 ft (39 m).

Two fixed-pitch, shaft-driven main propellers (5,500 kW each) provide a transit cruising speed of 13 knots. In order to upgrade the vessel to DP-2 (allowed for in the design), five retractable azimuth thrusters of 3,500 kW each will be needed.

## Allseas contracts DSME for *Pieter Schelte*

Daewoo Shipbuilding and Marine Engineering (DSME) in Korea will build Allseas' new multi-purpose construction vessel *Pieter Schelte*.

Detail design has been completed for the vessel, which will be equipped for pipelay, platform installations, and decommissioning.

DSME's contract is valued at $550 million. Allseas had ordered long-lead items, notably the power generation equipment and thrusters, in 2007, and the high-tensile steel for the topsides and jacket-lift systems, in 2008. The company says it plans to issue tenders for the lift systems this summer.

*Pieter Schelte* will be 382 m (1,253 ft) long and 117 m (384 ft) wide, with a topsides lift capability of 48,000 metric tons (52,911 tons) and a jacket lift capacity of 25,000 metric tons (27,558 tons). Its pipelay tension capacity will be 2,000 metric tons (2,205 tons), twice that of Allseas' *Solitaire*.

## Petrobras goes on vessel charter spree

Petrobras has chartered four anchor handling tug supply vessels from Siem Offshore and two platform supply vessels from Deep Sea Supply.

Siem says the four-year contracts are valued at $285 million and all the vessels will be in operation in Brazil by February 2011. Petrobras says it has the option to extend the Siem vessels contracts for four additional years, pending mutual agreement.

These four vessels will add to Brazil's current list of 10 vessels in operation and eight more under construction. The contract backlog for these was $335 million at the end of 1Q 2010 and the potential value of the contract extensions was $310 million.

Deep Sea will supply the *Sea Bass* and *Sea Halibut* PSVs for four years also, with operations to start in July for both. This will give Deep Sea five offshore supply vessels in Brazilian waters.

## Subsea 7, Candies join to extend GoM reach

Subsea 7 Inc. and Otto Candies LLC have an agreement to cooperate for access to the newbuild *Ross Candies* for life-of-field services. The companies say that in combination they will extend their range of inspection, repair, maintenance, and light construction services in the Gulf of Mexico.

The *Ross Candies* is US built and entered service this year. It is a DP-2 class vessel with a 100-metric ton (110-ton) offshore crane and a 100-metric ton module handling tower with a 1,000-sq m (10,764-sq ft) deck, two Triton XLS ROVs, and capacity to work in 10,000 ft (3,048 m) water depth.

## J-lay spread sails to Korea

IHC Engineering Business (EB) has shipped out the J-lay system for the new Saipem FDS2 (Field Development Ship).

The equipment is en route to Samsung Heavy Industries' Geoje shipyard in South Korea where EB's engineers will assist Saipem and Samsung with installation and commissioning on the vessel.

The new system will be able to accommodate pipes from 4- to 36-in. (10-91 cm) diameter, and is rated at 2,000-metric ton (2,205-ton) hang-off capacity. Through adjusting the angle of the tower from 45° to 96°, the system will be able to lay pipe in shallow and deepwater.

According to EB, the J-lay system is 65 m (213 ft) tall and 14 m (46 ft) wide. The total weight of the tower, including all pipe-handling equipment, is 2,500 metric tons (2,756 tons).

## J Ray, Oceanteam close newbuild contract

J. Ray McDermott S.A. and Oceanteam ASA have awarded a contract to Metalships and Docks S.A.U. shipyard in Vigo, Spain, to build a reel-lay pipelay vessel, to be named *North Ocean 105*. Due for delivery in early 2012, the vessel's vertical reel will have a nominal payload of 2,976 tons (2,700 metric tons) with tension capacity between 441 and 551 tons (400 and 500 metric tons), for installing 4- to 16-in. diameter pipe. It will be equipped with a 400-ton (363-metric ton) heave compensated crane and will be capable of working in about 9,000 ft (2,743 m) of water.

## Dockwise, COOEC sign heavy-lift accord

Dockwise has a memorandum of agreement with the China Offshore Oil Engineering Co. (COOEC) to manage a newbuild, 50,000-metric ton (55,115-ton) heavy-lift vessel.

The ship, similar in size to Dockwise's *Black Marlin*, is due to be delivered in February 2012.

# Eliminate Dropped Casing Strings In Deepwater

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## *Deepwater Horizon* saga continues

At this writing, the efforts to stop the flow of oil and gas at BP's Macando well in the Gulf of Mexico show no signs of ending. The relief wells, one main well and one contingency well, are drilling ahead and estimates are that the first well, from the *Development Driller II* may make contact this month (July). The second well, from the *Development Driller III*, is about 4,500 ft (1,372 m) behind the first well.

Once contact is made, plans are to attempt a "bottom kill" by pumping drilling fluids into the bottom of the well rather than the top. An attempted "top kill" failed.

On the production side of the efforts, estimates are that recovery capacity could be up to 80,000 b/d by month's end. Plans are to replace the containment cap with another one that has multiple hoses for a higher flow rate. More surface processing and storage is in the works in order to keep up with the anticipated increase in the production rate.

For the latest on this, visit www.offshore-mag.com.

## In Norway

As might be expected, the problems in the Gulf have generated action in other offshore arenas. Petroleum Safety Authority Norway (PSA), for example, has approached the Norwegian Oil Industry Association (OLF) to discuss emergency preparedness measures on the Norwegian continental shelf.

NPD seeks clarification on how the industry would respond to a subsea blowout offshore Norway. It has also asked OLF to assess existing strategies for limiting the effects of a blowout and to identify potential for improvement.

"We must assess the need for new practices, for developing innovative technology, and/or for a new understanding of response requirements," says Magne Ognedal, PSA director-general.

"BP has done much on a trial and error basis, and Norway can take advantage of the lessons learned. The PSA has emphasized the need to secure such benefits to the OLF, which has confirmed that it will coordinate the work and takes the issue seriously."

Following a report from US Secretary of the Interior Ken Salazar, PSA has compared its 21 recommendations for the US offshore sector with the minimum requirements set forth in Norwegian regulations. It appears that most of Salazar's proposed improvements have been largely implemented already in Norway.

PSA says it will constantly assess the need to make the Norwegian regulations and guidelines more precise and/or to improve methods for verifying technical condition on the basis of lessons learned from the *Deepwater Horizon* incident.

## In the UK

The UK plans to step up inspection of drilling rigs and the monitoring of offshore compliance on the UK continental shelf.

DECC plans to recruit additional inspectors for its Aberdeen office to double the annual number of rig inspections in UK waters.

It has also asked OSPRAG, the new oil spill prevention and response advisory group formed by Oil & Gas UK, to report on its findings on Britain's capability for dealing with oil spills.

DECC plans to review indemnity and insurance requirements for operating in the UK continental shelf. DECC adds that the European Union has asked companies operating in EU waters to provide assurances that they are working as hard as possible to ensure safe practice and that they are able to take on full responsibilities for environmental and other damage if an incident were to occur.

## First Romanian multi-stage frac raises production

Petrom has completed an improved recovery project at its Lebada Est and Lebada Vest fields in the Histria block in the Romanian sector of the Black Sea. As a result, the company expects additional production this year of more than 300,000 boe from two existing wells (LO2 and LO4) and a newly drilled offshore well, LV05.

L02 and L04 were drilled in 1998 on Lebada Est. They had been producing at low rates due to the low permeability of the reservoir rock. According to Petrom, Lebada Est and Lebada Vest are similar geologically.

The company applied multi-stage hydraulic fracturing – a pioneering technique for the Romanian sector, it claims – to increase the flow of reservoir fluids from the rock into the wellbores in the LV03 and LV04 wells on Lebada Vest.

Following the resultant improvement in production in both cases, the company decided to drill a new well on Lebada Vest – LVO5 – and to transfer the technique to wells L02 and L04 on Lebada Est.

Petrom currently produces 32,000 boe/d from five fields in the Black Sea, which accounts for around 18% of its overall production in Romania.


**Cairn Energy Plc. has received formal approval to drill the first two wells in its 2010 exploration program in the Disko West area offshore western Greenland. The program calls for four total wells. The approval comes from Greenland's Cabinet. Cairn has held acreage in Greeenland since late 2007. Subsidiary Capricorn signed license agreements for two blocks off West Greenland (Sigguk and Eqqua) and farmed in to two blocks that are operated by EnCana Corp. of Canada (Atammik and Lady Franklin). In 2008, Capricorn was awarded four more blocks in South Greenland (Kingittoq, Saqqamiut, Salliit, and Uummannarsuaq).**

## D&P equipment/service news

**Wellstream** has established an Integrity Management Division based at its headquarters. The new division will inspect and monitor existing and new risers and flowlines. The aim is to reduce operational, safety, and environmental risks by using real-time data to plan interventions, optimize offshore asset life and production availability, and minimize equipment operating costs.

Wellstream also has formed an exclusive partnership with MAPS Technology to develop and promote the latter's MAPS stress measurement technology. The agreement follows the successful development of a prototype system with a major offshore oil and gas company.

The V1 monitoring system can measure directly the integrity of load-bearing elements of a flexible riser or flowline without penetrating or adversely impacting the riser or flowline structure. In this way, it provides real-time information on load changes, and any loss of integrity or progressive failure occurring within all load-bearing elements.

**MODEC** has contracted VWS Westgarth and VWS Brazil for a seawater treatment package for a development project offshore Brazil.

The package will be supplied as a single-lift module comprising coarse strainers, media filtration pre-treatment, vacuum de-aeration, and sulfate removal process (SRP) systems. Water throughput capacity of the equipment will be 24,000 cu m/day (150,972 b/d).

*Gene Kliewer • Houston*

## EAGE kicks off round of new products

The European Association of Geoscientists & Engineers (EAGE) annual meeting has generated more than the usual number of new product introductions. Some of them were equipment oriented such as CGGVeritas' BroadSeis streamer system and Spectraseis borehole receiver. Most of the introductions were computer oriented. The following takes a quick look at some of these exploration aids, and starts with the equipment side.

The **CGGVeritas** BroadSeis officially came out of the company's Paris headquarters. BroadSeis is given as an integrated service resulting in high-resolution marine seismic returns. It is based on deploying Sercel Sentinel solid streamers in specific configurations in combination with new imaging technology. CGGVeritas says the system allows recording of an extra octave or more of low frequencies.

"This fully 3D solution is ideal for wide-azimuth acquisition as well as reservoir imaging and characterization in general," says Robert Brunck, chairman and CEO of CGGVeritas. "It is also immediately available on all CGGVeritas solid streamer vessels, which make up most of our fleet. BroadSeis creates remarkable images of the subsurface and represents a new technological advance in seismic imaging."

The borehole tool from **Spectraseis** is a receiver array for low-frequency and microseismic measurements. The 4.4-in. OD tool has six levels of active receivers is designed to be deployed and recovered on a tubing string in casing as small as 5 1/2 in. and in temperatures to 160 °F (70 °C).

Other features include broadband recording, multi-level array, and a gimbaling mechanism to allow for accurate measurements in wells deviated up to 24°.

## GoM survey now complete

**PGS says data should be available late this year from its recently completed Crystal III survey of the Western Gulf of Mexico. PGS is applying its velocity modeling and RTM imaging.**

**The wide-azimuth towed streamer survey covered 485 deepwater OCS blocks, or a total of 11,300 sq km (4,363 sq mi).**

**"Initial data quality is extremely promising and we believe that the program will deliver on its promise of a step-change in imaging quality necessary to unlock the Miocene and Lower Paleogene sub-salt potential in the East Breaks area," says Nathan Oliver, regional president of MultiClient NSA.**

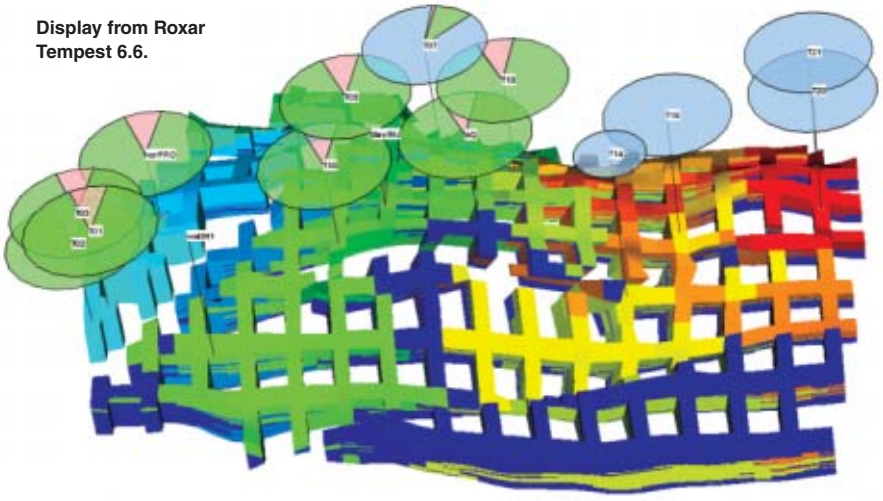
At EAGE proper, **Emerson Process Management** launched Roxar Tempest 6.6 integration program for "full field reservoir simulation." This is the latest version of the Tempest program and covers preparation and analysis of original data, compositional and black-oil simulation, results study and visualization, and economic evaluation.

Specific features of the new version include advanced processing capabilities, intuitive visualization through a consistent, powerful graphical interface, and an integrated workflow. The result is increased productivity and accessibility within reservoir asset teams.

While not yet an offshore use item, **Shell** and **PGS** announced plans to develop an ultra-high channel count fiber-optic seismic sensing system. The potential for migration to offshore use should be high. The collaboration says the results of higher channel counts with high-quality sensors will recover more seismic energy and help cancel noise for improved resolution and imaging.

Using the new system based on PGS' OptioSeis should overcome issues with scaling up the number of channels and also lower the weight of the cable to ease deployment.

**Petrosys** showed its new version of its petroleum EP mapping and data management software, 16.8. The company says this version adds the ability to directly display interpreted faults, seismic times, and other attributes from a range of workstations. The seismic and fault posting options can overlay information from a range of data sources.



Display from Roxar Tempest 6.6.

## Multiple scenarios

Petrosys 16.8 surface modeling now supports more advanced arithmetic formulae with conditional statements, as well as the ability to create and publish maps from within a surface modeling task. Extensions make it easier to run multiple scenarios, such as in velocity modeling, and for the routine creation and update of collections of maps and surface modeled data.

**JOA Oil & Gas BV** announced Impala, its new multiple point statistics (MPS) facies modeling module.

"MPS is rapidly becoming the tool of choice for facies modeling in the E&P industry," says Gerard de Jager, CEO of JOA Oil & Gas. "With our Impala plug-in, JewelSuite brings the full power of MPS technology for advanced facies modeling to the market."

## Geology and geophysics news

**Electromagnetic Geoservices** has won a $150-million, multi-year contract to supply one of its purpose-built 3D electromagnetic survey vessels on a continuing basis to an operating company.

EMGS says contract signing is expected in two weeks and mobilization of the vessel by the end of August.

"This award, by far the largest ever within marine EM, is a giant step forward for EMGS," says Roar Bekker, EMGS CEO. "A long-term project such as this provides us with a solid platform for future growth and allows us to manage our vessel utilization far more efficiently."

**CGGVeritas** says it has signed a technology cooperation agreement with **Petrobras** to collaborate on development and implementation of new geophysical technologies. The three-year term referenced 4D seismic processing, imaging, and reservoir geophysics.

CGGVeritas recently opened a technology center in Rio de Janeiro that also plans to develop partnerships with universities in Brazil.

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# NOCs hold keys to hot pace in Latin America

**Gene Kliewer**
*Technology Editor, Subsea & Seismic*

The waters of Latin America drive the region's upstream oil and gas business, and the potential for more success suggests the area will continue to draw attention. How the area will develop depends upon the national oil companies. The NOCs in Brazil, Venezuela, and Mexico hold about 90% of all reserves and account for 90% of all production. Even in the smaller arenas of Colombia and Ecuador, the NOCs produce more than half the oil. This reliance on NOCs remains a barrier to operations in Venezuela and Mexico, and to some degree Brazil which is considering new legislation to restrict some areas of operation to Petrobras.

Even without the political climate in Venezuela and the difficulties operating offshore Mexico, and the omen of possible geographic restrictions to exploration and development, Brazil still would be the shining star in Latin America's upstream oil and gas sky. Barring any dramatic changes in its operating environment, Brazil will continue to increase its position as the hottest spot in Latin America. Production records of more than 2 MMb/d of oil and plans for multiple drilling rigs and FPSO installations, and the lure of export dollars are expected to keep Brazil's Petrobras moving at its current pace for a long time to come. Add that to the formation of some local operators and the successes by international oil companies off its shores, and Brazil dominates Latin America's oil business.

Looking broadly, earlier this year Spectrum and the Hamilton Group were planning multi-client 2D seismic surveys plus basin analyses of offshore South America. In an even wider scope, Brazil's salt-related finds are prompting exploration for similar strata on the African side of the Atlantic. (See story on page 44).

ION Geophysical's BrasilSPAN regional seismic data acquisition program now has a total of 28,000 km (17,398 mi) of regional seismic data covering Brazil's southern Santos, Pelotas, and northeastern Equatorial basins with the recent addition of 28,000 km (17,398 mi) of data. This program combined with ION's CongoSPAN off Angola should be insightful for geoscientists investigating the geologic connections between Brazil and Africa.

## Brazil

There is big news on the production side of Brazil's oil and gas industry. Petrobras says it set a monthly oil production record in Brazil of 2,033,000 b/d in April. This surpassed the previous record by 29,000 b/d. Petrobras also says it set two consecutive daily oil and LNG production records on April 23-24 of 2,081,000 b/d and 2,084,000 b/d, respectively.

The results stem from operations at the platforms offshore Rio de Janeiro and Espirito Santo, especially the connection of new wells to the FPSO *Cidade de Vitoria* in Golfinho field and new wells on production in Marlim Leste.

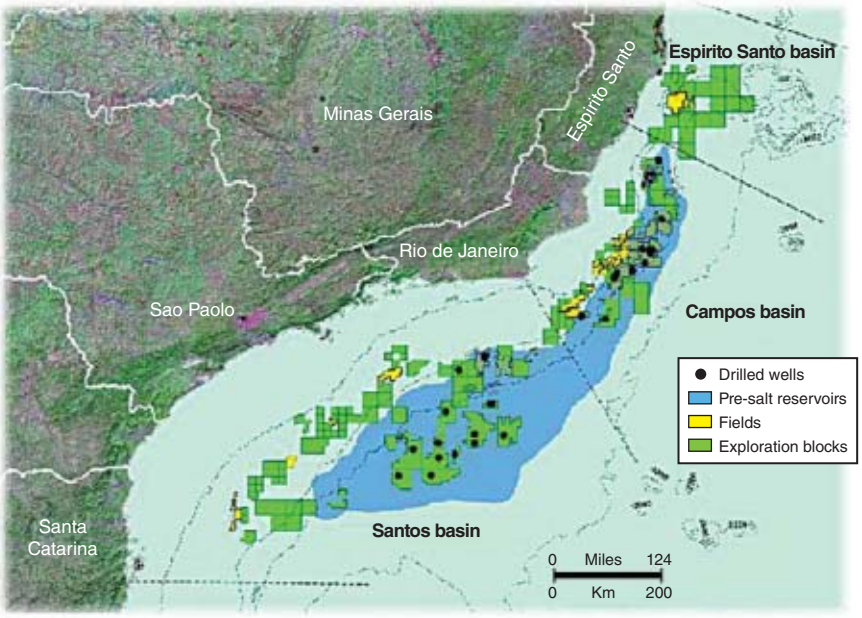
In the near future, production is expected to rise further when FPSOs *Cidade de Santos* in Urugua/Tambau and *Capixaba* in Cachalote/Baleia Franca are counted. *Capixaba* went onstream in June and ultimately is to connect to nine wells with peak production by year end of 100,000 b/d of oil.

The news items coming out of Brazil are continuing reports of new discoveries, both pre- and sub-salt. As expected, Petroleos Brasiliero (Petrobras) leads this way in drilling. Here are some of Petrobras' most recent successes:

- Well 6-MRL-199D-RJS in the pre-salt of Campos basin reached TD of 5,000 m (16,404 ft) and in the process found carbonatic reservoirs of the Aptian at 4,460 m (14,633 ft). The well is 4.5 km (2.8 mi) from the *P-27* platform which could hasten development.
- Well 6-CRT-43-RJS (Carimbé) found the same Aptian light oil and is thought to be an extension of the Barracuda field. It may be connected to the *P-48* platform for production.
- The Tupi appraisal well 3-RJS-666 in pre-salt Santos basin confirmed the original discovery of Tupi in BM-S-11 in 2,115 m (6,939 ft) water depth.

Petrobras is not the only successful driller offshore Brazil. OGX Petróleo e Gás Participações SA, a Brazilian company, reports a number of strikes, too. Among them:

- Well 1-OGX-11D-SPS in BM-S-59 block of Santos basin had gas and condensate in the Santonian section of the Natal some 104 km (65 mi) offshore. Water in the block is 170 m (558 ft) in depth.
- Both wells OGX-6 and OGX-8 in the BM-C-41 block were successful, according to OGX. OGX-6 well on the Etna prospect was drilled to TD of 3,604 m (11,824 ft), with hydrocarbon shows in the carbonate Albian and Aptian sections. It encountered




Pre-salt areas offshore Brazil.

an oil column of around 70 m (229 ft), with 38 m (124 ft) of net pay. Well OGX-8 on the Fuji prospect, drilled to 4,110 m (13,484 ft), encountered a 180-m (591-ft) oil column with approximately 43 m (141 ft) of net pay in carbonate reservoirs, also in the Albian section. OGX-8 is off Rio de Janeiro state in 135 m (410 ft) water depth.

OGX adds that samples and logs indicate a correlation between the Albian reservoirs of OGX-6 (Etna), OGX-3 (Waimea), and OGX-2 (Pipeline). The Etna prospect is 8.5 km (5.3 mi) northeast of the Waimea prospect and appears to be structurally 400 m (1,312 ft) above the Waimea reservoir. OGX estimates recoverable oil volumes at 1.4-2.6 Bbbl for the Pipeline/ Etna accumulation. For the potential Waimea/Fuji structure, the estimate is 600 MM -1.1 Bbbl.

Anadarko Petroleum also finds Brazil productive. A drillstem test at Wahoo-1 in Campos basin deepwater flowed at a rate of 7,500 b/d of oil and 4 MMcf/d of gas. Anadarko was moving 5 mi (8 km) north to spud Wahoo-2.

## Field development

The offshore finds are leading to production action. An extended well test from the semisubmersible *SS-11 Atlantic Zephyr* in exploratory block BM-S-40 in the Santos basin's Tiro e Sídon areas is under way for Petrobras.

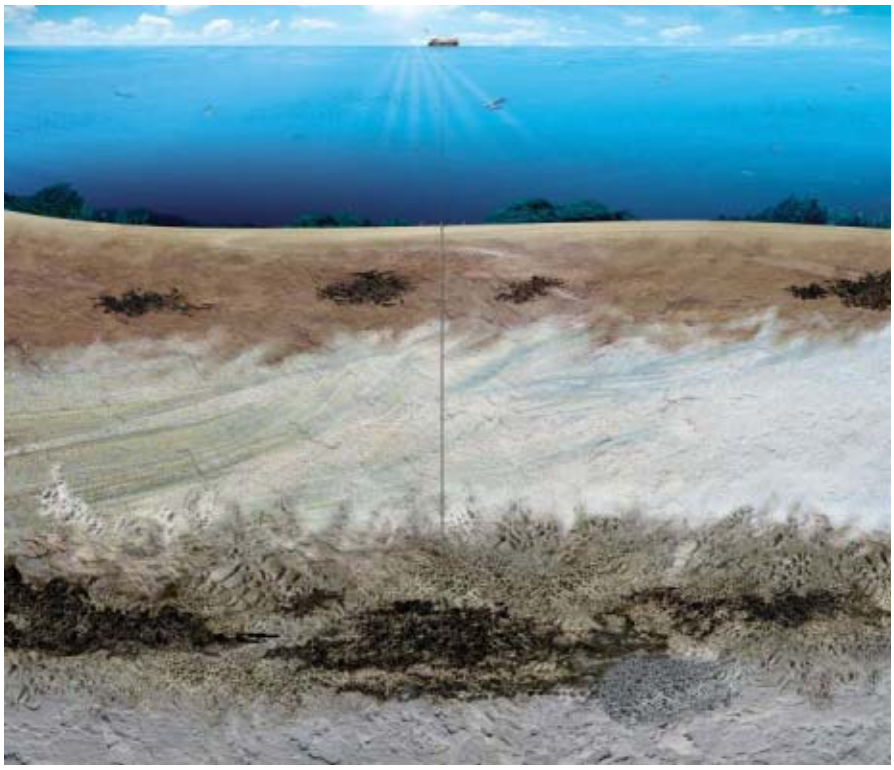


**Illustration of the salt intrusions. The pre-salt is below the salt and the post-salt is above. Courtesy Petrobras.**

The test program calls for one year of production from both well 1-SPS-56 in Tiro and well 1-SPS-57 in Sídon. Meanwhile, Petrobras says it plans to drill in block BM-2-12 to the east.

Evaluations from nearby Cavalo Marinho, Caravela, and Estrela do Mar fields added to results from the extended test, will determine the future of the Santos basin, Southern Pole discoveries and whether an integrated production system can be supported there.

The Papa Terra project, operated by Petrobras with Chevron as a partner and estimated to cost $5.2 billion to develop, is 70 mi (110 km) offshore in 3,900 ft (1,190 m) of water in block BC-20 of the Campos basin. As it stands now, the project will have the first tension-leg platform ever offshore Brazil. It will connect to an FPSO. Ultimate capacity is to be 140,000 b/d.

J. Ray McDermott holds the contract to build the *P-61* tension-leg wellhead platform for Papa Terra. J. Ray's scope is part of the larger project comprising design, engineering, construction, transportation, installation, and a three-year limited operations contract, that was awarded to FloaTEC Singapore, a joint venture between Keppel FELS and J. Ray.

The TLWP will be built at Keppel FEL's BrasFELS yard in Angra dos Reis, Brazil. J. Ray will fabricate the tendons, temporary buoyancy modules, and piles at Morgan City, Louisiana. The FloaTEC Singapore joint venture will supply risers, well systems, and tendon components, and J. Ray will install the facility in the Papa Terra field using *Derrick Barge 50*. J. Ray will also provide topsides engineering and procurement services.

The project is targeted for completion by mid-2013.

One of the largest new developments to come onstream offshore Brazil is the Shell-operated Parque das Conchas. The Parque das Conchas project, formerly known as BC-10, uses an FPSO with 100,000 b/d of oil and 50 MMcf/d of natural gas production capacity. Shell has a 50% share; partners Petroleo Brasileiro (Petrobras) holds 35% and India's ONGC Campos holds 15%.

Production comes from the Abalone, Ostra, and Argonauta B-West fields at depths of 950 m to 2,500 m (3,117 ft to 8,202 ft) below the seabed. This first phase involves nine producing wells.

In a technical first, oil and gas are separated on the seabed before electric pumps push the oil upwards from the low-pressure reservoirs to a specially converted production vessel on the surface that stores it for shipping to shore.

With its domestic oil and gas supply growing, Brazil is at the point of considering exports. For example, the BG Group and Petrobras are developing FLNG as an additional option to commercialize the Santos basin pre-salt production. A new FLNG vessel would operate near the planned Santos basin FPSOs. The vessel would process and liquefy the associated natural gas from the pre-salt fields before offloading to LNG ships. The FLNG processing capacity is anticipated to be up to 14 MMcm/d of associated gas.

By developing its reserves with subsea equipment, Petrobras and Brazil have become leaders in application of the technology.

Aker Solutions has signed a $300-million frame agreement with Petrobras to supply 40 vertical subsea trees for its Iara and Guara field developments in the pre-salt Santos basin. Contract party is Aker Solutions do Brasil Ltda.

The full work scope includes engineering and manufacturing of the 40 trees for operations in 2,500 m (8,202 ft) water depth, associated subsea control systems, and 17 tool sets. Consignments will be delivered in phases over the next four years.

Petrobras has awarded FMC Technologies a four-year subsea tree frame agreement. FMC's scope of supply includes the manufacture of up to 107 subsea trees and related tools for use offshore Brazil in water depths of 6,500 ft (2,000 m). Deliveries are scheduled to begin in 2012.

Petrobras has awarded Nexans a $48-million contract to develop, manufacture, and supply the electro-hydraulic control umbilicals for the Tambau and Urugua fields in the Santos basin. The umbilicals will connect the FPSO *Cidade de Santos MV20*, serving the Tambau and Urugua gas and oil fields, to the subsea manifolds, and then connect the manifolds to the production wells.

## Falkland Islands

A small spot with a disproportionate amount of activity, the Falkland Islands continue to see drilling. Rockhopper Exploration has updated the analysis of its Sea Lion oil discovery in the offshore North Falkland basin. According to independent consultants RPS Energy, the field could contain 242 MMbbl of recoverable oil, with significant upside potential.

Well 14/10-2 was drilled in April and May to a depth of 2,744 m (9,002 ft), and following completion of final logging, was suspended for future testing. The well penetrated what is thought to be a regional seal between 2,250 and 2,374 m (7,382 and 7788 ft) subsea. Based on log analysis, well site evaluation of shows and samples, sidewall cores, and wireline formation testing, all sands encountered beneath the regional seal at this location appear to be charged with oil. No oil/water contacts were encountered.

The top oil sand in Sea Lion was encountered at 2,374 m (7,789 ft) subsea, and the base of the lowest oil sand at 2,591 m (8,500 ft) subsea. Rockhopper estimates the total vertical oil column at 217 m (712 ft), with total net pay of 53 m (174 ft) in seven identified pay zones, the thickest around 30 m (98 ft) gross.

Pressure data suggest there may be two separate oil columns, although this will have to be confirmed by the well test. The main Sea Lion fan has a net pay interval of 34.5 m (113 ft). Other underlying sands have total net pay of around 18 m (59 ft), some of which appears to be connected to a Sea Lion lower fan, which had been regarded as a primary prospect. The well also intersected a further 2 m (6.5 ft) of deeper pay.

Oil down to 2,591 m subsea is 116 m (380 ft) beneath the lowest mapped point of the entire Sea Lion fan, which has an aerial extent of over 45 sq km (17 sq mi). There are seismic indications of thicker reservoir compartments elsewhere in the fan.

Rockhopper believes the well has opened a new play fairway in licenses PL032 and PL033.

The play around the Falklands may be set to expand, too. Desire Petroleum has classified its first well in the North Falkland basin as a gas discovery. The Liz well 14/19-1 reached a TD of 3,667 m (12,031 ft), and is currently being plugged and abandoned.

Initial log interpretation suggests that the well encountered 17 m (56 ft) of net hydrocarbon pay at sub-surface depths between 2,961 and 3,031 m (9,714 and 9,944 ft) within a zone of over-pressured, and chiefly sandstone, reservoir. A hydrocarbon sample and formation pressures were recovered from this interval.

Early analysis indicates wet gas, with no apparent water-leg in this interval. Desire adds that further work will be needed to evaluate reservoir quality, to determine the trapping mechanism, and to assess the discovery's potential.

The well also recovered dry gas in a separate accumulation in a different pressure regime from a deeper interval below 3,400 m (11,155 ft). This suggests that gas pay is present in generally poor quality reservoir. However, there is uncertainty over the rock

type and its reservoir potential.

The Liz fan was encountered between 2,540 and 2,568 m (8,333 and 8,425 ft). Desire says that good oil shows were recorded while drilling, but logging and sampling confirmed that this reservoir interval was tight. The company believes the Beth fan was also penetrated between 2,654 and 2,672 m (8,707 and 8,766 ft), again with oil shows in tight reservoir. Further weak oil shows were recorded in conglomeratic zones between 2,706 and 2,932 m (8,878 and 9,619 ft).

Liz was the first in a multi-well, multi-operator campaign offshore the Falkland Islands using the semisub *Ocean Guardian*. Rockhopper will now drill two wells in the North Falkland basin and BHP one in the East Falkland basin before the rig returns to Desire for further drilling later in the year.

Desire says it will use the next three months to evaluate data from the Liz well. These and the results of the Rockhopper wells should assist planning of future well locations.



## Other Latin America

Tullow Oil has signed a Heads of Agreement with Staatsolie concerning block 47, a 2,369-sq km (915-sq mi) deepwater exploration license offshore **Suriname**.

The signing will allow the two parties to finalize a production sharing contract for the block. Tullow plans to acquire seismic data during 2011 and anticipates drilling wells, as part of its near-term exploration program in the Equatorial Atlantic region of South America. It also has exploration interests offshore **Guyana** and **French Guiana**.

Tullow will operate the license with a 100% interest during the exploration phase. Staatsolie has the option to participate during the development and production phases with a 20% interest.

The Hydrocarbons General Bureau (DGH) of **Peru** has approved BPZ Resources application for extended well testing on the first five oil wells on the Corvina field. The company will continue the tests until first commercial production, currently set for May 31, subject to limits on natural gas flared from each well.

**Trinidad and Tobago** has released the offshore blocks available in its 2010 round of leasing. The tracts are offered under two protocols, one for shallower waters and one for deepwater (1,000 - 3,500 m [3,281 - 11,483 ft]).

The Energy ministry says this year's lease sale is simplified and shortened compared to prior years, has fewer biddable items, focuses on the work program and share of profit offer, reduces upfront costs, and fixes the bid winner's financial obligations. The biggest difference, the government says, is that the tax system was not attractive to bidders and the new system will be more like a production sharing contract.

Follow-up drilling to the late 2009 gas discovery at Perla, offshore **Venezuela**, confirms the discovery as "one of the most significant in recent years and the largest ever in Venezuela," according to Eni. The second shallow water Gulf of Venezuela well, Perla 2, exceeded expectations and has increased Eni's initial reserves estimation by 30%.

Perla 2, in 60 m (198 ft) of water, found 260 m (840 ft) of net pay in a carbonate sequence with good reservoir characteristics. Production testing flowed 50 MMcf/d plus 1,500 b/d of condensate. Eni says normalized production per well should be more than 70 MMcf/d and 2,000 b/d of condensate.

The Cardon IV block is a joint operation of Eni and Repsol, each with 50% interest. Petroles de Venezuela, the state oil company, has 35% back-in rights it can exercise in the development phase.

# Geological similarities with Brazil's pre-salt attract investments to Africa

**Peter Howard Wertheim**
*Contributing Editor*

Available data today, mostly provided by 3D seismic, oil and source rock geochemistry, and 3D basin modeling reveals a close match between the South American and West African margin basins with respect to their pre-salt depositional sequences, including reservoir and source facies of the pre-salt tectono-sedimentary sequences.

This strong similarity allows the predictions of huge discoveries of light oil and gas in the pre-salt sequences of Angola, Namibia, Gabon, and Congo, Marcio Mello, president of the Brazilian Association of Petroleum Geologists and CEO of the recently launched Brazilian company HRT Oil & Gas, told *Offshore* magazine.

"With the support of petroleum system technology, it has been proven that there is an almost perfect similarity (duplication) between all the elements and processes of the petroleum system such as source rocks, reservoirs, seals and traps, and oil types of the pre-salt sequences of Brazil when compared with the pre-salt systems of West Africa," asserts Mello.

However, asymetric rifting has resulted in different subsidence histories, which has, in turn, created major differences in the distributions of oil and gas quality and depth of occurrence. As a result, the Brazilian margin is dominated by Lacustrine black to light oil in the pre-salt sequences. In contrast, West Africa expects a higher amount of light oil/condensate and wet gas. Also, in West Africa the pre-salt reservoirs are found toward higher temperatures and pressures than in its Brazilian counterpart, says Mello.

"What exists in Brazil, exists in Angola, even the rocks containing oil are the same. It's a certainty, not a possibility. Giant deposits will be found there," affirms Mello.

Petrobras geologists believe West Africa's pre-salt geology has many similarities to that of offshore Brazil because, when the single southern subcontinent, dubbed Gondwana began to split into Africa and South America, mirror imaging started.

Since the geological structures in the pre-salt have generally remained unchanged since South America and Africa separated some 165 million years ago, experts say that it is a must to look on the western coast of Africa and the eastern side of Brazil.

Batimetric and magnetometric measures started during the 1940s confirm duplications. During the 1960's consolidation of the plate tectonics theory, data started to accumulate. That continues today along the South Atlantic margin with the technology of 2010.

Some differences between Brazil and Angola do exist. For example, unlike in Brazil, Angola's pre-salt region is found offshore and onshore. Angola's onshore pre-salt is about 4,000 m (13,123 ft) below the ground, while the offshore pre-salt is even deeper.

The common sense is that the salt layer worked as a seal and the geological structures below remained generally unchanged since then. Existing onshore and near-shore pre-salt fields in West Africa provide additional support for the existence of deepwater pre-salt opportunities.

## The HRT/African connection

HRT Oil & Gas was launched last year by Brazilian oilfield consultants HRT Petroleum. The company holds operator stakes in 21 blocks in the onshore Solimões basin in Brazil's Amazonas state.

**Angola block 18/06 partner Petrobras made a discovery on the block last November with Drillship *Petrobras 10000*. The Manganês-01 well, drilled to a depth of 1,500 m (4,921 ft) from the waterline, struck an 82-m (269-ft) column in sandy Miocene reservoirs. Photo courtesy of Banco de Imagens Petrobras.**

Mello, who worked as a geologist in Angola, for three years and for 24 years for Petrobras, recently ventured into international waters, gaining the rights to explore three blocks offshore Namibia.

"The basins off Namibia have been forgotten for decades, being overshadowed by the success offshore Angola. Our recent petroleum system modeling and prospect resource analyses have identified large prospects in three of the studied blocks," says Mello.

"We think there could be more than 5 Bboe in these unrisked prospects with objectives in the Upper Cretaceous turbidite sandstones as well as the syn-rift carbonates and sandstones that are analogous to the Tupi and Jupiter fields in southern Brazil," he adds.


**The South Atlantic joined showing the close ties between the sedimentary basins in Brazil and those of West Africa. Map courtesy of HRT Rio de Janeiro.**

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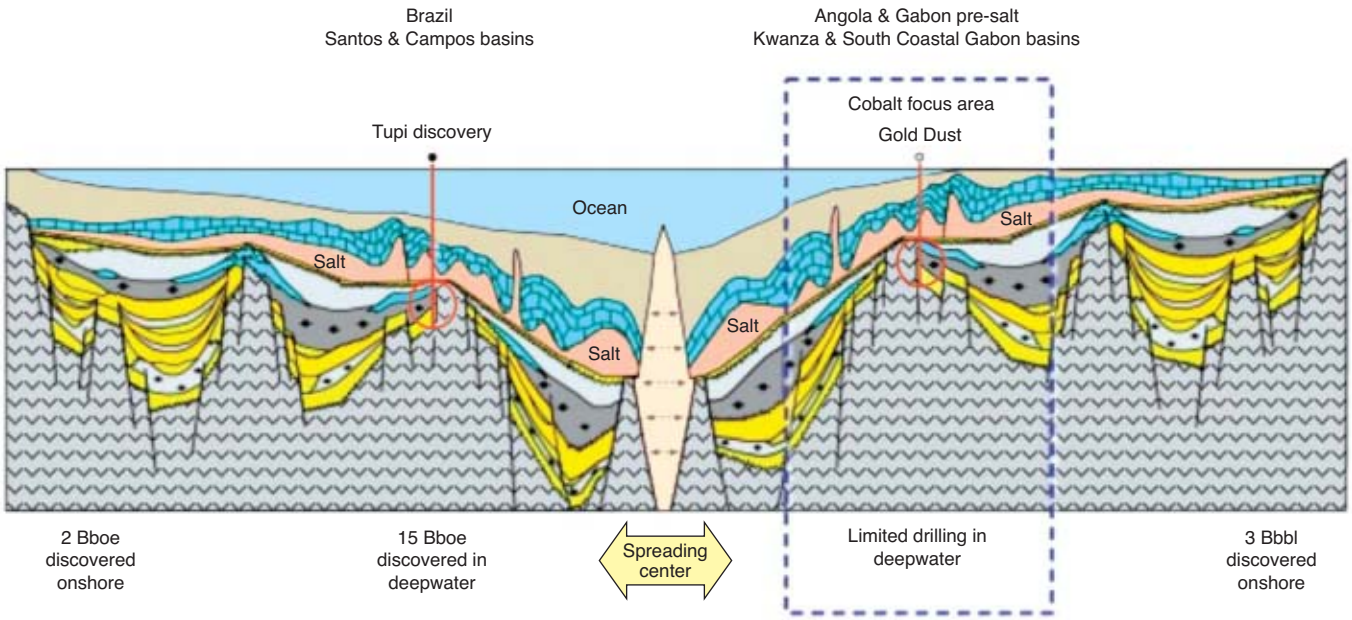


**Brazil (Santos and Campos basins) and on the right side Angola and Gabon pre-salt. Analysis of both the Brazil and West African continents strongly suggest geological features similar to the super-giant Brazilian discoveries also exist in West Africa.**

Under its license agreement, HRT will collect and analyze all existing and historical data for blocks 2713A and 2815 and will source potential farm-in partners.

Block 2713A is owned by Universal's 90% controlled subsidiary Kunene Energy Ltd. Universal Power Corp. has retained HRT Petroleum to do technical analysis on two of its blocks offshore Namibia. Universal currently has a 30% carried interest in block 2815 through Cumoxi Investments Ltd., a 100% owned subsidiary.

Universal Power is an independent oil and gas exploration and development company with broad-based Black Economic Empowerment partnerships. The company currently holds interests in six blocks of offshore concessions covering over 32,000 sq km (12,355 sq mi) in Namibia.

Block 2713A is next to block 2714A owned by Enigma Oil & Gas Ltd. In May of 2009, Petrobras signed a farm-in agreement for a 50% interest in block 2714A. The terms were $16 million cash plus reimbursement of past costs including 3D seismic. The technical work and data room for this project was managed by HRT.

"The special location of both blocks closely associated with the Kudu field and directly related to two very important oil and gas hydrocarbon kitchens located in the southern and western portions of the basin, gives the area a very special geological situation regarding the charge of oil and gas over the structures already envisioned. Based on the current and historical data already analyzed, I am very confident about the oil and gas potential on these blocks," Mello says.

HRT will operate Orange basin blocks 2813A, 2814B, and 2914A with a 40% stake. Universal Power Corp. will have a 40% share, and Acarus Investments will hold the remaining 20%. The blocks are west and southwest of the Kudu region, where a natural gas deposit holding an estimated 1.3 tcf was recently discovered, HRT says.

The concession license calls for three exploratory periods, with the first lasting four years and encompassing 2D and 3D seismic data. Investments for the first exploration period were pegged at $8.5 million.

HRT Oil & Gas plans to spend in both areas, not only to prove its analyses, but more importantly to certify billions of boe and start production before June 2011.

## Sonangol

Sonangol, the national Angolan oil company, recently started preliminary studies into Angola's pre-salt region. Sebastião Gaspar Martins, head of research at Sonangol, says the company plans to drill one or two pre-salt wells by 2012.

During the last months, the company has been preparing for seismic and other geological studies. After being focused on deepwater and ultra deepwater offshore reserves, Sonangol now expects that the pre-salt is Angola's next exploration frontier and to assess the overall situation will require spending in the hundred of millions of dollars range.

Luman Sebastião, a geoscientist for Sonangol's exploration unit, says the pre-salt region in Angola is very large and could hold promising reserves and he also notes that "the Angolan and the Brazilian continental shelves have various similarities, as they have been joined for a certain geological period."

The interest in pre-salt E&P started growing after Petrobras announced several massive oil finds in the pre-salt area off that country's coast that together contain dozens of billions of barrels. Oil found in the area is usually in water depths of around 2,000 m (6,560 ft) and several thousand meters further below layers of sand, rocks, and salt, which makes exploration and production challenging and expensive. Angola's pre-salt reserves could be "gigantic," and even as big as Brazil's, Sebastião says.

Cooperation in this field is growing between Sonangol and Petrobras, at present via the start up of a bilateral study of Angola's pre-salt region. Angola's studies into its pre-salt area at first are concentrating on the Kwanza offshore and onshore basin, and the Congo basin. At a later stage, Angola plans to study more southern regions.

## Petrobras operations in Africa

Petrobras has been buying a lot of acreage offshore Angola, because it can apply its understanding of oilfields offshore Brazil to those offshore Angola.

In an exclusive interview for *Offshore* magazine, Jorge Luiz Zelada, Petrobras international director, presented an overview of the Brazilian company's activities in Africa.

The director pointed out that Petrobras' latest Business Plan calls for investments of $174.4 billion in the 2009-2013 period. In total, $15.9 billion is earmarked for international activities from 2009 to 2013, about 9% of Petrobras' total investments.

Petrobras' fourth biggest international investment, some $900 million for the 2009-2013 period is for Angola. Meanwhile, for the same period, investments planned for Nigeria total $2 billion.

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**Jorge Luiz Zelada, Petrobras international director. Photo courtesy of Banco de Imagens Petrobras.**

At the time of this writing, Petrobras approved its Business Plan for the 2010-2014 period, which calls for total investments of $224 billion, of which 5% ($11.7 billion) will be allocated for international activities.

*Petrobas offshore Angola*. In 1997, Petrobas offshore Angola kicked off its activities, and currently works in six offshore blocks there – it operates three exploratory blocks (18/06, 6/06, and 26) and holds stakes in three others (15/06, 2/85, and 34).

Of these six blocks, one is in production (block 2/85), and the other five are in exploration. Sonangol E.P. is the concessionaire of all Angolan blocks that Petrobras has stakes in.

Petrobas holds a 5% stake in block 15/06, and Eni Angola is the operator. Other partners are Sonangol P&P, SSI Fifteen Ltd., Total, Falcon Oil Holding Angola AS, and Statoil Angola Block 15/06 AS.

Petrobras is the operator of block 18/06, with a 30% stake, and has Sonangol Sinopec International - SSI, Sonangol P&P, Falcon Oil, and the Gema Group as its partners there.

Petrobras also holds 27.5% of the equity stakes in block 2/85, and works with Sonangol P&P (operator), Chevron, Somoil, Polyhedron, and Kotoil in it.

Another Petrobras interest: 30% of the stakes in block 34 where it works with Sonangol P&P (operator) and Statoil.

Petrobras is the operator of block 6/06, located in shallow waters, in with a 40% share. Other partners are Sonangol P&P, Interoil, Falcon Oil, and Initial O&G.

In block 26, also in deep and ultra-deep Kwanza basin waters, Petrobras is the operator with 80% interest and works in partnership with Sonangol P&P.

*In Namibia*, Petrobras has been active since 2009, when it acquired a 50% stake from Chariot to explore block 2714A offshore in the southern part of the country. Chariot's local subsidiary Enigma is the operator of the block.

Covering an area of approximately 5,500 sq km (2,123 sq mi), in waters ranging from 150 to 1,500 m (492 to 4,920 ft) in depth, the block is located between the Orange and Luderitz sub-basins, at an average distance of 80 km (50 mi) off the coast. A 3D seismic program over 2,500 sq km (965 sq mi) has been carried out for the block. The data are being processed and interpreted.

Petrobras says it is committed to undertake geological and geophysical studies that will allow a model to be developed for the area's oil system. The company has the option to drop out of the agreement before drilling any wells. The initial exploration period for the block ends in August 2011.

After completing the data evaluation, Petrobras may elect to renew the contract, which includes the commitment to the exploration program to drill an exploratory well. Enigma will remain the operator of the block until the end of the initial exploration period, and Petrobras may take this position later, if it decides to carry on with the activities in the block in the next phase.

*In Nigeria*, Petrobras started its activities in 1998, in deep Niger River delta waters. The company currently holds interests in three blocks: OML-127 (Agbami) and OML-130 (Akpo), as a non-operator; and OPL 315, as the operator.

The entry into production of the giant fields of Agbami (July 2008) and Akpo (March 2009) turned the country into one of Petrobras' international production highlights.

In block OML-127, Petrobras has a 13% stake. The project was developed in conjunction with Chevron (operator), Statoil, Famfa, and NNPC. The average water depth at the field is 1,400 m (4,593 ft), and the oil that is lifted there is light, at 45 to 49° API.

In block OML 130 where Petrobras holds a 20% interest, the partners are Total (operator), Sapetro, CNOOC, and NNPC. The oil in this field is also light. Water depths range from 1,200 m (3,937 ft) to 1,400 m (4,593 ft).

Production is carried out at both fields by means of an FPSO capable of producing 250,000 b/d of condensate and of storing up to 2 MMbbl.

In March 2009, the conceptual development plan for Egina field, also in block OML 130, was approved by the government of Nigeria. The development phase and production is estimated to start by 2015.

Forty wells and subsea export facilities, in addition to a new FPSO with capacity to produce 200,000 b/d of oil, are expected to be ordered for operations at the Egina field.

Since February 2006, Petrobas has operated block OPL 315. The company holds a 45% stake in partnership with Statoil and Nigerian Ask Petroleum System. Ranging over a total area of 1,006 sq km (388 sq mi) and at water depths ranging from 1,000 m (3,280 ft) to 2,000 m (6,561 ft), the block is under assessment for drilling planned for this year. The block is on the northern boundary of the Niger River delta.

*In Libya*, Petrobras owns a 70% stake in the offshore exploratory block Area 18 as the operator and works in partnership with Australia's Oil Search Ltd.

*In Tanzania*, Petrobras has a 100% interest in offshore exploratory blocks 5 and 6. The local office started operations in 2009, and since then activities have been related to the 3D seismic. This survey will cover a total area of 2,800 sq km (1,081 sq mi).

In Africa, Petrobras produces in Angola and Nigeria. According to the latest production note that was announced, with data for March 2010, Petrobras' production on the continent topped-out at 57,444 boe/d, which corresponds to 24% of the company's total international production.

## Other companies in Africa

US independent Cobalt International Energy, Chevron, Anadarko, ExxonMobil, Shell, TOTAL, Maersk Oil, BG Group, Chinese National Offshore Oil Co. (CNOOC), BP, and Petronas, are other companies attracted to offshore West Africa.

By early 2011, Cobalt intends to drill subsalt wells in Angola. At the turn of the year the company raised $1 billion – the largest ever US IPO for an exploration and production company – partly on hopes they will contain reservoirs similar to those found in Brazil.

As it drills farther out in the sea and deeper down, Chevron is inspired by a model 5,000 km (3,107 mi) across the Atlantic Ocean to the coast of South America and particularly Brazil for guidance, say Chevron sources.

Maersk Oil has finalized the appraisal well Chissonga-2 off Angola which was drilled down dip of the Chissonga-1 discovery well in block 16 in 1,355 m (4,445 ft) water depth. The well was drilled to TD of 6,052 m (19,855 ft). One production test was conducted in turbidites of Oligocene age, flowing 6,650 b/d of 36° API oil on a 36/64 in.-choke. Wells will most likely be required to reduce the remaining uncertainties before commerciality can be determined, says the company.

A six-month licensing round from May 2010 to November will offer blocks from two Gabon deepwater basins: Zone Sud, where the targets are pre-salt, and Zone Nord, containing both pre- and sub-salt targets.

Gabon, which was largely ignored, is now showing big potential in the pre-salt section. Much work has been done on source rocks and oil types from both margins of the South Atlantic Ocean, and published work indicates that direct comparisons can be made to pair basins such as the Sergipe basin in the northeastern Sergipe state of Brazil with the North Gabon basin and the Reconcavo basin in Bahia, Brazil, with the South Gabon and Congo basins. However, it is unknown how far offshore the pre-salt reservoir extends.

In Gabon's onshore and shelf blocks, the pre-salt section has been drilled and discoveries have been made, proving a pre-salt petroleum system is present.

# Time-depth imaging offshore India

**Roberto Fainstein**
**Stephen F. Traylen**
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**Alexander Zarkhidze**
**Antonio Stempel**
*WesternGeco*

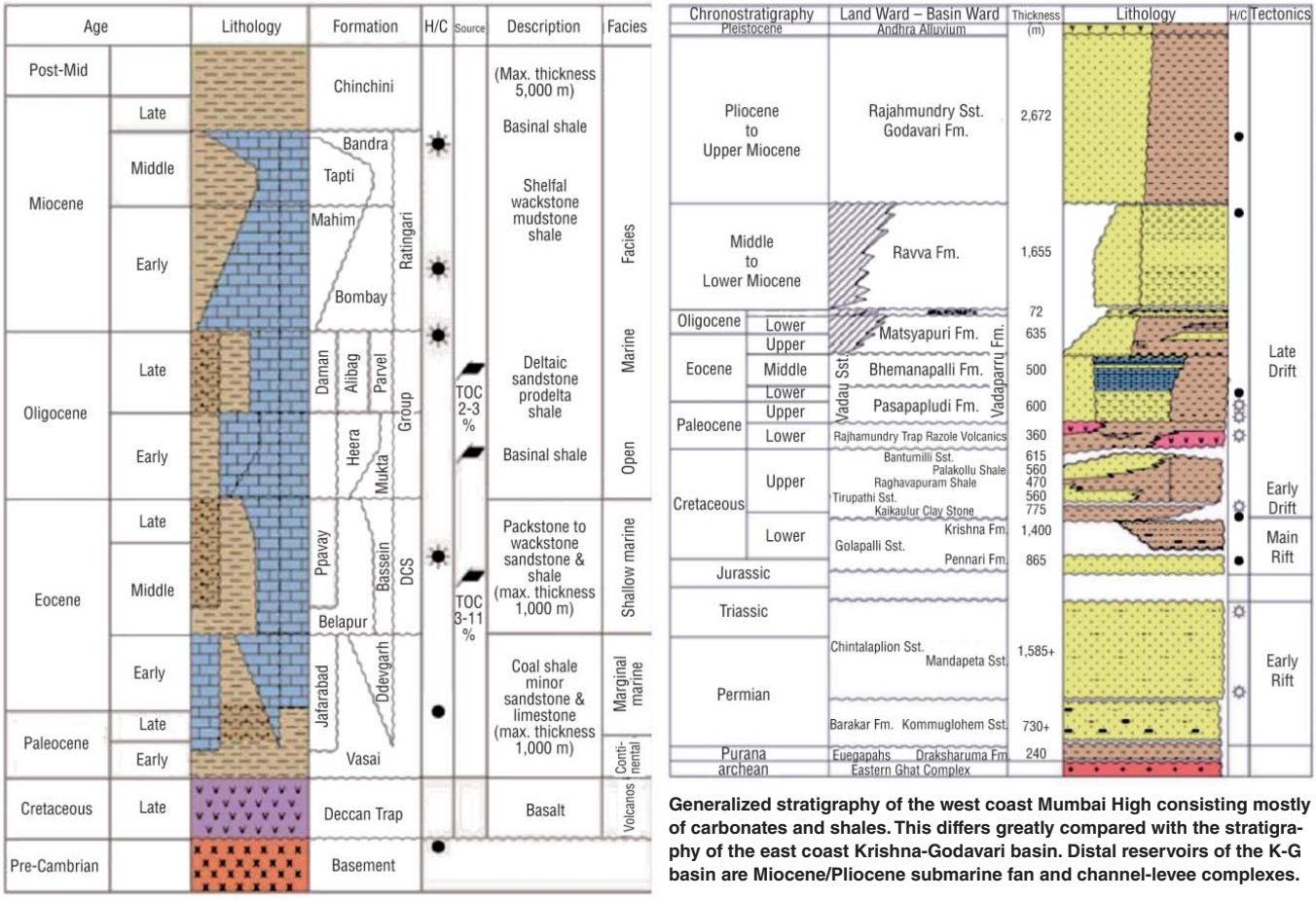
Prestack depth migration (PSDM) projects of regional lines and 3D surveys have a major impact on exploration and development projects offshore India because the technique can reduce risks. PSDM can handle complex structures and rapid vertical and lateral changes in the velocity field, so the resulting images can enhance interpretations compared to those based on the time processing results alone.

Depth imaging (PSDM) displays several advantages compared to time imaging, and anisotropic depth imaging improves isotropic depth imaging. The gathers are flatter, fault paths and displacements are focused, and misties are minimized. Anisotropic updates improve the lateral data resolution through better analyses of gathers, and depth images better resolve the structure and stratigraphy compared to time images. Horizontal projections of time-slices clearly show the geometrical differences between mapping in depth versus mapping in time. For the purpose of seismic interpretation the velocity model derived from this method provides better confidence on the structural dynamics of the seismic section. It must be stressed however that data input to migration processing always needs be performed with full aperture coverage.

Anisotropic depth migration reduces inherent distortions of isotropic depth migration particularly on complex structuring, resulting in improved imaging of faults and of deeper horizons and for allowing the depth section to be tied correctly to well data. This technique has been used extensively in offshore India to reduce exploration and development risk in these complex structures.

Optimally, input to PSDM is time pre-processed seismic data and unsmoothed final velocities either from NMO/DMO (normal moveout and dip moveout) legacy stacks or from a contemporaneous Prestack Time Migration (PSTM) workflow. These velocities are then converted to interval velocity in depth and subsequently smoothed. The initial velocity model is built using these velocities. The depth imaging workflow consists of multiple iterations of PSDM and reflection tomography-based velocity analysis of residual moveout on common image point gathers (CIP gathers) with final calibration to well data.

Data is from modern marine 3D Q-surveys conducted with long spreads. These, together with new technologies employed in data processing, have brought remarkable improvements in imaging resolution of the key components of deepwater petroleum systems. Interpretive comparisons have been made for time-depth migrations over deepwater turbidite reservoirs of the Krishna-




**Generalized stratigraphy of the west coast Mumbai High consisting mostly of carbonates and shales. This differs greatly compared with the stratigraphy of the east coast Krishna-Godavari basin. Distal reservoirs of the K-G basin are Miocene/Pliocene submarine fan and channel-levee complexes.**

Godavari, Cauvery, and Mahanadi basins off the east coast of India and further east off the Andaman–Nicobar islands. Additional comparisons have been made off the west coast in the shallow water carbonates of the Mumbai Offshore Province and in the Kerala-Konkan basin in deeper waters. The latter is a frontier area were the aim is visualization of the Mesozoic strata buried under the late Cretaceous flood basalts of the Deccan Traps.

## Offshore discoveries

Currently three of the hydrocarbon basins produce: the Mumbai offshore basin off the west coast, and the Cauvery and Krishna-Godavari basins off the east coast. In addition, there are deepwater discoveries being evaluated in the K-G, Cauvery, Mahanadi, and Bengali basins in the east coast and attractive prospects in the Andaman Sea.

The stratigraphic columns of the east coast basins are strikingly similar, with successive sequences of open marine clastics laid down during the Upper Cretaceous, Tertiary, and Plio-Pleistocene. The west coast basins differ because carbonates predominate. The stratigraphy of continental margin basins reflects the evolutionary phases of subcontinental migration and marginal basin accretionary processes during India's continental drift.

In the east coast, abundant sedimentation occurred after the Eocene with thick sediment wedges in the Oligocene essentially partitioning the deeper water realm from the associated sediments onshore. The basins generally are broad drape anticlines. Most structures along the eastern continental margin of India consist of rotated seaward-tilted faulted blocks with anticline and roll-over features formed in association with block-bounding listric faults.

The west coast carbonates were deposited in several pulses of marine transgression associated with vertical uplift of the basins. The typical seismic section off the west coast differs sharply from the east coast types due to the distinct phases of sediment accumulation in the Arabian Sea.

## Processing overview

As mentioned, the best input to PSDM is pre-processed seismic data and unsmoothed final velocities from NMO/DMO legacy stacks or from a contemporaneous PSTM workflow. These velocities are converted to interval velocity in depth and subsequently smoothed. The initial velocity model is built using these velocities. The depth imaging workflow consists of multiple iterations of PSDM and reflection tomography based velocity analysis of residual moveout on common image point gathers (CIP gathers) with final calibration to well data.

Once the final velocity model is built and CIP gathers are flat at the correct depth, the full isotropic depth migration is run. If there are indications of anisotropy, the anisotropic parameters are estimated and propagated through the velocity model during model building for a final anisotropic migration. Interpretation mapping of the PSTM/PSDM paired images provides for new enhanced domain with 3D structure and stratigraphic features correctly placed in depth and adding new parameters to visualize deepwater drilling.

## Tomography workflow

Grid-based CIP tomography uses all the primaries at all horizons (Schulz and Canales, 1997). This can handle non-hyperbolic events, mainly velocity anisotropy. The tomography workflow begins with a velocity model derived from the stacking velocities obtained from the PSTM processing. First, an accurate water depth is picked on the PSTM stack converted to depth. The final RMS velocity is converted to interval velocity in depth and is smoothed to build the velocity model. If the gathers are flat, the velocity model is inherently correct and gives rise to the initial PSDM section. However, gathers usually are not flat so further iterations are necessary to correct the residual move-out.

This requires selected residual non-hyperbolic events to be input to 3D-ray-traced linear tomography equations; the solution represents the velocity model update for the iteration under consideration. This is followed by another PSDM step using the new, updated velocity model.

The initial iterations of CIP-tomography are parameterized such that velocity updates are done using large-scale lengths. Choice of scale length depends on lateral and vertical (anisotropic) velocity variations. As the velocity model improves through successive iterations, progressively smaller scale lengths resolve the finer details in the velocity field.

## Anisotropy estimation

From the initial velocity model, up to four isotropic iterations are run. Anisotropic coefficients, Epsilon and Delta, can be calculated using the time-depth curve from well data (Ball, 1995; Kirtland Grech et al., 2001). Vertical transverse isotropy (VTI), also called polar anisotropy, is caused by sedimentary layering, whereas intrinsic anisotropy is due to clay particle alignments (shale) during deposition. In anisotropic media, compression wave seismic migration velocity changes with the angle of propagation, as given by the Thomsen equation.

$$V_p(\theta) = V_v(1+\delta \sin 2\theta \cos 2\theta + \varepsilon \sin 4\theta)$$

The isotropic gathers indicate the peak event flattens but it doesn't tie to the top-carbonate depth marker in the well; the trough event also flattens but does not tie to the top-reservoir depth marker in the well. After correcting for anisotropy, the events flatten and the peak ties to the depth of the top of the carbonate marker in the well and the trough ties to the top of the reservoir in the well. Anisotropic updates are run to develop a final velocity model, which is then converted to the final anisotropic PSDM section.

## PSTM vs. PSDM

Although interpretation is still conducted on time sections, the inherent distortions these bring need to be understood. In time migration (post-stack or pre-stack) the velocity profile is retrieved at the CMP and the program either computes the travel time via the DSR equation (straight ray) or ray traces through the local model (curved ray). No lateral velocity changes are discerned; the ray path is always symmetric for a flat event (1D velocity model). Upon depth migration, a full travel-time table is built externally. The travel-time generator program comprehends velocity changes both vertically and laterally. The migration program retrieves the travel-time from the table to move the sample. The ray path can be nonsymmetric even for a flat reflector (3D velocity model).

## Post-migration processing

One historical paradigm is the interpretation of volumes of data exclusively in time section. This view is changing and geophysics is entering a new phase in which interpreters tend towards exclusive use of depth sections.

Post-migration processing consists of the following steps:

1) Sort the migrated offsets to CMP
2) Convert to time
3) Run a residual multiple attenuation filter with Hi-Res Radon
4) Conduct primal, inverse Q, outside mute
5) SRAC, TVF, RAAC processing.

This results in the APSDM stack. This section then gets spectral whitening frequency enhancement and time variant filtering. At this point the newly obtained APSDM is final. The example indicates the improvement in the imaging of the Tertiary strata above basalt flood and of the Mesozoic strata under the basalt off the west coast of India.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# New opportunities, new standards with dual-sensor streamer

**Andrew Long**
*PGS*

An increasing catalogue of case studies demonstrates that the dual-sensor Geo Streamer enables more accurate reservoir description, and, reduces the dependence on well log data. This goes beyond the well-known survey efficiency, signal penetration, and resolution improvements.

The much broader frequency bandwidth of the target signal at all depths enables a cascading series of benefits. Attenuation in the earth is better understood, enabling more robust wavelet extraction at the target. In addition to greater high frequency signal resolution, the low frequency signal is stronger. This translates to a reduced dependency upon well log data to constrain the low frequency model of the earth, and improve our ability to characterize rock and fluid properties directly from the GeoStreamer data alone. Furthermore, advanced methods such as full-waveform inversion (FWI) to build accurate velocity models for depth imaging also benefits from stronger frequencies below 5 Hz, and allows better resolution and description of reservoir properties. Finally, recent reservoir monitoring ("4D") experience also demonstrates the flexibility and power of dual-sensor data processing for achieving very high levels of target signal repeatability.

By the end of February 2010, PGS' dual-sensor GeoStreamer had been in 3D operation for just over a year, and in 2D operation for two and a half years. More than 10,000 sq km (3,861 sq mi) of 3D had been acquired worldwide, and more than 100,000 line km (38,610 mi) of 2D in a variety of geologies and geographies. In all cases, the data and operational benefits have been clear. But the real benefits for characterizing reservoir properties and structure are just beginning to be seen.

The seismic results delivered by dual-sensor acquisition and processing benefit from improved low- and high-frequency amplitudes, delivered with a low noise floor over the entire bandwidth. This low noise level occurs because the GeoStreamer usually is towed 15 to 25 m (49 to 82 ft); deeper than conventional streamers. While conventional (hydrophone-only) streamers towed deep would be strong in low frequencies, they would be very weak in mid and high frequencies. In contrast, the dual-sensor is strong in both. This difference is because the effects of the receiver ghost can be removed by dual acquisition and processing. The high frequency content is greater than even if a conventional streamer was towed shallow, but does not suffer from the surface-related noise problems.

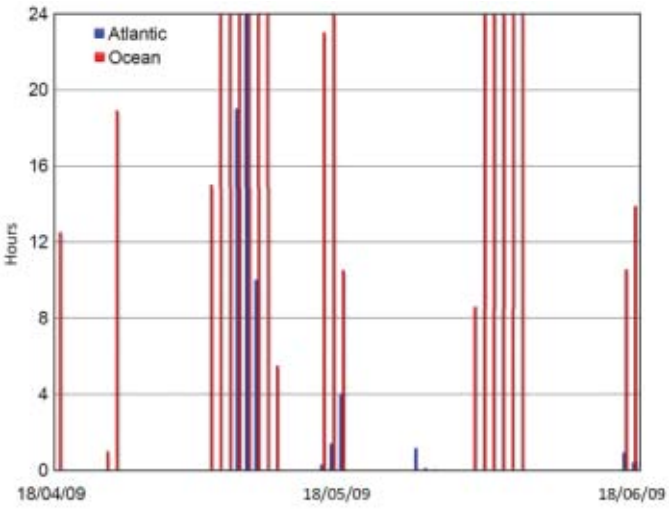
Operationally, deep towing has advantages. Where sea surface and environmental forces cause operational downtime for conventional streamers towed shallow, deeper tow operations often can continue.

## Opening new regions

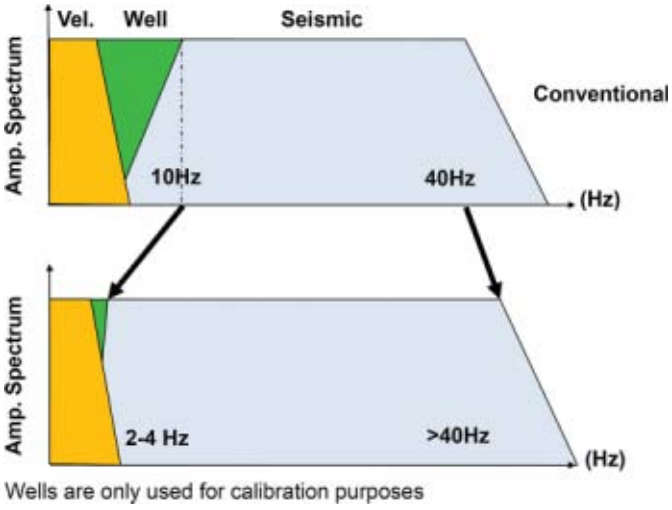
Undiscovered oil and gas are believed to occur beneath the Arctic and other regions that are accessible only with conventional streamers for short periods each year. Even then, operations are sporadic. A recent example from the North Sea (Osnes et al., 2010) shows that adjacent six streamer operations yielded entirely different weather-related downtime. The conventional streamer experienced 24% downtime, whereas the GeoStreamer experienced 4% downtime through the same two months. This performance advantage becomes relevant in harsh environments such as the Arctic, where seasonal acquisition windows are short. Experience also demonstrates that GeoStreamer operations are less affected by seismic interference.

## More bandwidth, more control

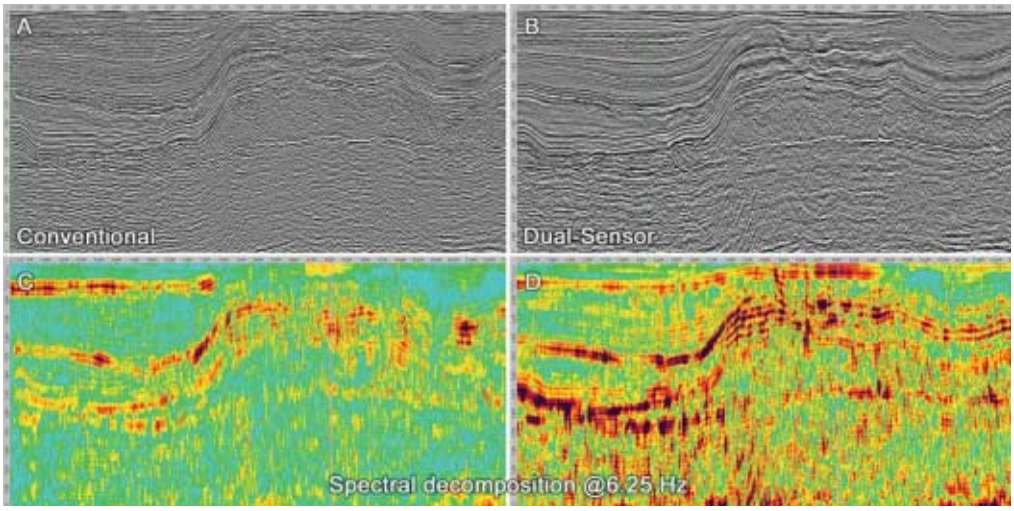
Historically, the effects of the receiver ghost on high frequencies could be addressed only by deterministic processing methods such as spectral shaping and corrections for earth attenuation such as "Q compensation." In all cases, signal-to-noise content is unacceptably




**Weather downtime statistics (hours per day) for two vessels operating in close proximity between April 15 and June 19, 2009. Red bars: vessel with conventional streamers towed at 8 m depth; blue bars: vessel with dual-sensor GeoStreamers towed at 15 m depth. From Osnes et al. (2010).**




**Schematic amplitude spectra for conventional and dual-sensor streamer data. The extended bandwidth of the dual-sensor streamer data has a significant effect on the low end of the amplitude spectrum, and typically also has more content at the high end of the spectrum. From Reiser and Ribeiro (2010).**




**Dutch sector 2D lines for conventional streamer vs. dual-sensor data. A:, conventional seismic; B, dual-sensor seismic. C and D illustrate the spectral decomposition for conventional and dual-sensor streamer data at 6.25 Hz. The warm color indicates high energy, and cold color indicates low energy in the seismic data at this frequency. From Reiser and Ribeiro (2010).**

damaged near the receiver ghost notches, as noise typically is boosted more than signal (Tabti et al., 2009). In contrast, dual-sensor processing removes the notches in the frequency spectrum without affecting noise, and provides a much larger frequency bandwidth that can be used for subsequent seismic interpretation and reservoir characterization.

In Vigner et al. (2010), the noise floor in the data dictated that conventional streamer processing only could recover useful target frequencies up to 55 Hz, whereas dual-sensor processing could recover useful target frequencies up to 85 Hz. In other words dual-sensor data delivered a 55% resolution improvement. This is likely to directly impact the quality of interpretation. Better control of both low- and high-frequency signal improved the estimation of the quality factor, Q, which describes the rate of attenuation in the earth. Conventional streamer data delivered a Q estimate of 134, whereas dual-sensor data delivered a Q estimate of 178. This difference affects the stability of the wavelet extracted during seismic inversion used for estimating rock and fluid properties.

Exploration focus is moving towards complex reservoirs containing thin stratigraphic layers, often complicated by internal reservoir flow barriers and faulting. Detailed reservoir characterization studies require broader frequency bandwidth, particularly at the low frequency end. As schematically represented on page 54, frequencies below 10 Hz that are necessary for quantitatively accurate inversion must be derived from well log data, if available, as they are absent on conventional streamer data. In contrast, dual-sensor data contains stronger low frequencies, and thus seismic inversion has less dependence upon well data calibration.

Reiser and Ribeiro (2010) demonstrate an Australian example where the amplitudes of target signal at 4 Hz are 6 dB stronger on GeoStreamer data than conventional streamer data in the same location. This resulted in better resolution and delineation of the gas-water contact of a giant gas field, and better resolution of internal reservoir stratigraphic layering (see below). In another example from the Dutch sector of the North Sea, a spectral decomposition example reinforces the significantly better signal content at only 6.25 Hz.

The benefits of GeoStreamer low frequency data also translate to improved reservoir characterization, through better full-waveform inversion (FWI). This is a high-end technology used to derive accurate velocity models for depth imaging, and, ultimately, to constrain density models of the reservoir. As described in Kelly et al. (2010), FWI theoretically can resolve smaller heterogeneities than the ray theory (i.e. conventional tomographic-based solutions to velocity model building), but only if very low frequencies (less than 5 Hz) are available in the seismic data. This may seem to be a paradox, but demonstrates that both low- and high-frequency signal are necessary for high resolution reservoir characterization.

Kelly et al. (2010) achieved a high resolution velocity model inversion from the combination of high signal-to-noise ratio across a broad frequency bandwidth and strong low frequency signal content present within GeoStreamer data from offshore Cyprus. The ability to flatten pre-stack image gathers across a larger range of offsets translates to higher resolution imaging, particularly at depths. As discussed earlier, this will also be complemented by better reservoir characterization of rock and fluid properties.

## Monitoring the past, constructing the future

There are opportunities for 4D. A full-scale, time-lapse 3D experiment in the North Sea during 2009 demonstrates non-repeatable seismic noise of 11%, despite quite different survey line geometry and tidal conditions (Day et al., 2010). Unique to dual-sensor streamer processing is the ability to reconstruct the seismic image at any effective receiver depth and the ability to identify and correct for errors in receiver depths along the streamer, if they occur (Söllner et al., 2008). It is possible to precisely match a 4D baseline survey acquired with conventional streamers and a 4D monitor survey acquired with dual-sensor streamers at different towing depths. In this scenario it is necessary to process the streamer data to preserve the effects of the receiver ghost, thus matching the baseline survey. Ideally, both the baseline and monitor surveys will be acquired with GeoStreamers, allowing high survey repeatability to be complemented by higher target resolution.

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# Advances in visualization support innovative interpretation

**Philip Neri**
*Paradigm*

The world of volume interpretation and visualization is evolving with the advent of a new parameter that exceeds the capabilities of traditional systems. While it has been possible to visualize pre-stack data for some time with some ingenious adaptations of a full multi-attribute 3D viewer, the azimuth component demands specific viewing techniques, as well as the support of tools such as illumination ray path features and attributes volumes. Together, they deliver a better view of a reservoir under a complex anisotropic overburden.

Visualization technologies have come a long way since the first 3D voxels started showing novel concepts such as transparency and sculpting on computer screens about 15 years ago. The evolution has followed two trends: One, handling ever-increasing amounts of data; two, enriching the visualization process with a larger number of data types and rendering of specific data objects.

In terms of simply viewing data, the possibility emerged in 2003 to use disk cache instead of live memory to store large data objects such as seismic, making it possible to view datasets many times larger than the physical memory of the computer. This led to the use of 3D display and interpretation tools within routine workflows, while leaving high-end capabilities such as automated sub-volume detection to the dedicated visualization tools which worked only on data in live computer memory.

More recently, the performance of input/output devices has improved dramatically, in parallel with a significant increase in the computer's own internal bus speed and its improved data handling architecture. This opens the way to many capabilities once only possible from computer memory to become a realistic proposition for working on data residing mostly on disk. While this does not imply there is no need for dedicated voxel visualization tools, some key capabilities are emerging.

One of them is the application of transparency capabilities to 2D seismic surveys. This allows the geoscientist to line up a succession of 2D profiles and move the display around in three dimensions while looking for a preferential direction along which sometimes elusive features may come to the fore. Known as optical stacking, this eliminates tedious back-and-forth workflows to verify assumptions regarding a fault's direction and development. This is particularly relevant to 2D seismic profiles, where ambiguities are more frequent due to the nature and limitations of the data and of sections, as opposed to 3D migrated volumes.

## The age of pre-stack

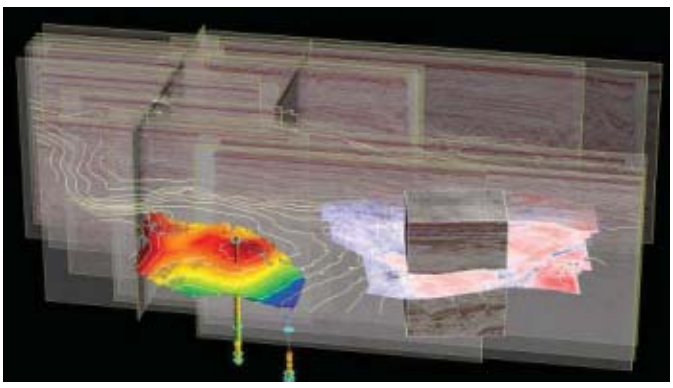
In terms of real change, however, the growth of interest in pre-stack seismic data puts pressure on visualization tools to help interpreters manipulate not only large amounts of data, but also data objects that are not part of the post-stack x-y-time or x-y-depth coordinate system. This demand for visual access to pre-stack versions of the stacked image volume stems from the challenges of investigating very detailed and intricate features in the process of qualifying and characterizing the subsurface.

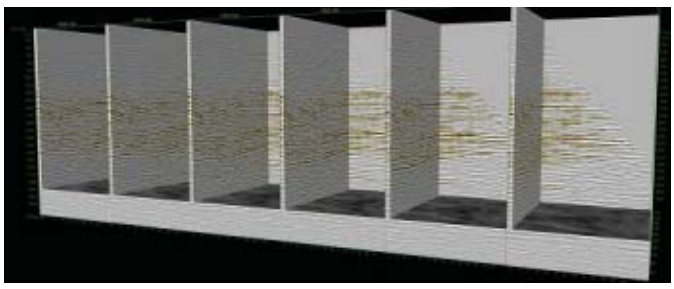
In the field of Amplitude Versus Offset (AVO), for a long time interpretation of such anomalies used 3D volumes of an attribute of the AVO effect, such as the AVO gradient, a value calculated for each point which assesses the variation in amplitude over a range of offsets. Such attribute volumes were more readily useable for interpreters, and they avoided the need to have pre-stack data accessible directly to the interpretation software. Often oil and gas operators do not have even access to pre-stack data, for example licenses to non-proprietary seismic data sets, so the availability of attribute volumes representing characteristics of the pre-stack data is acceptable. Amplitude Versus Angle (AVA) attributes are designed to extract elastic properties from the seismic data based on the Zoeppritz equation. In modern systems, it is good to co-visualize post stack data, pre-stack data, and AVA attributes, as AVA pitfalls are many.

Pre-stack data is stored mostly in an object generically described as a gather. This terminology denotes that all the traces are combined (stacked) into a single trace. That single trace is one of the constituent elements of either a 2D profile or a 3D volume. A common way to visualize pre-stack data for a single section or traverse within a 3D seismic survey has been to display the gathers along the y-axis of a 3D volume, with the x-axis representing each trace. This is not new; it has been practiced since the very early days of interpretation workstation technology, albeit with some background manipulation of data.

## Azimuth added to attributes

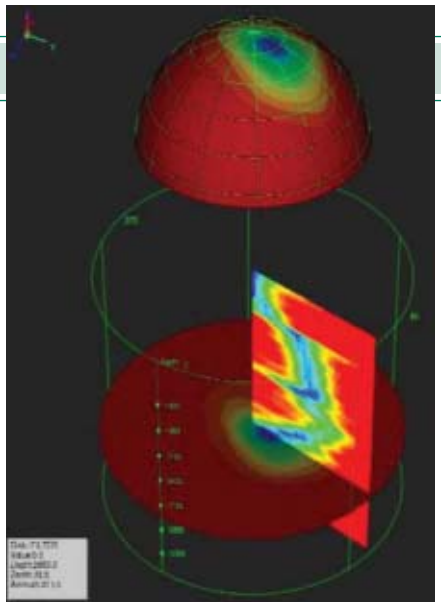
The advent of voxel visualization added investigative possibilities to these pre-stack volumes. What stimulates further development and a more formal data environment is the advent of additional attributes associated with pre-stack data samples, notably azimuth. A gather has to embody a data parameter if it is to organize the traces in some order. Typically, this has been the offset, i.e. the distance from

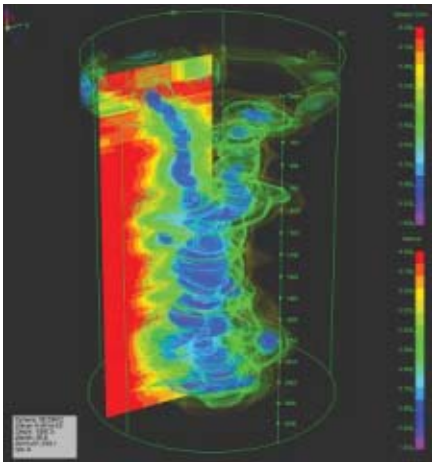


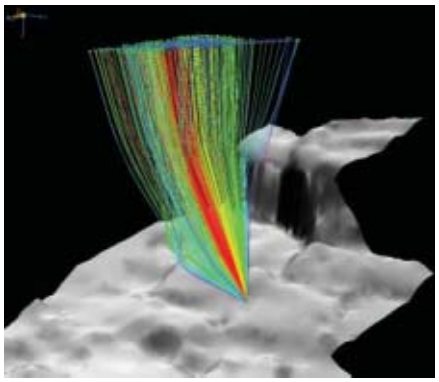


**(Left) 2D seismic survey displayed with transparency.**

**(Right) Pre-stack data displayed for a series of profiles, each expended into the offset domain.**







(Top left) Pre-stack, full-azimuth gather view.

(Bottom left) Pre-stack, full-azimuth gather in a sculpted view.

(Above) Illumination of a point on the surface.

shot to receiver for each particular trace.

Target-based migration has introduced reflector angle as the sequencing parameter for gathers. However, by representing gathers of either type as a planar section, there is an implicit assumption that all the traces in the gather occurred in the same vertical plane. This is true mostly for 2D data, where the source and the receivers follow an identical and mostly rectilinear path. For 3D data and in modern offshore multi-streamer or onshore multi-swath acquisition patterns, there is a strong directional component to the energy which contributes to a gather. What began as a byproduct of larger and wider source-receiver patterns aimed mostly at cost-effective and high-productivity data acquisition, has become critical to the need to model and measure anisotropy where it exists.

Today, in many high-profile hydrocarbon plays, energy companies are ordering rich azimuth data, which entails the use of field acquisition geometries that optimize the spread of different source-receiver azimuth directions for the areas and depths of interest. Papers have been written about ways to plan, acquire, and process rich azimuth data. This article concentrates on the outcome, i.e. gathers where each trace is organized not only by reflector angle, but also with an azimuth component.

## 'Natural' display

The challenge is to develop a visual tool that naturally displays the information to the geoscientists, and allows them to understand what has become information-rich data. They need it to relate to the 3D volumes of processed data which they use to interpret the stratigraphic and structural elements of the subsurface, and to infer the characteristics of individual formations and reservoirs with the help of pre-stack information.

This new viewing tool uses the same visualization components as the traditional interpretation canvas; the novelty is the projection coordinate system. It consists of a cylinder, where the vertical dimension is depth, and the central axis carries the value zero for reflector angle. Points away from this axis are defined by angle and azimuth (0° to 360°), and their position on the vertical axis.

Where the background velocity is correct, any given reflector appears flat for all angles and all azimuths. The case of an asymmetric, non-flattened seismic event indicates velocity variations stemming from a higher level of heterogeneity and azimuthal anisotropy effects. This level of information becomes increasingly important as propagating seismic energy to deep targets under complex overburdens becomes more challenging.

The use of the cylindrical offset viewer is similar to a traditional voxel visualization tool, except for the circular reference system. Transparency, sculpting, and other methods can be applied to seek and to highlight events of a certain type or level of energy. A horizontal, circular slice tool can be moved up and down to see the whole value range in a transparent view. A vertical panel centered around the zero axis can be rotated around the 360° circle to see data projected onto it.

The slice or disk view is of particular interest to visualize complex illumination situations in an anisotropic environment. However, since the eye does not readily interpret an angle in a planar view, the viewer has an additional display space above the cylinder view that is shaped as a half-sphere or dome. As the slice tool slides up and down the vertical axis, the same data is projected into the dome, with the higher-angled data on the steeper flanks of the dome and the small angles close to the summit of the dome near the apex. This is visually more approachable and makes it easier to relate to effective angles.

One can obtain a detailed view of the constituent energies of any stack volume trace by clicking on it and activating the cylindrical viewer for full and interactive access to the original data. Once anomalous events are noted, the challenge is to understand their origin and to validate that they relate to overburden anisotropy or other verifiable particularities of the subsurface, and are not the result of processing or modeling error. The best verification is to visualize the actual assumed ray path that the seismic energy would have followed from the source to the target and back to the receiver.

Ray path viewing becomes necessary to the overall visualization, interpretation, and modeling workflow. The illumination function is not only operational, but also is linked to the pre-stack data viewer to make it possible to highlight a particular ray path or ray paths associated with a specific point in the subsurface.

## Closing the loop

This closes the loop for the geoscientist: to investigate a crucial area of the subsurface, he uses a pointer tool to activate the pre-stack full azimuth viewer, and in the event of an indication of potential anisotropy or other preferred azimuth, can then see the ray paths that illuminate the area of interest on the current subsurface model.

This workflow is far from trivial, especially in the context of a large survey for which it is difficult to allocate the time and resources for all these checks. A number of derivative data volumes can help high-grade a dataset to focus on the areas with an azimuth-related risk to the prospect ranking and subsequent drilling activities. Azimuth gradients are an obvious candidate, but beyond such computations a more valuable indicator takes the form of a reliability attribute. This evaluates the complexity of the illumination of each point in the volume, and highlights areas of little or no zero-angle energy. Such areas, once brought to the geoscientist's attention, should be investigated with the workflow established for pre-stack azimuth anomalies.

These new tools are at today's technology frontier. It will be interesting to see how quickly they become a ubiquitous solution for routine activities.

# Rig deliveries outpace demand, new orders fall

*Increasing supply puts downward pressure on day rates*

**Thomas E. Marsh**
*ODS-Petrodata*

New mobile offshore drilling rigs are being delivered into a market ill-suited at present to absorb new capacity, and some rigs are being delivered with no work prospects in hand. In conjunction, new rig orders have fallen dramatically over the past year, according to data compiled by ODS-Petrodata.

## New rigs without contracts

In January 2006, the global offshore drilling fleet included 590 mobile rigs, and deliveries in the most recent new rig construction cycle were beginning in earnest. The fleet increased in size more or less steadily as shown in Figure 1 and as of May 2010, 703 mobile offshore drilling rigs were in existence, representing a 19% increase in the fleet size. The increase in fleet size will continue, as 126 new offshore rigs are still under construction, most for delivery by the end of 2012. As a result, many segments of the offshore rig market may be over-supplied.

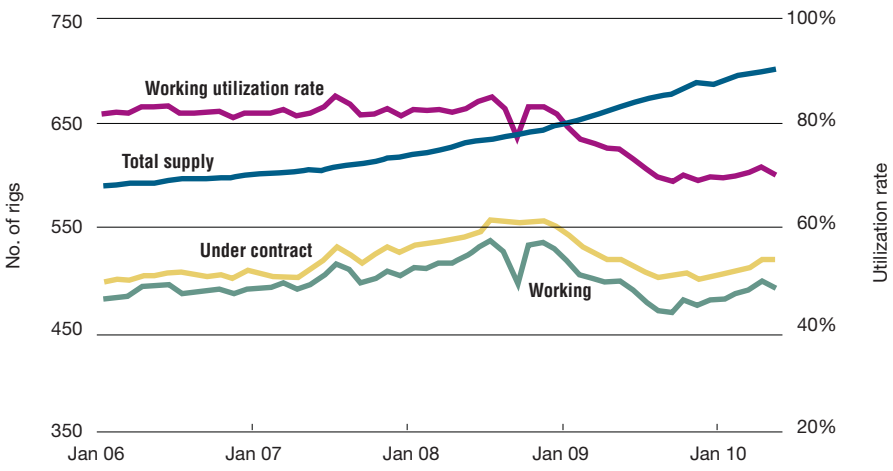
The soft demand situation in the global rig market as a whole is creating problems for owners of some new rigs. Of the 63 new mobile offshore drilling units delivered since January 2009, 17 entered the fleet without their owners having firm contract commitments in hand. All 17 have since landed contract commitments, although not all are actually working yet.

More uncommitted supply overhangs the market. Of the 126 offshore rigs that are under construction, 67 do not have firm contract commitments as of May 2010. These include 39 jackups, 12 semisubmersibles, 15 drillships, and one drilling tender.

## The end of the boom

As had been expected, the number and value of new rig orders fell dramatically in 2009 compared to the four preceding years when the new rig construction boom was in full

**Figure 1. Worldwide MODU supply & demand 2006-2010 YTD**




Source: ODS-Petrodata Consulting & Research

**Figure 2. Estimated total value of MODU orders 2001-2010 YTD**

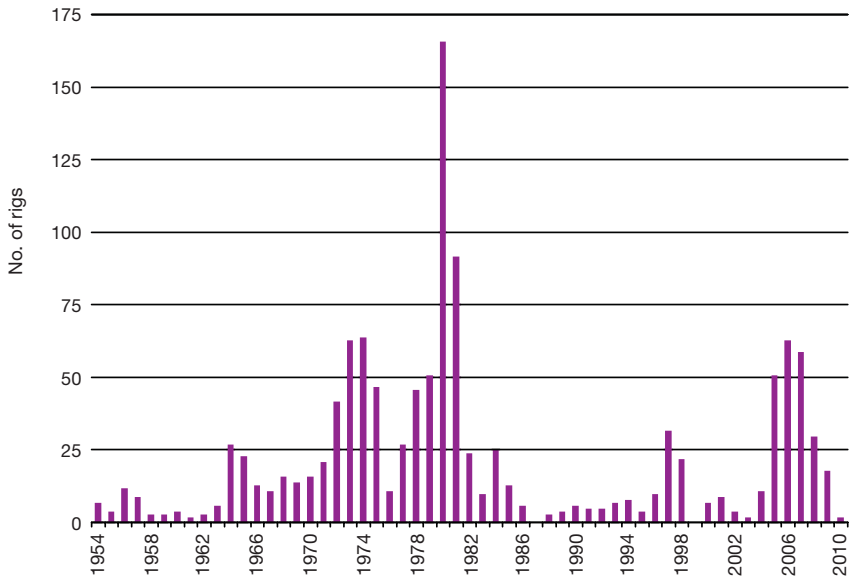

Source: ODS-Petrodata RigBase

swing (Figures 2 and 3). In 2008, 57 offshore drilling rigs were ordered at an estimated cost of $26.2 billion. In 2009, 18 rigs were ordered at an estimated cost of $4.1 billion.

New offshore rig orders to date in 2010 are running at a slower pace than 2009, with only two ordered as of May at an estimated cost of $837 million. One of these units, a semisubmersible, is being built at an estimated cost of $700 million, accounting for the bulk of the value in the rigs ordered so far in 2010.

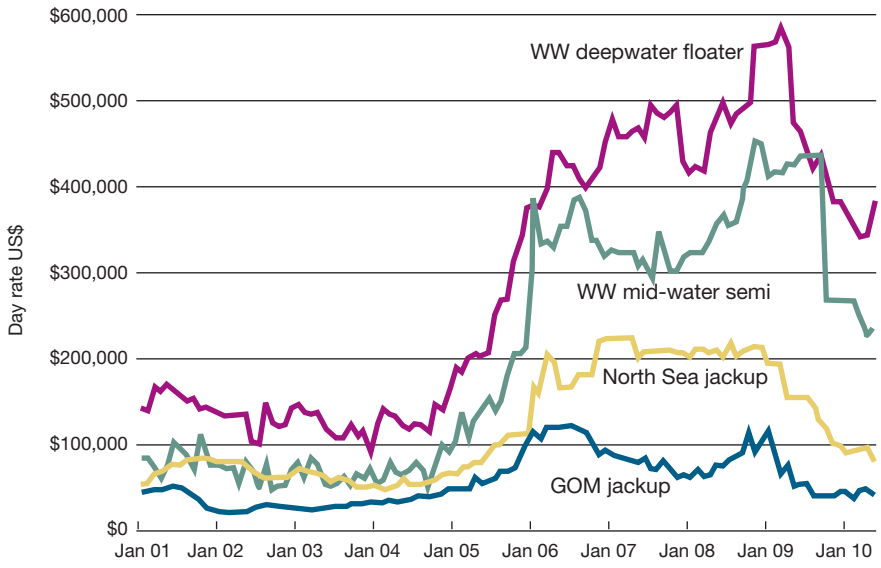
With prospects slim for significant numbers of additional rig orders, shipyard owners may look back on the mid-2000s with longing: The estimated total value of the mobile offshore drilling units ordered between 2005 and 2008 approaches $85 billion.

**Figure 3. MODU orders 1954-2010 YTD**




Source: ODS-Petrodata Consulting & Research

**Figure 4. Average MODU rates, selected markets 2001-2010 YTD**




Source: ODS-Petrodata Consulting & Research

## Day rates take a hit

As illustrated in Figure 1, worldwide offshore rig demand was on the rise in late 2007 and the first three quarters of 2008 when the global financial crisis hit. Since then, the working offshore rig count has fallen below – then returned to – the level it was at in late 2006/early 2007, but rig owners in some markets continue to struggle to find work for their equipment. With supply continuing to grow and uncertainty still dogging the global financial and oil markets, downward pressure on day rates is another challenge for rig owners.

The movement in average day rates for many offshore rig market segments reflects this pressure. As illustrated by four selected rig market segments in Figure 4, average offshore rig day rates tumbled in late 2009, although rates have leveled off in recent weeks. Historically, offshore rig day rates tend to move down more quickly than they recover, and as operators in a number of rig markets are likely to be at an advantage due to the over-supply of rigs, that pattern is likely to repeat this market cycle.

## Wild card in the Gulf

The tragic explosion on the semisubmersible *Deepwater Horizon* that killed 11 people and subsequently saw the rig lost at sea and oil washing ashore uncontrolled has cast a pall on the Gulf of Mexico rig market. However, the ultimate effect on the offshore rig market cannot be predicted at this early date.

We can put the deepwater US Gulf in context with the rest of the world. The deepwater component of the US Gulf rig market at the time of the April 20 explosion represented a significant portion of the worldwide deepwater rig market. Of the 93 existing rigs in the world rated for 6,000-ft (1,829-m) water depths or greater, 29 were deployed in the US Gulf, the most of any single market. In addition, around half a dozen other deepwater rigs were scheduled to move into the US Gulf by the end of this year. Only time – and the playing out of the post-*Deepwater Horizon* regulatory and political process – will tell if the US Gulf can maintain its status as one of the world's most active deepwater oil and gas provinces, and a destination for some of the new deepwater drilling units scheduled to enter service over the next few years.

## About the author

*Thomas E. Marsh is Vice President – Marine for ODS-Petrodata.*

## 2010 Worldwide MODU construction/upgrade survey as of June 1, 2010. Source: ODS-Petrodata RigBase

| Owner or manager/ Rig name | Rig type | Rated water depth (ft) | Status | Delivery date from yard* | Shipyard | Shipyard location |
|---|---|---|---|---|---|---|
| **Aker Drilling** | | | | | | |
| Aker Spitsbergen | Semisubmersible | 10,000 | Yard - upgrade | - | Aker Stord | Norway |
| **Atwood** | | | | | | |
| Atwood Osprey | Semisubmersible | 6,000 | Under construction | 1Q 2011 | Jurong Shipyard Pte Ltd | Singapore |
| Atwood Semi Tbn2 | Semisubmersible | 10,000 | Under construction | 2Q 2012 | Jurong Shipyard Pte Ltd | Singapore |
| **Construtora Norberto Odebrecht** | | | | | | |
| P-59 | Jackup | 350 | Under construction | 1Q 2012 | Sao Roque do Paraguacu | Brazil |
| P-60 | Jackup | 350 | Under construction | 2Q 2012 | Sao Roque do Paraguacu | Brazil |
| **COSL** | | | | | | |
| COSL 921 | Jackup | 200 | Under construction | 3Q 2010 | Offshore Oil Engineering | China |
| COSL 922 | Jackup | 200 | Under construction | 3Q 2010 | Offshore Oil Engineering | China |
| COSL 923 | Jackup | 200 | Under construction | 3Q 2010 | Offshore Oil Engineering | China |
| COSL 924 | Jackup | 200 | Under construction | 3Q 2010 | Offshore Oil Engineering | China |
| COSLInnovator | Semisubmersible | 1,640 | Under construction | 3Q 2011 | Yantai Raffles | China |
| COSLPioneer | Semisubmersible | 1,640 | Under construction | 3Q 2010 | Yantai Raffles | China |
| COSLPromoter | Semisubmersible | 1,640 | Under construction | 2Q 2012 | Yantai Raffles | China |
| Hai Yang Shi You 981 | Semisubmersible | 7,500 | Under construction | 4Q 2010 | Shanghai Waigaoqiao Shipbuilding | China |
| **CPTDC** | | | | | | |
| CPTDC JU Tbn1 | Jackup | 300 | Under construction | 3Q 2011 | CPLEC | China |
| **Delba** | | | | | | |
| Delba VII | Drillship | 10,000 | On order | 1Q 2012 | Samsung Heavy Industries | South Korea |
| Delba VIII | Drillship | 10,000 | On order | 2Q 2012 | Samsung Heavy Industries | South Korea |
| Delba III | Semisubmersible | 7,874 | Under construction | 4Q 2010 | Gulf Piping Company | UAE |
| Delba V | Semisubmersible | 8,000 | On order | 2Q 2012 | TBD | China |
| Delba VI | Semisubmersible | 8,000 | On order | 2Q 2012 | TBD | China |
| **EGAS** | | | | | | |
| El Qaher I | Jackup | 375 | Under construction | 4Q 2010 | PPL Shipyard Pte Ltd | Singapore |
| El Qaher II | Jackup | 375 | Under construction | 1Q 2011 | PPL Shipyard Pte Ltd | Singapore |
| **Egyptian Drilling** | | | | | | |
| Setty | Jackup | 375 | Under construction | 3Q 2010 | PPL Shipyard Pte Ltd | Singapore |
| **Ensco** | | | | | | |
| ENSCO 102 | Jackup | 400 | Yard - upgrade | - | Keppel Verolme | Netherlands |
| ENSCO 8503 | Semisubmersible | 8,500 | Under construction | 4Q 2010 | Keppel FELS | Singapore |
| ENSCO 8504 | Semisubmersible | 8,500 | Under construction | 3Q 2011 | Keppel FELS | Singapore |
| ENSCO 8505 | Semisubmersible | 8,500 | Under construction | 1Q 2012 | Keppel FELS | Singapore |
| ENSCO 8506 | Semisubmersible | 8,500 | Under construction | 3Q 2012 | Keppel FELS | Singapore |
| **Essar Oilfields Services** | | | | | | |
| Essar JU Tbn1 | Jackup | 350 | Under construction | 2Q 2011 | ABG Shipyard | India |
| Essar JU Tbn2 | Jackup | 350 | Under construction | 4Q 2011 | ABG Shipyard | India |
| **Etesco** | | | | | | |
| ET-VIII | Drillship | 10,000 | On order | 1Q 2012 | Samsung Heavy Industries | South Korea |
| **Foresight Drilling** | | | | | | |
| Foresight Driller VII | Jackup | 350 | Yard - upgrade | - | L&T Modular Fabrication Yard | Oman |
| **Frontier Drilling** | | | | | | |
| Bully I | Drillship | 12,000 | Under construction | 3Q 2010 | Shanghai Shipyard & Chengxi Shipyard Co., Ltd. | Singapore |
| Bully II | Drillship | 12,000 | Under construction | 4Q 2010 | Shanghai Shipyard & Chengxi Shipyard Co., Ltd. | Singapore |
| Frontier Discoverer | Drillship | 1,000 | Yard - upgrade | - | TBD | Philippines |
| **Gazflot** | | | | | | |
| Arkticheskaya | Jackup | 328 | Under construction | 4Q 2010 | Zvezdochka Shipyard | Russia |
| Polyarnaya Zvezda | Semisubmersible | 1,148 | Under construction | 1Q 2011 | Vyborg Shipyard | Russia |
| Severnoye Siyanie | Semisubmersible | 1,148 | Under construction | 3Q 2011 | Vyborg Shipyard | Russia |
| **Great Offshore** | | | | | | |
| Great Offshore JU V351 | Jackup | 350 | Under construction | 4Q 2010 | Bharati Shipyard | India |
| **GSP** | | | | | | |
| GSP Orizont | Jackup | 295 | Yard - upgrade | - | Lamprell | UAE |
| **Hercules Offshore** | | | | | | |
| MENAdrill Hercules I | Jackup | 300 | Under construction | 3Q 2010 | Maritime Industrial Services | UAE |
| MENAdrill JU Tbn2 | Jackup | 300 | Under construction | 4Q 2010 | Maritime Industrial Services | UAE |
| **IPC** | | | | | | |
| La Muralla III | Semisubmersible | 10,000 | Under construction | 3Q 2010 | Daewoo | South Korea |
| La Muralla IV | Semisubmersible | 10,000 | Under construction | 3Q 2011 | Daewoo | South Korea |

## 2010 Worldwide MODU construction/upgrade survey

| Owner or manager/ Rig name | Rig type | Rated water depth (ft) | Status | Delivery date from yard* | Shipyard | Shipyard location |
|---|---|---|---|---|---|---|
| **Island Offshore** | | | | | | |
| Island Innovator | Semisubmersible | 2,300 | Under construction | 4Q 2011 | COSCO Zhoushan | China |
| **Japan Drilling** | | | | | | |
| Sagadril 2 | Jackup | 300 | Yard - upgrade | - | Lamprell | UAE |
| **Larsen Oil & Gas** | | | | | | |
| PetroProd JU Tbn1 | Jackup | 492 | Under construction | 1Q 2011 | Jurong Shipyard Pte Ltd | Singapore |
| **Mermaid Drilling** | | | | | | |
| KM-1 | Tender | 800 | Under construction | 3Q 2010 | Kencana H.L. Engineering | Malaysia |
| MTR-1 | Tender | 600 | Yard - upgrade | - | Lamprell Thailand | Thailand |
| **Momentum Engineering** | | | | | | |
| Yantai Raffles JU Tbn4 | Jackup | 300 | Under construction | 4Q 2011 | Yantai Raffles | China |
| **Nabors** | | | | | | |
| Nabors 240 | Jackup | 115 | Yard - upgrade | - | Lamprell | UAE |
| **NIDC** | | | | | | |
| Pars JU Tbn1 | Jackup | 300 | On order | 2Q 2012 | Sanaye Farasahel Co (SAF) | Iran |
| Pars JU Tbn2 | Jackup | 300 | On order | 2Q 2012 | Sanaye Farasahel Co (SAF) | Iran |
| **Noble** | | | | | | |
| Noble Globetrotter | Drillship | 10,000 | Under construction | 3Q 2011 | STX Heavy Industries | China |
| Noble David Tinsley | Jackup | 300 | Yard - upgrade | - | Lamprell | UAE |
| Noble Roger Lewis | Jackup | 400 | Yard - upgrade | - | Lamprell | UAE |
| Noble Jim Day | Semisubmersible | 12,000 | Under construction | 2Q 2010 | Jurong Shipyard Pte Ltd | Singapore |
| **Ocean Rig** | | | | | | |
| Ocean Rig Corcovado | Drillship | 10,000 | Under construction | 4Q 2010 | Samsung Heavy Industries | South Korea |
| Ocean Rig Mykonos | Drillship | 10,000 | Under construction | 3Q 2011 | Samsung Heavy Industries | South Korea |
| Ocean Rig Olympic | Drillship | 10,000 | Under construction | 3Q 2011 | Samsung Heavy Industries | South Korea |
| Ocean Rig Poseidon | Drillship | 10,000 | Under construction | 1Q 2011 | Samsung Heavy Industries | South Korea |
| **Odebrecht** | | | | | | |
| Norbe IX | Drillship | 10,000 | Under construction | 2Q 2011 | Daewoo | South Korea |
| Norbe VIII | Drillship | 10,000 | Under construction | 1Q 2011 | Daewoo | South Korea |
| Norbe X | Drillship | 10,000 | On order | 1Q 2012 | Daewoo | South Korea |
| Norbe XI | Drillship | 10,000 | On order | 1Q 2012 | Daewoo | South Korea |
| Norbe VI | Semisubmersible | 7,874 | Under construction | 3Q 2010 | Gulf Piping Company | UAE |
| **Odfjell Drilling** | | | | | | |
| Deepsea Metro I | Drillship | 10,000 | Under construction | 2Q 2011 | Hyundai Heavy Industries | South Korea |
| Deepsea Metro II | Drillship | 10,000 | On order | 4Q 2011 | Hyundai Heavy Industries | South Korea |
| Deepsea Stavanger | Semisubmersible | 10,000 | Under construction | 2Q 2010 | Daewoo | South Korea |
| **ONGC** | | | | | | |
| Sagar Ratna | Jackup | 300 | Yard - upgrade | - | Hindustan Shipyard Ltd. | India |
| **Pacific Drilling Services** | | | | | | |
| Pacific Bora | Drillship | 10,000 | Under construction | 3Q 2010 | Samsung Heavy Industries | South Korea |
| Pacific Mistral | Drillship | 10,000 | Under construction | 2Q 2011 | Samsung Heavy Industries | South Korea |
| Pacific Santa Ana | Drillship | 10,000 | Under construction | 3Q 2011 | Samsung Heavy Industries | South Korea |
| Pacific Scirocco | Drillship | 10,000 | Under construction | 1Q 2011 | Samsung Heavy Industries | South Korea |
| **Petroserv** | | | | | | |
| Petroserv Drsh Tbn1 | Drillship | 10,000 | Under construction | 1Q 2012 | Daewoo | South Korea |
| Petroserv Semi Tbn1 | Semisubmersible | 10,000 | On order | 4Q 2012 | Daewoo | South Korea |
| **PetroVietnam** | | | | | | |
| PetroVietnam JU Tbn1 | Jackup | 200 | On order | 1Q 2012 | PV Shipyard | Vietnam |
| **Pride** | | | | | | |
| Deep Ocean Clarion | Drillship | 10,000 | Under construction | 3Q 2010 | Samsung Heavy Industries | South Korea |
| Deep Ocean Mendocino | Drillship | 10,000 | Under construction | 1Q 2011 | Samsung Heavy Industries | South Korea |
| Deep Ocean Molokai | Drillship | 10,000 | Under construction | 4Q 2011 | Samsung Heavy Industries | South Korea |
| **PV Drilling** | | | | | | |
| PV Drilling Tender Tbn1 | Tender | 600 | Under construction | 4Q 2011 | Keppel FELS | Singapore |
| **Queiroz Galvao** | | | | | | |
| Alpha Star | Semisubmersible | 9,000 | Under construction | 3Q 2011 | Keppel FELS | Singapore |
| **Rosneft** | | | | | | |
| Bolshaya Medveditsa | Semisubmersible | 6,562 | On order | 4Q 2014 | Zvezda Shipyard | Russia |
| **Rowan** | | | | | | |
| Charles Rowan | Jackup | 350 | Yard - upgrade | - | Lamprell | UAE |
| Joe Douglas | Jackup | 400 | Under construction | 3Q 2011 | LeTourneau | USA |
| Rowan California | Jackup | 300 | Yard - upgrade | - | Lamprell | UAE |

## 2010 Worldwide MODU construction/upgrade survey

| Owner or manager/ Rig name | Rig type | Rated water depth (ft) | Status | Delivery date from yard* | Shipyard | Shipyard location |
|---|---|---|---|---|---|---|
| Rowan EXL II | Jackup | 350 | Under construction | 3Q 2010 | Keppel AmFELS | USA |
| Rowan EXL III | Jackup | 350 | Under construction | 1Q 2011 | Keppel AmFELS | USA |
| Rowan EXL IV | Jackup | 350 | Under construction | 1Q 2012 | Keppel AmFELS | USA |
| Rowan Middletown | Jackup | 350 | Yard - upgrade | - | Lamprell | UAE |
| **Saipem** | | | | | | |
| Standard JU Tbn4 | Jackup | 350 | Under construction | 2Q 2010 | Drydocks World – Graha | Indonesia |
| Scarabeo 8 | Semisubmersible | 9,843 | Under construction | 3Q 2010 | Fincantieri | Italy |
| Scarabeo 9 | Semisubmersible | 10,000 | Under construction | 4Q 2010 | Yantai Raffles | China |
| **Saudi Aramco** | | | | | | |
| Saudi Aramco JU Tbn1 | Jackup | 300 | Under construction | 3Q 2012 | Keppel FELS | Singapore |
| **Schahin** | | | | | | |
| Petrobras II 10000 | Drillship | 10,000 | Under construction | 2Q 2010 | Samsung Heavy Industries | South Korea |
| Schahin Drsh Tbn1 | Drillship | 10,000 | Under construction | 2Q 2011 | Samsung Heavy Industries | South Korea |
| Schahin Drsh Tbn2 | Drillship | 10,000 | Under construction | 4Q 2011 | Samsung Heavy Industries | South Korea |
| Amazonia | Semisubmersible | 7,875 | Under construction | 4Q 2010 | Yantai Raffles | China |
| Pantanal | Semisubmersible | 7,875 | Under construction | 3Q 2010 | Yantai Raffles | China |
| **Seadrill** | | | | | | |
| West Gemini | Drillship | 10,000 | Under construction | 3Q 2010 | Samsung Heavy Industries | South Korea |
| West Callisto | Jackup | 400 | Under construction | 3Q 2010 | Keppel FELS | Singapore |
| West Juno | Jackup | 400 | Under construction | 4Q 2010 | Keppel FELS | Singapore |
| West Leda | Jackup | 375 | Under construction | 3Q 2010 | PPL Shipyard Pte Ltd | Singapore |
| West Capricorn | Semisubmersible | 10,000 | Under construction | 4Q 2011 | Jurong Shipyard Pte Ltd | Singapore |
| T-8 | Tender | 410 | Yard - upgrade | - | Malaysia Marine & Heavy Engineering | Malaysia |
| West Jaya | Tender | 6,500 | Under construction | 1Q 2011 | Keppel Shipyard | Singapore |
| **Sevan Drilling** | | | | | | |
| Sevan Brasil | Semisubmersible | 7,874 | Under construction | 1Q 2012 | COSCO Nantong | China |
| **Shengli Offshore** | | | | | | |
| Shengli X | Jackup | 164 | Under construction | 2Q 2010 | Dalian Shipbuilding Industry Co. | China |
| **Sinopec** | | | | | | |
| Kan Tan VI | Jackup | 375 | Under construction | 3Q 2010 | PPL Shipyard Pte Ltd | Singapore |
| **SinoTharwa Drilling** | | | | | | |
| Bahari-1 | Jackup | 400 | Under construction | 4Q 2010 | Dalian Shipbuilding Industry Co. | China |
| **Skeie Technology/Norsupply** | | | | | | |
| SKDP 1 | Jackup | 400 | Under construction | 3Q 2010 | Keppel FELS | Singapore |
| SKDP 2 | Jackup | 430 | Under construction | 4Q 2010 | Keppel FELS | Singapore |
| SKDP 3 | Jackup | 430 | Under construction | 2Q 2011 | Keppel FELS | Singapore |
| **Songa Offshore** | | | | | | |
| Songa Eclipse | Semisubmersible | 7,500 | Under construction | 2Q 2011 | Jurong Shipyard Pte Ltd | Singapore |
| **Stena** | | | | | | |
| Stena DrillMAX ICE | Drillship | 7,500 | Under construction | 4Q 2011 | Samsung Heavy Industries | South Korea |
| **Swecomex** | | | | | | |
| Independencia 1 | Jackup | 400 | Under construction | 2Q 2011 | Operadora Cicsa | Mexico |
| **Swift Drilling** | | | | | | |
| Swift 10 | Jackup | 147 | Under construction | 4Q 2010 | Drydocks World - Nanindah | Indonesia |
| **Transocean** | | | | | | |
| Deepwater Champion | Drillship | 10,000 | Under construction | 3Q 2010 | Hyundai Heavy Industries | South Korea |
| Discoverer India | Drillship | 10,000 | Under construction | 4Q 2010 | Daewoo | South Korea |
| M.G. Hulme, Jr. | Semisubmersible | 5,000 | Yard - upgrade | - | Keppel FELS | Singapore |
| **UMW Standard Drilling** | | | | | | |
| Naga-3 | Jackup | 350 | Under construction | 2Q 2010 | Drydocks World – Graha | Indonesia |
| **Vantage Drilling** | | | | | | |
| Cobalt Explorer | Drillship | 12,000 | On order | 3Q 2013 | Daewoo | South Korea |
| DragonQuest | Drillship | 12,000 | Under construction | 3Q 2011 | Daewoo | South Korea |
| Platinum Explorer | Drillship | 10,000 | Under construction | 4Q 2010 | Daewoo | South Korea |
| SeaDragon I | Semisubmersible | 10,000 | Under construction | 4Q 2010 | Jurong Shipyard Pte Ltd | Singapore |
| SeaDragon II | Semisubmersible | 10,000 | Under construction | 2Q 2011 | Jurong Shipyard Pte Ltd | Singapore |
| **Vietsovpetro** | | | | | | |
| Tam Dao 02 | Jackup | 375 | Under construction | 3Q 2010 | PPL Shipyard Pte Ltd | Singapore |
| **Yantai Raffles** | | | | | | |
| Yantai Raffles JU Tbn1 | Jackup | 300 | Under construction | 4Q 2010 | Yantai Raffles | China |
| Yantai Raffles JU Tbn2 | Jackup | 300 | Under construction | 2Q 2011 | Yantai Raffles | China |
| Yantai Raffles JU Tbn3 | Jackup | 300 | Under construction | 4Q 2011 | Yantai Raffles | China |

# Global deepwater drilling fleet posts significant growth figures


Songa Offshore's dynamically positioned *Eclipse* semisubmersible is an F&G ExD Millennium design rig scheduled for delivery in 2011.

The worldwide deepwater (4,000 ft [1,219 m] water depth and greater) rig fleet has grown significantly since 2008 when *Offshore* last presented *its* Worldwide Survey of Deepwater Drilling Rigs. The deepwater rig survey is conducted every other year, with a jackup survey published in alternate years. The deepwater rig survey was conducted during May and represents a snapshot of the existing operational deepwater fleet capable of drilling in 4,000 ft of water and greater. Rigs under construction are not included in the survey. New rigs with a construction date in 2010 are included if they are delivered from the shipyard, or expected to be delivered from the shipyard, by the end of June.

In 2008, the survey recorded 103 deepwater rigs, including 46 moored semisubmersibles and drillships and 57 dynamically positioned rigs. Only two years later, the deepwater rig fleet had grown to 129 rigs, a 25% increase. However, in the industry's push toward ever deeper waters, the number of DP rigs rose by 24 to 81 units, translating into a 42% growth since 2008. On the other hand, moored deepwater rigs experienced only a 2% growth, to 48 rigs in 2008.

Several offshore drilling contractors in the survey posted increases in their deepwater rig fleets, however, none as dramatic as Transocean. In the 2008 survey, Transocean reported 12 moored vessels and 24 dynamically positioned rigs in its fleet, plus eight rigs under construction at that time. In the 2010 survey, the contractor reported it still had 12 moored rigs but its fleet included 31 DP rigs (eight newbuild rigs minus the *Deepwater Horizon*). Transocean still has two DP rigs under construction that are scheduled for delivery later this year.

Transocean's fleet growth illustrates the industry's general growth trend of deepwater and ultra deepwater DP vessels. Several of the rigs are designed and equipped for drilling in up to 10,000 ft (3,048 m) of water with a few designed and equipped to operate in up to 12,000 ft (3,658 m) of water.

ENSCO also posted dramatic growth of its DP rig fleet, from one semisubmersible in 2008 to four in 2010 plus another four under construction, including one unit scheduled for delivery in late 2010 that is not listed in this year's survey due to its delivery schedule. The contractor's first DP semisubmersible, the *ENSCO 7500*, was delivered in 2000. The rig is designed for drilling in up to 8,000 ft (2,438 m) of water and equipped to work in up to 7,500 ft (2,286 m) water depths.

There was a nine-year span from delivery of the *ENSCO 7500* to its next newbuild rig, *ENSCO 8500*, in 2009. The *ENSCO 8501* and *ENSCO 8502* were delivered in 2009 and 2010, respectively. The four DP semisubmersibles under construction are essentially identical rigs, all of the 8500 series, and are consecutively numbered to *ENSCO 8506*, with deliveries stretching to 2012. The 8500 series semisubmersibles are designed to drill in up to 10,000 ft of water and will be equipped to drill in up to 8,500 ft (2,591 m) of water.

Stena Drilling increased its deepwater rig fleet to four DP rigs from three in 2008. The contractor also has one drillship under construction scheduled for


Stena Drilling's *Drillmax Ice* will be the world's first ice class, dual mast, ultra deepwater drillship designed for arctic conditions. The rig is under construction at Samsung Heavy Industries in South Korea and is scheduled for delivery in 2012.

**(Left) The drillship *Pacific Bora* is one of four Pacific Drilling rigs presently under construction. The rig is a Samsung 10000 design rated to drill in up to 10,000 ft of water. The rig is scheduled for delivery in September 2011.**
**(Right) Sevan Marine's *Sevan Driller* semisubmersible design is based on the company's Sevan 650 patented design. The rig can drill to 40,000 ft in up to 12,000 ft of water. The unit has a variable deck load of more than 20,000 metric tons and an internal storage capacity of 150,000 bbl of oil.**

delivery during 2012, a Stena/Samsung design dubbed the *Drillmax Ice*. The rig has essentially the same specifications as its existing fleet of Drillmax design drillships except it will be, according to the company, the world's first ice class +1A1 dual mast, ultra deepwater drillship designed specifically for arctic conditions. Like its other drillships, the *Drillmax Ice* is designed for 10,000 ft water depths and equipped for 7,500 of water.

## New companies included in survey

Several drilling contractors are new to the list in 2010, including Maersk Drilling, which didn't have deepwater rigs in 2008 that met the survey criteria of greater than 4,000 ft of water, although several were under construction at the time. The contractor took delivery of three new KFELS MSC Gusto DSS 21 design semisubmersibles, two in 2009 and one this year. Each of the rigs is designed and equipped to work in up to 10,000 ft of water.

Sea Dragon is another company that didn't have rigs meeting the water depth criteria in 2008, although the company had two deepwater semisubmersibles under construction then. Those rigs have since been delivered. The *Sea Dragon I* and *II* are essentially identical rigs, both Moss Maritime CS50 Mk II designs. The *Sea Dragon I* was delivered in 2009 and the *Sea Dragon II* was delivered in 2010. Both rigs are rated and equipped to drill in up to 10,000 ft of water.

Pacific Drilling is another company new to the listing. The company has had two deepwater drillships in its fleet, owned by a 50/50 joint venture with Transocean, which operates and manages the rigs. The rigs, *Dhirubhai Deepwater KG1* and *Dhirubhai Deepwater KG2*, are included in Transocean's fleet.

This year, Pacific Drilling has a separate listing a result of four deepwater drillships that were under construction. One unit, the *Pacific Bora* was delivered in 2010. The remaining three units are scheduled for delivery during 2011. Like the Dhirubhai drillships, the *Pacific Bora* and the *Pacific Mistral*, to be delivered in 2011, are Samsung 10000 designs rated and equipped for operating in 10,000 ft of water. Both rigs are rated to drill to 37,500 ft. The *Pacific Scirocco* and the *Pacific Santa Ana* are Samsung 12000 designs for 12,000 ft of water and equipped for drilling in 10,000 ft of water. These rigs are rated to drill to 40,000 ft deep. The *Pacific Santa Ana* recently was contracted by Chevron for five years beginning in late 2011.

Continuing the companies new to the survey this year are Petroserv, with two DP semisubmersibles, Queiroz Galvao Oleo & Gas with one new rig meeting the 4,000 ft water depth criteria, Sevan Marine, whose *Sevan Driller* semisubmersible is unique with its nearly circular design rather than the traditional square or rectangular configuration, and IPC, a Grupo R holding company division with its *La Muralla V*.

## Rigs under construction

There will be a few new contractors added to the 2012 edition of the survey as a result of deepwater rigs presently under construction for delivery late 2010 and beyond. For example, Songa Offshore, which has one drillship and four semisubmersibles rated for water depths of less than 4,000 ft, will join the survey in 2012 as a result of its semisubmersible *Songa Eclipse* scheduled for delivery in 2011. The rig is an F&G ExD Millenium 6th generation semisubmersible designed to drill in up to 10,000 ft of water. As it is currently being built, it will be equipped to drill in up to 7,500 ft water depth. Its rated drilling depth is 40,000 ft.

While many drilling contractors reported increased rig fleets, there were several that did not change. Among those contractors are Aker Drilling, Atwood Oceanics (which has two semisubmersibles under construction), Dolphin Drilling, Frontier Drilling (which has two DP drillships under construction in a joint venture with Shell), and Aban.

The 2012 Worldwide Survey of Deepwater Drilling Rigs is anticipated to grow significantly compared with this year's survey, and should include many companies not listed in previous surveys due to deepwater rigs under construction for delivery during 2010, 2011, and early 2012. Some of the companies that could be new to the 2012 survey are CNOOC, Delba, Larsen Oil & Gas, Odebrecht, Odfjell Drilling, Saipem, Songa Drilling, and Ocean Rig.

# 2010 WORLDWIDE SURVEY OF DEEPWATER DRILLING RIGS

Drilling Rigs Operational for Water Depths >4,000'

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For additional copies or general comments E-mail: posters@pennwell.com.
Downloads available at www.offshore-mag.com

## CONVENTIONALLY MOORED RIGS

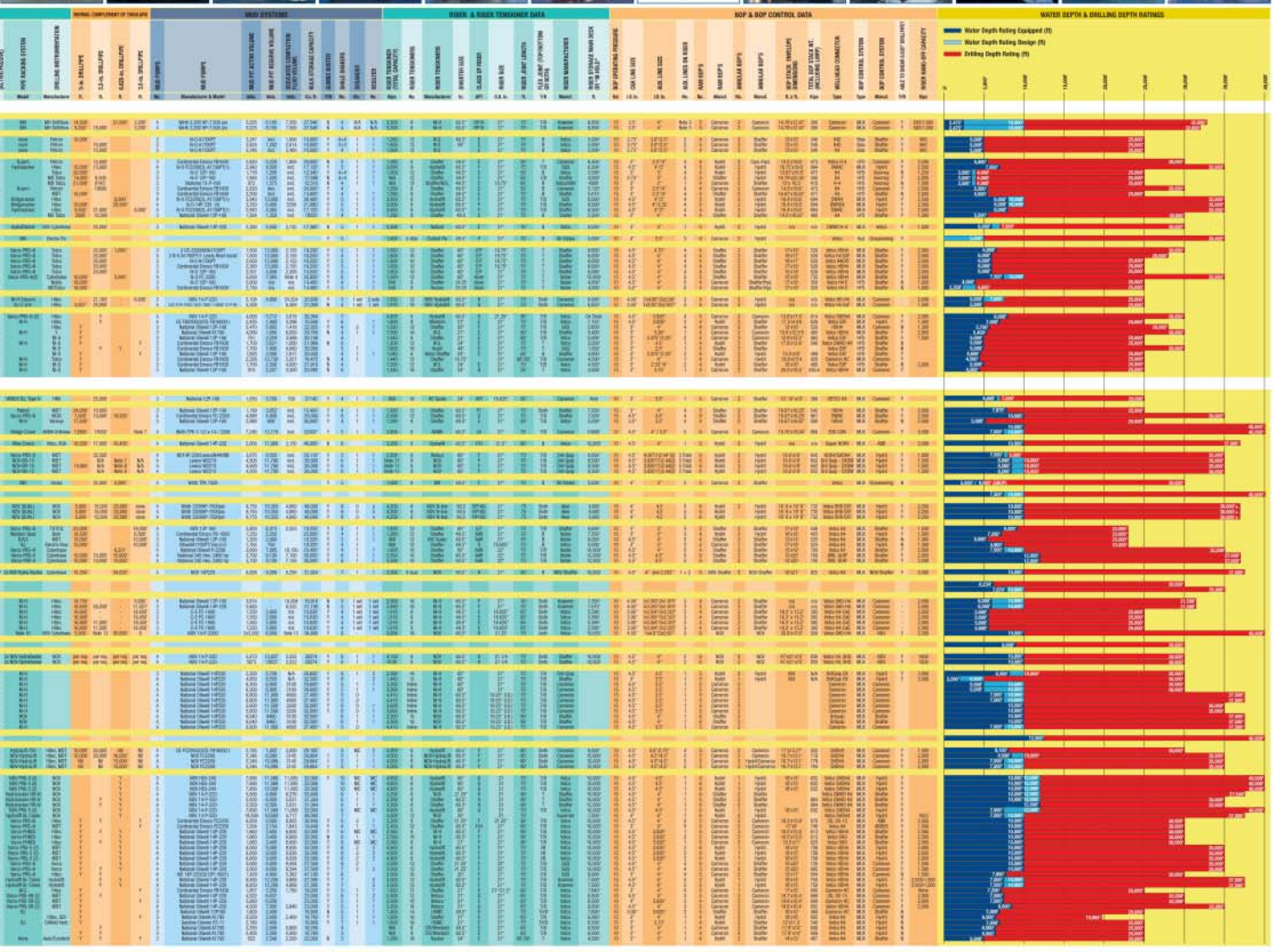
## DYNAMICALLY POSITIONED RIGS

| | Percentage: |
|---|---|
| No. of Deepwater Semis (SS) 84 | 69% |
| No. of Deepwater Drillships (DS) 37 | 31% |
| TOTAL 121 | 100.0% |

WORLD WATER DEPTH DRILLING RECORDS (As of June, 2010)

1. CONVENTIONALLY MOORED
• Operator: Shell
• Drilling Contr: Noble Drilling Corp.
• Rig: Clyde Boudreaux
• Location: Gulf
• Prospect/Field: Perdido – AC 857
• Deepest Anchor: 9,100 ft
• Date: 2007

2. PRE-SET MOORING (PENTESTER ROPE)
• Rig: Baldor
• Location: Gulf
• Prospect/Field: Perdido – AC 857
• Operator: Chevron
• Contractor: Hanover



# Solid expandables take operators to previously unreachable deepwater reserves

**Kevin Waddell**
**Jerry Fritsch**
**Mark Holland**
*Enventure*

More than 1,100 installations worldwide in myriad conditions – including over 115 in deepwater – demonstrate the effectiveness of solid expandable systems in offshore programs. Expandable systems can be an advantage in challenging wells where lack of offset data and unknown formations can disrupt the planned drilling program. When these conditions necessitate setting casing higher than planned, expandable technology may mitigate wellbore diameter reduction and enable the operator to return to the original casing program to complete the well, meeting hole size and depth objectives.

The continuing evolution of expandable applications has increased the frequency of planning expandable systems into a wellbore design. Successful applications demonstrate that solid expandable systems can reduce non productive time, provide larger hole size for maximum completion/evaluation flexibility, or extend casing programs.

The current deepwater records for solid expandable systems are represented by three installations: deepest use at about 28,750 ft (8,763 m), the longest liner at 6,867 ft (2,083 m), and an installation in more than 7,800 ft (2,377 m) water depth. These are not the limit for expandable tubulars, simply the milestones to-date. The technology has room for additional upside to meet the ever-escalating description of "extreme well conditions."

The following offshore case histories demonstrate the application of expandable systems to deepwater applications.

## Record-setting liner

The 9⅝-in. base casing was at about 15,000 ft (4,572 m), and the well needed to be drilled below about 23,000 ft (7,010 m). The interval to be drilled included depleted sands with a narrow pore pressure/fracture gradient.

Multiple attempts to drill and side track the section to reach the target zone were foiled and running a conventional casing string would impact the production liner size. The operator decided to use a solid expandable system. In a new side track, a window was carefully prepared in the existing 9⅝-in. casing, and the section for the expandable liner was drilled to about 20,650 ft (6,294 m) with an 8½-in. bit and opened up to 9½-in. with an underreamer. The 6,867-ft (2,093-m) 7⅝ x 9⅝-in. solid expandable open hole liner was installed and expanded. The operator achieved zone isolation and maintained wellbore diameter. Because of the expandable, total depth was reached with a hole size large enough to complete with a 7-in. flush liner versus the conventional option of a 5½-in. production liner. The larger size increased productivity, accelerated recovery of the investment, and avoided mechanical risks associated with drilling and evaluating a smaller diameter hole.

## Staying on track in ultra deepwater

The challenges of this ultra-deep deepwater, high-pressure well were complicated by a narrow pore pressure/fracture gradient window and multiple salt sutures that constrained the mud weight changes. While drilling the 8½-in. section, lost circulation was encountered and multiple lost circulation material (LCM) squeezes did not succeed. At this point, the operator was faced with a compromised completion size because the use of conventional 7⅝-in. casing carried the penalty of losing a hole size, which would threaten the original well objectives.

To ensure reaching total depth with the desired ID, the operator installed a 1,900-ft (579-m), 7⅝ x 9⅝-in. solid expandable open hole liner to isolate the higher pressure. Once isolated, the mud weight could be reduced to manage the lower-pressure zones, which were causing the lost circulation. As an additional benefit, the larger hole size provided by the expandable, created enough clearance to drill an underreamed 8½-in. hole from the expandable liner shoe to TD of about 30,000 ft (9,144 m). This strategy produced sufficient clearances to allow another contingency casing size to be run, if needed.

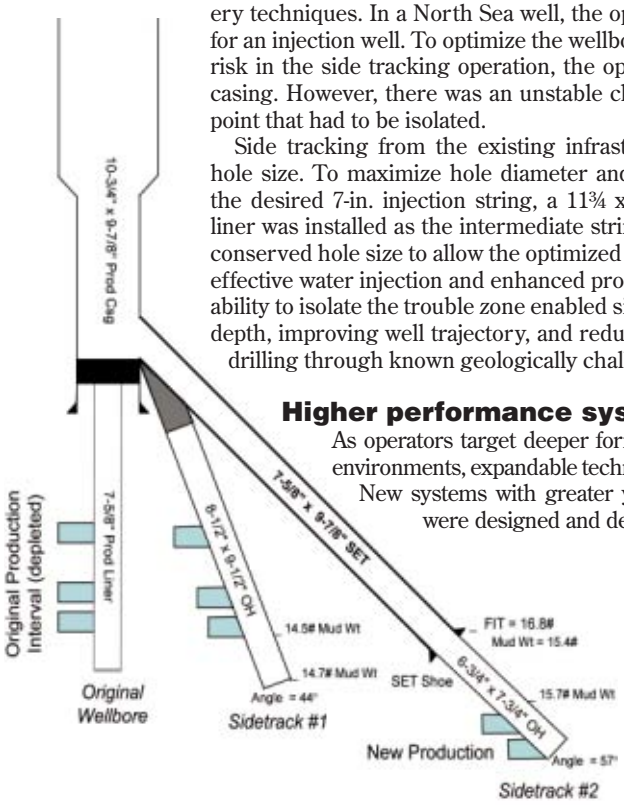
## Expandables in brownfields

As offshore developments mature and infrastructure ages, production wanes. To maximize the value of capitalized assets, operators target deeper or stranded reserves by using enhanced oil recovery techniques. In a North Sea well, the operator was side-tracking for an injection well. To optimize the wellbore trajectory and reduce risk in the side tracking operation, the operator exited from 14-in. casing. However, there was an unstable clay zone near the kickoff point that had to be isolated.

Side tracking from the existing infrastructure constrained the hole size. To maximize hole diameter and complete the well with the desired 7-in. injection string, a 11¾ x 14 in. solid expandable liner was installed as the intermediate string. The expandable liner conserved hole size to allow the optimized completion size for more effective water injection and enhanced production. Additionally, the ability to isolate the trouble zone enabled side-tracking at an optimal depth, improving well trajectory, and reducing risk associated with drilling through known geologically challenging zones.

## Higher performance systems

As operators target deeper formations in more complex environments, expandable technology adapts and evolves. New systems with greater yield and collapse ratings were designed and developed specifically to ad-




**Record setting liner – The solid expandable liner provided adequate ID to enable the well to be underreamed to 7¾-in. hole size and completed with a 7 in. flush-joint production liner.**

dress more-demanding operations. The first high-performance system was a 7⅝ x 9⅝-in. liner for an operator drilling in the UK sector of the North Sea. The system was about 79% more collapse-resistant with a collapse strength of about 4,750 psi (32.75 MPa), versus the previous systems' collapse strength of 2,550 psi (18.27 MPa) in 47 lb/ft base casing.

The initial application went as follows: The target reservoir was below a high-pressure cap rock of questionable shale stability. Uncertainty surrounding shale stability necessitated careful progression through this section to minimize stimulating movement or collapse. The operator needed an expandable liner capable of passing through the 9⅞-in. casing and into the 8¾-in. underreamed hole. The objectives required the system to expand and isolate across the cap rock with a post-installation collapse rating of about 4,000 psi while still allowing the planned 5½-in. completion. Isolating the cap rock by the conventional casing off the section would have resulted in telescoping the wellbore, thereby reducing valuable production volume and compromising commercial viability.

This first application of the high-collapse 7⅝ x 9⅞-in. solid expandable system successfully cased the trouble interval, which facilitated drilling the next hole section with a lower mud weight. By isolating the high-pressure zone while maximizing hole diameter, the operator could drill to the planned total depth of a heavily depleted reservoir and case it with a conventional-size liner.

**11¾-in. high-performance expandable liner inside 13⅜-in. 72 ppf casing (with elastomeric seal compressed between) covered existing wear and provided the wear resistance to side-track to the desired total depth and meet completion objectives.**

The second high-performance system developed is 11¾ x 13⅜-in. It has over 200% more collapse-resistance than previous systems (3,800 psi vs 1,220 psi) in 72 lb/ft base casing.

The first installation of a 11¾ x 13⅜-in. high-performance liner was in the GoM – in an innovative fashion. An operator side-tracking from an existing wellbore had significant wear in the 13⅜-in. casing. To continue drilling, a substantial increase in casing integrity was required. The 11¾-in. solid expandable system installation enabled the operator to clad over the worn area in the 13⅜-in. casing and continue drilling to target depth.

Offshore drilling raises new, more difficult challenges every day. Technology is required to meet these challenges safely, while lowering risk and increasing productivity efficiently and reliably. These case histories not only demonstrate how solid expandable technology can adapt to address challenging drilling issues in deepwater, but also show operators' willingness to apply a proven technology.

# Selecting, sizing, maintaining accumulators for BOPs

*Pressure requirement is key consideration*

**Joe Cheema**
*Fluid Energy Controls*

Gushers may look great in films like 2007's *There Will Be Blood*, but like many of Hollywood's ideas, they are far better on the screen than in real life. Fortunately, drilling is much safer since 1922 when James Smither Abercrombie walked into Harry Cameron's machine shop in Humble, Texas, and explained his idea for a ram-type blowout preventer. Cameron was dead within six years, but Cameron International Corp, now a $5-billion Houston-based international flow equipment firm, still makes BOPs. The designs, of course, have advanced considerably over the years, and Cameron offers dozens of models designed to prevent surface and subsea blowouts on different sizes of drill pipes. That company has been joined by a dozen or more BOP manufacturers such as Hydril and National Oilwell Varco/Shaffer.

Whether you are using an annular BOP, a blind ram, a shear ram, or any combination of devices in the BOP stack, they are only as safe, effective, and reliable as the hydraulics that drive them. The accumulators storing the hydraulic fluid must be appropriately sized for volume, speed, and pressure.

## Types of accumulators

An accumulator is essentially a pressure vessel that stores the hydraulic pressure needed to close the BOP in the event of a blowout. The amount of pressure required varies depending on the type of BOP. Annular or spherical BOPs, usually the first line of defense against a blowout, require a far lower pressure than a shear ram which is intended to cut through the drillstring. While the original Cameron BOP operated at 3,000 psi, a remarkable figure for the time, today pressures run as high as 15,000 psi, and 20,000 psi is well into development.

There are several types of accumulators to be considered for application in conjunction with BOPs. The following describes these and explains which work best for BOPs and why:

*Spring accumulators* – Use a spring-loaded piston in a cylinder. As the oil line pressure

## Sizing the system

**Selecting the right size accumulator and the correct pre-charge pressure requires an understanding of the underlying principles. Bladder accumulators operate based on Boyle's Law, which states that the product of the pressure (P) and volume (V) of a fixed quantity of gas is a constant (C), assuming the temperature remains constant (PV=C). In simple terms, if you double the pressure, you halve the volume. Since the expansion and contraction of the bladder take place in under a minute, however, there is no transfer of heat into or out of the gas as the pressure changes. As a result, the formula for a nitrogen charged bladder becomes $P_1V_1^{1.4}=P_2V_2^{1.4}$ .**

**Applying this data to the sizing and operation of an accumulator, results in the following:**

**$V_1$ = Size of the accumulator required in cubic inches. This is the maximum volume of gas in the accumulator bladder at the pre-charge pressure $P_1$.**

**$V_X$ = The volume of lube oil to be discharged from the accumulator in cubic inches. This the volume of lube oil demanded by the system. The $V_X$ value is a function of the lube oil system for a particular type of turbo-machinery and can be obtained from the manufacturer's specifications.**

**$P_1$ = Pre-charge gas pressure of the accumulator in psia. This pressure is always less than the minimum system pressure $P_3$.**

**$P_2$ = Maximum system design operating pressure in psia.**

**$V_2$ = Compressed volume of gas at maximum system pressure $P_2$, psia.**

**$P_3$ = Minimum system pressure, psia, at which the additional volume $V_3$ of lube oil is required.**

**$V_3$ = Expanded volume of gas at minimum pressure $P_3$ in cubic inches.**

**Here is how this applies to sizing an accumulator for a BOP that requires a flow rate of 15 gpm at 1,500 psig system pressure and a maximum operating pressure of 3,000 psig. If the main oil pump shuts down, system pressure must be maintained within 10% of the system pressure for 15 seconds while the stand-by pump accelerates from idle to operating speed.**

**In this case, the volume of fluid needed by the accumulator is $V_x$ = (15 gpm / 60 sec) x 15 sec x 231 (cu in/gal) = 866.2 cu in.**

**Minimum system pressure (within 10% of the system pressure):**

**$P_3$ = (1,500 x 0.9) + 14.7 = 1,350 + 14.7 = 1,364.7 psia.**

**Maximum operating pressure:**

**$P_2$ = 3,000 + 14.7 = 3,014.7 psia.**

**Polytropic constant for Nitrogen: n = 1.4.**

**Pre-charge pressure of the accumulator (at 75% of working pressure):**

**$P_1$ = 75% of P3 = 0.75 x 1,364.7 = 1,023.5 psia.**

**Inserting these values into the formula below gives the size of the accumulator required ($V_1$):**

$$V_1 = \frac{V_x \dfrac{(P_3)^{1/n}}{(P_1)^{1/n}}}{1 - \dfrac{(P_3)^{1/n}}{(P2)^{1/n}}}$$

**This formula yields a volume of 2,461.4 cu in., or 10.7 gal.**

**The accumulator comes in that exact size, so the next larger size should be selected, not the next smaller one. There is no harm in being able to provide additional oil when needed, but there is a risk of damage if the undersized accumulator runs out of oil too soon.**

increases, more oil flows into the cylinder to compress the spring until the spring pressure matches the hydraulic pressure. Then, when the pressure drops, the spring forces the oil back out of the cylinder into the system. Spring loaded accumulators have three primary shortcomings. As the spring expands, pressure gradually drops rather than remaining constant. Since these types of accumulators have moving parts, those parts do wear and need replacement. In addition, repeated compression and expansion of the spring fatigues the metal and reduces the amount of pressure the spring can provide. This limits usefulness in high-cycle applications as the metal fatigues and loses its elasticity.

*Gravity-loaded accumulators* – These are similar to the spring accumulators but, instead of a spring, these use weights to drive the piston and to provide the desired pressure. The advantage is that it supplies a near constant pressure. It is, however, larger, heavier, and more costly than other types of accumulators. In addition, it has moving parts that require maintenance. If the packing on the piston wears and develops a leak, oil gradually migrates to the top of the piston, adding to its weight and reducing the effective amount of oil in the accumulator.

*Gas-loaded accumulators* – There are several types of accumulators that use compressed gas to provide the pressure. These divide into two main categories: separator and non-separator accumulators. Non-separator accumulators do not have a barrier between the gas and the liquid. This is the simplest design and can store the greatest amount of oil. However, its drawbacks make it unsuitable for use with a BOP. Since there is no barrier separating the gas from the oil, the gas may be absorbed by the fluid, particularly at higher pressures. Then, as the pressure drops, the absorbed gas forms bubbles in the oil, causing sponginess in the system and possibly damage to the equipment through cavitation.

*Bladder-type accumulators* – The type of accumulator that is proven best for BOPs is the bladder accumulator. The BOP control unit contains up to a several dozen accumulators of 10 gal or larger size. The accumulator vessels are made of carbon steel designed to withstand pressures in the range of 3,000 psi. Inside is a bladder made of nitrile compound (BUNA-N) or other material as appropriate. Because of its high flexibility and low weight, the bladder has a very rapid response time, allowing the accumulator to close the BOP in less than a second. If the working pressure will be below 500 psi, a screen can be welded inside the flange to keep the bladder from extruding through the fluid port. At higher pressures, the bladder may extrude through the screen, so a plug and poppet assembly is used. As the pressure drops, the bladder pushes against the poppet to close the fuel port, keeping the bladder inside the vessel.

Bladder-type accumulators are installed vertically with a gas valve molded into the top of the bladder and a fluid port at bottom of the vessel. The bladder is pre-charged to 70-80% of the minimum working pressure of the system, and this pressure must be verified periodically. Typically, nitrogen is used because it is very stable and non-reactive, even under pressure. Air is not a good choice because of its corrosive properties and risk of explosion under high pressure.

By selecting the proper size accumulator and properly maintaining it, operators can avoid the injuries, and costly and catastrophic damage caused by blowouts. Given the number of things that can potentially go wrong, whether through natural events, or component or human failure, correctly designed and maintained accumulators are an easy means of gaining a little margin of safety.

# Market changes pressure development of rules for specialized offshore well intervention vessels

**Alexander Wardwell**
*DNV*

Driven by global demand for energy, subsea exploration and well construction has boomed in the past decade. According to consultants Infield Systems and Douglas Westwood, the total number of subsea wells will balloon to more than 5,500 by the end of this year. While some projects may be delayed due to financing issues related to the global economic downturn, the rapid construction of new wells is likely to continue, if not accelerate, in the years to come.

This creates challenges for energy companies and suppliers alike. Increased demand has forced many energy companies to:

- Re-evaluate stranded or marginal fields
- Work in deeper waters
- Use more complex tieback solutions
- Improve recovery rates for aging wells, which are about 10-20% below platform wells.

These demands push well intervention operators to develop new technologies to improve access to subsea wells, creating a demand for more efficient subsea well intervention systems, including Riserless Light Well intervention (RLWI) units. While not appropriate for deepwater, RLWI units are optimal for repair, scale removal, installation, and manipulation of some equipment (such as valves, plugs, screens, etc.), re-perforation, zone isolation, fluid sampling, PLT, chemical treatment, and well abandonment, among other services.

In the past, this work was performed by semisubmersible drilling rigs. However, developments in dynamic positioning systems, ROVs, and other specialized onboard systems allow well intervention equipment to be placed on monohull units that can move quickly from one well to the next to help reduce chartering costs and to improve well recovery rates by up to 50%. Riser well intervention units still are preferred for some work and in water depths up to 500 m (1,640 ft), but new composites in development for wire lines may soon allow RLWI units to work in deeper waters.

## Vessel or offshore unit?

The first monohull well intervention unit (*Seawell*) was built in 1986 by WellOps. The concept succeeded, and over the next 10 years, demand for LWI units grew. However, because these units are often similar in design to offshore supply, support, or multi-purpose vessels, there was uncertainty on how to class them: Are they vessels or mobile offshore units?

Based on its experience in the North Sea (home to about 40% of the world's subsea wells) and other regions, DNV moved to manage these issues. According to Per Jahre Nilsen, DNV's business development manager for well intervention, the development project, which began in 2007, created some challenges.

"At the time, there was not a lot of useful data out there to help us develop the right approach," he says. "But based on our experience, technical research, and feedback from the industry, we concluded that if the unit is capable of taking control of subsea equipment, such as opening or closing valves on a producing well, it would be classed as offshore, not maritime."

Nilsen says these criteria are consistent with the way many national authorities differentiate between offshore operation and maritime ships/vessels operation and notes that Mobile Offshore Development Units (MODUs) code compliance applies to offshore. Once developed, the new rules were submitted to external hearings for review and additional comments were solicited from owners and operators.

## Class notation

Today, DNV is the only class society offering the Well Intervention Unit class notation. Nilsen says that defining the parameters for a mandatory class notation for well intervention units required an exhaustive review of different technical elements and a broad range of safety principles, including ventilation, areas classification, shut down and gas detection, escape, evacuation, and communication. The organization used in-house expertise on structural design to account for substructure and foundations for well intervention equipment and drill floors, when applicable. Other issues include fire protection, dynamic positioning, and a number of supplementary requirements, ranging from gas treatment in the event of a leakage to rescue ladders in the moonpool. Based on experience gained by developing these new rules, DNV released a new, optional notation known as WELL Intervention this past October. Nilsen explains that the scope the WELL class notation includes design verification of the well intervention equipment and systems, and survey and follow-up during fabrication. Once completed or certified, the equipment follows traditional classification principles and is inspected regularly.

"By introducing the new, voluntary WELL class notation together with the revised and mandatory Well Intervention Unit notation, DNV was able to offer owners and operators of well intervention units the same options that owners of drilling units have had in the past," says Nilsen.

To date DNV has issued certification for six well intervention vessels, including four optional WELL notations, for a number of subsea service companies.

## Early adopter

One early adopter of the new DNV rules was Aker Oilfield Services. The company has a newbuild program to provide subsea intervention, light drilling, and riser and riserless well intervention services.

Alf Kristensen, manager engineering projects at Aker Oilfield Services, says the company has one well intervention unit classed by DNV – the newbuild *Skandi Aker*.

"While there are many components to winning a contract, we felt the DNV notations gave us an advantage over competing oilfield services companies," says Kristensen.

**Marine Subsea's *Sarah*, an Ulstein SX121 designed OCV/IMR type vessel, is designed for light well intervention and subsea construction. Its hullform is designed to give low noise and reduces fuel consumption.**

# Challenges of deepwater development

*Performance, operational integrity are the targets*

**Genebelin Valbuena**
*Technip USA*

Oil and gas companies are extending their operational domain to deep and ultra deepwater; which challenge the performance and operational integrity of conventional subsea technology, jeopardizing the value proposition of the enterprise and increasing the downside risk to stakeholders.

The tendency to use electronic-based equipment in subsea and the high impact of unscheduled downtime caused by any failure of this electronic equipment and associated instrumentation, in terms of loss/deferred production and environmental issues, increase the necessity to consider reliability concepts not only during the operational stage of the field, but more importantly, during the conceptualization, design, and execution of the development.

Some efforts have been made to consider reliability during the first stage of a subsea development. In some cases, by defining generic reliability goals while in other cases by imposing arbitrary reliability targets. In most cases, these requirements are limited to the component level (e.g. electronic-based equipment such as trees, BOP, and HIPPS). At this level, some of the techniques and approaches used to embed reliability into the design aim to evaluate the product itself. Some other approaches look at the process by which the product is created. Probably the more integrated and holistic approach includes not only the product and the process, but also the people and the resources (e.g. tools and work processes) used to design, manufacture, install, and commission the equipment.

## First stage

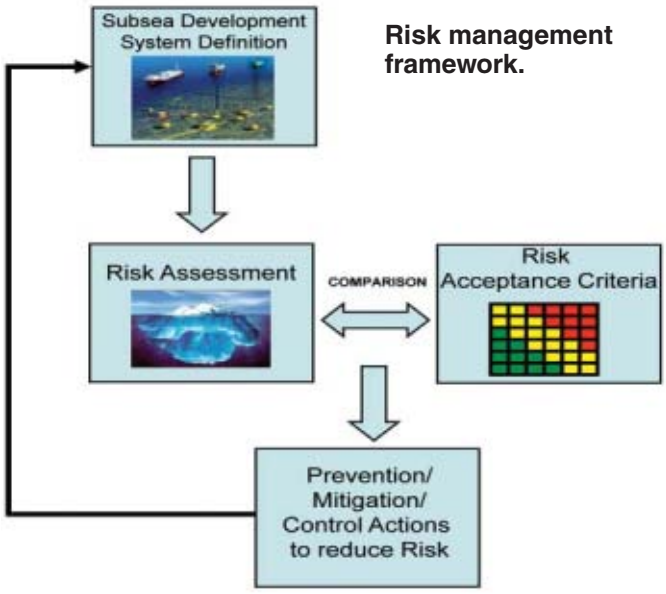
During the first stage of a subsea development, the emphasis should be on the system level, because the ultimate goal is to meet enterprise value proposition, which depends not only on the independent behavior and performance of individual components but on the system (integrated development) as a whole.

At the system level it is important to define how reliable the infrastructure that supports the production system should be. Not all applications require the same level of reliability and availability. Reliability requirements for the entire system, and for critical system components, should be defined progressively during development to align the design, manufacturing, and execution of these requirements.

One way to address the level of reliability/availability is the use of a risk-based approach, in which the reliability is allocated in order to maintain the level of technical risk "As Low As Reasonably Practicable" (ALARP).

This traditional risk management framework is based on the estimation of the risk associated with the subsea development of interest, the comparison of the assessed risk to the risk acceptance criteria pre-established, and the identification and implementation of prevention, control, and mitigation actions to reduce the level of risk as low as reasonably practicable. This framework has been used not only in the safety arena, but it also has been applied in decision making processes involving environmental, health, and financial risks.

The first step of this approach is the system definition. This involves developing a clear definition of the subsea development under consideration. This should include, but not be limited to, defining the system in terms of physical boundaries, objectives, regulatory requirements, environmental and operational context, and maintenance and intervention philosophy.




**Risk management framework.**

The second step is assessment of the subsea development technical risk. This may be addressed by systematic brainstorming sessions, formal risk identification techniques, and/or prior experience. Risks associated with the particular project should be identified and the likelihood/probability of occurrence and consequences associated with each one of the undesirable events should be assessed.

Risk can be estimated as:

**RISK = Probability of Undesirable Events x Consequence**

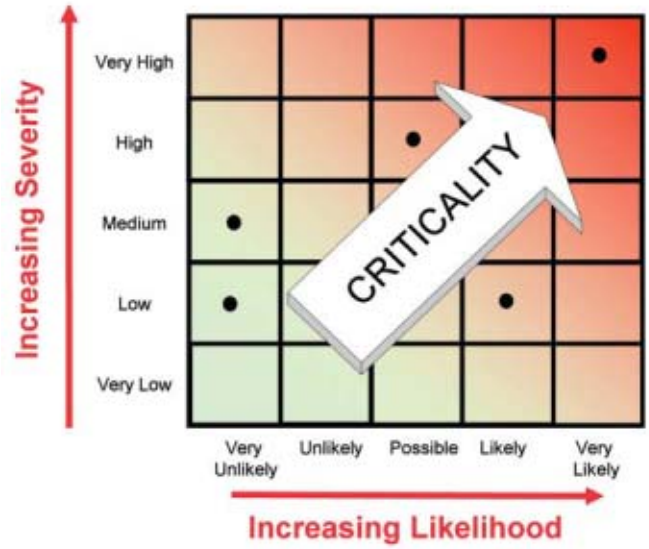
This should use a qualitative and/or quantitative approach. Initially, a qualitative approach based on a criticality matrix may be implemented. When a better understanding of the system is obtained the approach can become more quantitative. Typically, an initial screening is based on a qualitative (e.g. risk matrix) and the quantitative or semi-quantitative approach is used to analyze the events identified in the initial screening as medium to high risk.

In this context, undesirable events refer to any event or scenario associated with the design, operation, and maintenance equipment failure and/or operational context with the potential of affecting the performance and integrity of the subsea production system.

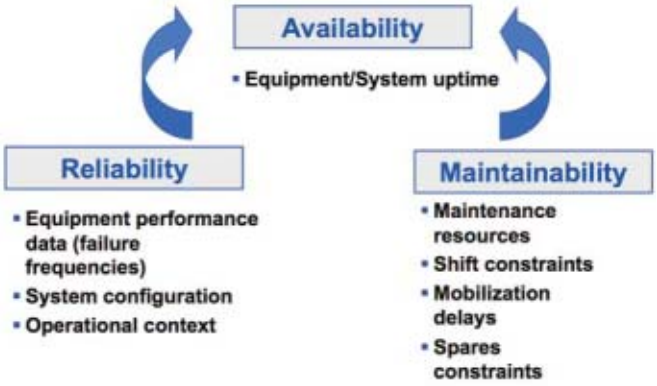
The third step must have a reference to compare against the risk. This reference or risk acceptance criteria, which should be set before risk assessment is performed, must reflect if applicable legal or statutory requirements and/or requirements of the stakeholders regarding the level of risk they will accept. The risk acceptance criteria are meaningful benchmarks that ensure consistent application of the risk management framework.

The fourth step is identification of the different options/mechanisms available to reduce the risk according to ALARP. An effective mechanism to reduce the assessed risk, and consequently reduce the gap between the assessed risk and the risk acceptance criteria,

**Criticality matrix.**




**Availability.**




is through the improved reliability.

Reliability at the system level can be improved by increasing the inherent reliability of the system constituents; by implementing a quality assurance program during the manufacturing, installation, and commissioning stages; and by providing competent people in an organizational climate that enables their synergy.

During design, reliability can be improved by incorporating redundancy. However, redundancy does not necessarily significantly improve reliability, particularly a "common cause failure" (CCF) can jeopardize overall system reliability. One powerful aspect to consider when improving reliability is diversity. Diversity is defined as the use of different means to perform a required function.

For subsea production, application of this concept depends on the target reliability goal and the availability and readiness of existing technology. The concept of diversity can be extended to installation, commissioning, operational, and maintenance activities, where the main goal is to reduce the likelihood of CCF.

The interrelation between risk and reliability is obvious. Undesirable events triggered by equipment or system failures can be reduced by improving component and system reliability. The key is the specific nature of risk involved in subsea developments. Risks associated with subsea equipment are varied, and in some cases such as BOP or HIPPS, the risks are safety and environmental related. In cases such as multiphase meters or wellbore intelligent instrumentation, risks are associated more with loss of revenues or costs arising from lost production. Regardless of the nature of these risks, they can be characterized as a combination of probability consequence, and as such the risk management framework can be applied.

The level of reliability required is driven by the gap between the assessed risk and the risk acceptance criteria. As a result of the comparison, system reliability goals and requirements in terms of Mean Time To Failure (MTTF), Mean Time To Repair (MTTR), production availability, reliability, and/or availability can be defined. It provides a clear understanding of the performance requirements in place. High-risk field developments will require a highly reliable subsea production system and, consequently, more resources and effort should be put in place during their development.

Effort should achieve the required level of reliability, but considering that the subsea production system may fail eventually, appropriate maintenance/ intervention strategies have to be in place to restore operations efficiently and effectively. To achieve a high level of system availability, both the reliability and maintainability should be addressed.

All aspects of maintenance resources, mobilization delays, spare part constraints, intervention philosophy, and diagnostic capacity are key to reach an appropriate level of maintainability. In subsea applications, consideration should be given to the intervention strategy and the availability of intervention vessels (e.g. intervention vessel mobilization time), which usually drive the overall availability of the field.

The effort to improve subsea system availability and to achieve the risk reduction demanded by the application will be justified by reduced risk expenditures in each of the cost elements (capex, drillex, and opex). These unexpected expenditures, referred to as riskex, represent the cost of unwanted events not commonly considered in conventional life cycle cost analysis.

Overall system reliability/availability, which represents a key driver for riskex, can significantly impact the affected party, jeopardize the value proposition of the enterprise, and increase the downside risk to stakeholders. This emphasizes the importance of improving the overall reliability/availability of the system as much as reasonably practicable.

An immediate consequence of the lifecycle cost analysis is that subsea enterprises focus on capex, drillex, and opex rather than on lifecycle cost (LCC) analysis, where the financial impact of unwanted events (riskex) are evaluated and the value of reliability/availability are considered in the economic model (reliability-value analysis).

## Risk vs. lifecycle

Once the reliability/availability requirements for the subsea development are defined during the first stages of the enterprise, specific reliability and availability requirements can be allocated progressively to systems, subsystems, components, and procedures as the enterprise progresses (reliability allocation process).

It is important to mention that the implementation of a framework to assess and improve the reliability of a system, subsystem, component, or procedure, and ultimately work toward the fulfilment of a subsea development reliability goal, involves a series of interacting activities during the complete project/asset lifecycle, from the feasibility and concept design to the decommissioning phase, passing through engineering design, manufacture, and operation.

## About the author

*Genebelin Valbuena has over 22 years of experience in the oil and gas industry. Dr. Valbuena's areas of expertise include process safety management, probabilistic risk analysis, asset integrity management, and decision making process. He holds a BSEE from the Army Polytechnic College Institute (IUPFAN), a MSEE from UNEXPO, a MSRE and a PhD from University of Maryland. Dr. Valbuena currently works as a principal specialist in the Risk and Integrity Management group at Technip USA (gvalbuena@technip.com).*

# First deepwater horizontal ESP boost set for GoM

The first subsea horizontal electrical submersible pumping booster system is scheduled for installation later this year in the Gulf of Mexico. The installation will be the first use of a horizontal ESP-based booster system in ultra deepwater.

Subsea ESP systems can operate effectively, but intervention expense is a concern offshore. As a result, Baker Hughes' Centrilift designed an ESP subsea booster system in a horizontal configuration to reduce installation and intervention expenses.

The horizontal boosting system is a modular, self-contained ESP cartridge consisting of a horizontal, open-framed structure to contain the production tubing, two ESP systems, the electrical penetrator connections, and the fluid connections to tie into the subsea flowlines. Subsea power to the ESP system is to be wet-mated using an ROV.

The production tubing linking the two Centrilift ESP systems loops back and forth with the cartridge framework. Two ESP systems were necessary to maximize the needed pressure within the minimum length and weight footprint. The pumps are hydraulically in series, but not mechanically connected to each other. Rather than lying end to end, the ESPs are connected by hairpin turns in the production tubing. The side-by-side pump layout reduced pump cartridge length from 200 ft (61 m) to about 90 ft (27 m). Because both pumps are in a shorter frame, weight also was reduced. Centrilift used AutographPC design software to develop the pumping systems.

The ESP cartridge design makes the booster systems easier to adapt to existing subsea infrastructure and allows faster, easier, less expensive installation or replacement. The ESP booster system becomes a permanent seafloor structure and is easy to change out when necessary. Plus, all preparations to install the ESP cartridge can be made onshore, to reduce surface work vessel time.

The ESP systems include 17 stage mixed flow pumps, which can handle flow rates up to 20,000 b/d. The motor on the first ESP system in series will be monitored by a Baker Hughes Sureflo HARVEST sensor pod. The pod will gather pump data such as intake pressure, intake temperature, motor winding temperature, and vibration. The second ESP system in series will be identical to the first except for the second system will have two sensors – one at the bottom of the motor and one at the pump discharge. The bottom sensor works like the one in the first system while the second sensor will measure discharge pressure and discharge temperature. There will be two sensor data lines, one for each system.

To resist corrosion and increase reliability, special metallurgy is used throughout these systems. The variable speed drive surface control systems will be housed in air-conditioned structures on the FPSO.

The horizontal boosting systems are planned for installation in the third quarter of this year and first oil from the field is planned by year-end.

## Deepwater vertical application

Baker Hughes already has installed Centrilift XP ESP systems in two vertical subsea boosting stations on the seabed at Shell's Perdido field in the Gulf of Mexico in 8,000 ft (2,438 m) of water. The pumping systems at Perdido are designed to boost up to 125,000 b/d of fluid. Baker Hughes contracted for five enhanced run life systems, engineering design, and qualification and testing services for Perdido in 2007. The remaining three ESP systems are scheduled for installation later this year.

Horizontal electrical pump under construction.

Perdido, which began producing in March, is the world's deepest application of a full-scale seabed separating and boosting system. The 1,600-hp ESP systems – designed to lift liquids 8,000 ft from the seafloor to the production platform – are installed in five, 350-ft (107-m) long caissons connected directly to the platform's production risers. The caissons are located near the spar production facility. Each caisson has cylindrical-cyclonic gas separation systems to separate natural gas entrained in the fluids before the fluids enter the ESP system. The boosting systems handle production from three subsea satellite fields (Great White, Silvertip, and Tobago) tied back to the Perdido spar.

Each Perdido ESP has remote, real-time monitoring and control, and an ESP cable/control line cutting tool in the event the tubing inside a production riser must be cut and retrieved.

"Baker Hughes has made a major contribution to achieving first production at two of Shell's top deepwater projects. Reliable ESP performance is critical to the overall success of Perdido in the Gulf of Mexico and BC-10 offshore Brazil," says Ernst den Hartigh, vice president of technical support, Shell Deepwater. "Baker Hughes has consistently demonstrated a commitment to project success that began with a full-scale technology qualification and demonstration effort in 2006 and has continued through installation and startup. Baker Hughes' perseverance, commitment to quality and excellence in engineering design and application were major factors in helping us achieve this success," he notes.

# How BC-10 got its pipes

*Challenges linked to welding, complex riser system*

**Cesar Bartz**
*Subsea 7*

Subsea 7 did the pipeline installation for the Parque das Conchas (BC-10) development, offshore Brazil. Parque das Conchas is operated by Shell on behalf of the BC-10 Joint Venture (Shell 50%, Petrobras 35%, ONGC 15%).

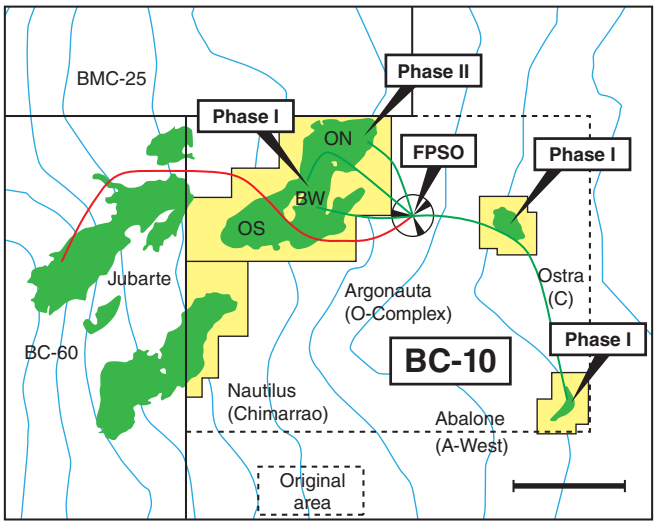
Located 120 km (75 mi) southeast of Vitória, Brazil, north of the Campos basin, the Parque das Conchas in block BC-10 comprises four fields: Ostra, Abalone, Nautilus, and Argonauta. Water depths range from 1,700 to 2,050 m (5,577 to 6,726 ft).

First production from BC-10 started about one year ago, and plans are for it to ramp-up to include nine producing wells and one gas injector well. The FPSO *Espírito Santo* serves the field and is capable of producing 100,000 b/d of oil and up to 3.5 MMcm/d (123.6 MMcf/d) of natural gas.

The Subsea 7 scope of work for BC-10 included:

- Fabrication and installation of 11 flowlines in a total of approximately 130 km (81 mi) including three gas pipelines and eight oil pipelines
- Fabrication, welding, and installation of seven Steel Lazy Wave Risers (SLWRs) totaling 21 km (13 mi)
- Transportation and installation of three dynamic and two static umbilicals totaling approximately 55 km (34 mi)
- Installation of four manifolds
- Manufacture and installation of 25 rigid jumpers
- Installation of over 60 flying leads.

Most of the company's technical challenges were linked to welding and AUT inspection, pipe wall thickness variation, and the overall challenge to build a complex riser system for ultra deepwater.




**BC-10 layout.**

## Extensive engineering

Installation analysis for the BC-10 pipelines and welding development for fabrication of the pipelines was a challenge technically. Several finite element analyses (FEA) ensured the reeling and straightening process would not reduce the fatigue life of the risers.

Matching the large wall thicknesses variation with the fabrication tolerances of the linepipes led to individual measurement of all pipe ends and segregation of several dimensional groups of the same riser. Following grouping, all riser bores were machined to tight tolerances to allow a maximum high-to-low down to 0.5 mm.

The process of treating each linepipe as an individual item on a huge fabrication list was performed for 15,000 pipe joints. Over 15 months, the BC-10 pipes were received, measured, grouped, machined, welded, inspected, and field-joint coated in what has been to date, the largest reeled steel pipeline installation project in Brazil.

**FlexJoint pieces on workstation – first weld (pipe to forged).**

Subsea 7 worked to strict technical requirements on the SLWRs; with enormous stress to be exerted on the risers, the welding had to meet the required quality to assure the 30-year field design lifecycle. This was achieved by using automatic tungsten inert gas (TIG) welding.

## Vessels mobilized

Subsea 7's flagship vessels, the *Seven Oceans*, a rigid reeled pipelay vessel and the *Seven Seas*, a pipelay and construction vessel, were important in the success of BC-10 operations.

Delivered in 2007, the *Seven Oceans* is designed to operate in deepwater globally. The 157-m (515-ft) long vessel is fitted with a main reel capable of carrying 3,500 metric tons (3,858 tons) of rigid steel pipe that itself weighs 1,000 metric tons (1,102 tons); a pipelay tensioner with a 400-metric ton (441-ton) capacity; a 400-metric ton capacity deepwater crane; and an ability to lay pipe in water depths of up to 9,000 ft (2,743 m). A lay ramp system is installed permanently for deployment of rigid pipelines between 6-16 in. The vessel can accommodate up to 120 crew.

Delivered in 2008, the *Seven Seas* is sister to the *Seven Oceans*, but rather than having a rigid reel and lay tower, it has a versatile multi-lay tower and twin under-deck carousels. With a top tension capacity of 400 metric tons, the vessel can operate in flexlay and rigid J-lay mode in water depths of up to 3,000 m

# Allseas

## 1/4 of a century

1985 - 2010

Offshore Previous Page | Contents | Zoom In | Zoom Out | Front Cover | Search Issue | Next Page qMags

**(Left) Flexjoint ready for transfer to FPSO.**

**(Above) *Seven Oceans* delivers a SLWR.**

(9,842 ft); enabling Subsea 7 to offer J-lay for the first time.

In addition, its 1,750-sq m (18,837-sq mi) deck area and 400-metric ton crane mean it can install large structures associated with deepwater subsea field developments.

The vessels had extensive work scopes and 770 vessel days were consumed to complete the project. Installation also was supported by the *Seisranger* ROV support vessel over 278 vessel days.

*Seisranger* is a multi-purpose offshore support vessel with a primary ROV function. The main workclass ROV can operate in up to 2,000 m (6,562 ft) of water, deployed through the vessel's centreline moonpool.

## Operations begin

While 75 km (47 mi) of 12-m long (39-ft) coated X-60 and X-65 steel linepipes were being joined to form 1-km long (0.6-mi) stalks in Subsea 7's Ubu spoolbase near Vitória, umbilicals were being loaded onto the *Seven Seas* in Florida for the trip to Brazil. The vessel arrived in Brazil in October 2008 to start the installation.

The *Seven Seas*' scope of work included installing:

- Two artificial lift manifolds and two production manifolds with a maximum weight of 231 metric tons
- Three dynamic and two static umbilicals totaling approximately 55 km (134 mi) – this was the first time Subsea 7 had installed umbilicals of such large outer diameter (220 mm or 8⅔ in.) in such deepwater – up to 2,050 m (6,726 ft)
- 25 rigid jumpers – one of the largest ever subsea jumper installations campaigns

Manufacturing the rigid jumpers was another challenge as this was the first time it was ever done in Brazil.

Designed to connect the wells to the manifolds and pipelines, the 25 jumpers required a special area within the Companhia Portuária de Vila Velha facilities at the Vitória Port, Espírito Santo, to allow for fabrication of the required length. The jumpers were manufactured and tested prior to transport for installation.

To be certain the jumper dimensions were correct, detailed metrology and pre-installation tests were conducted at the fabrication base by reproducing the actual dimensions for fabrication. Consequently, each jumper was installed and fitted due to control of the dimensions and connector angles.

The *Seven Oceans* arrived in Brazil in early October 2008. The spooling activities took place at Subsea 7's Ubu spoolbase where the SLWRs and flowline stalks were fabricated and stored.

On sailing to the BC-10 site that October, the *Seven Oceans* began to install the SLWRs and flowlines, laying the lines from the Pipeline End Terminations (PLETS) towards the FPSO. In total, the vessel made 12 trips over the offshore campaign.

Assembly of the SLWRs was complex. In the 3 km (1.9 mi) length of the dynamic section of the pipeline, several items had to be installed.

In all seven risers, a total of 257 buoyancy modules weighing 2 metric tons (2.2 tons) each were installed to form the lazy-wave arches. The quantity varied from 25 buoys in the 6-in. gas export riser to 77 buoys in the 10-in. oil production riser. In each riser, a total of 1 km of strakes and 200 m (656 ft) of fairings were installed to suppress vortex induced vibration.

A milestone for the *Seven Oceans* was the installation of the flex joints. The installation engineering of the joints was complex.

Work started with the positioning of the first of three forged pieces in the vessel's work station and continued until completion and transfer of the flex joint and riser to the FPSO.

Over eight months the *Seven Oceans* installed the entire subsea pipeline system including transfer of the SLWRs and flex joints to the FPSO.

# Goliat subsea power cable designed for long-distance service in harsh conditions

**Nick Terdre**
*Contributing Editor*

ABB has won a contract to supply subsea power cables for Eni Norge's Goliat development in the Barents Sea. The NOK 676-million ($104 million) assignment covers design, manufacture, and installation, the latter scheduled for summer 2013.

Taking power from shore to run offshore production operations should bring environmental benefits. Even though Eni also will use a gas turbine on the platform, it expects carbon dioxide emissions to be halved compared with a solution based on offshore power generation alone.

It is also looking to the future beyond 2014, when Goliat is due to come onstream, and its long-term plan for the platform to serve as a hub for the tieback of other fields in the area. The cable will be engineered to deliver up to 75 MW at a voltage of up to 123 kV, but, according to Eni, power transmission in the project's initial stages will be significantly below capacity.

Power will be transmitted as alternating current. Higher power ratings can be achieved through the transmission of direct current, as in ABB's HVDC (high-voltage, direct current) Light technology. This solution has been supplied to Statoil's Troll A platform and BP's Valhall redevelopment in the North Sea, but it requires converter stations at either end, adding to the weight of the offshore equipment and also to the cost.

ABB's previous delivery of an AC subsea power cable to a Norwegian project was for Statoil's Gjøa development in the North Sea. That cable, installed this spring, shares common features with the Goliat cable: both will transmit power over a similar distance – 106 km (66 mi) for Goliat compared with 100 km (62 mi) for Gjøa – and both involve sections hung from floating platforms in a water depth of 380 m (1,247 ft).

When the Gjøa cable was designed, according to ABB's Project Manager Magnus Larsson-Hoffstein, its power rating of 40 MW was close to the practical limit for an AC solution over a distance of 100 km. Although the design for Goliat will be similar, improved analysis methods and more favorable thermal conditions allow ABB to increase the power rating.

**ABB is a leading player in the design and manufacture of subsea power cables in the Norwegian offshore development sector.**

## ABB charters cable-lay vessel

**The Goliat power cable will be installed in 2013 by Aker Solutions' new cable-lay vessel *Aker Connector*. ABB has agreed to charter the vessel, currently under construction and due for delivery in 2012, for two years with options to extend the contract a further three years.**

**The vessel, originally intended to be part of Aker Solutions' deepwater subsea well intervention fleet, will be outfitted instead for installing heavy power cables over long distances. Aker Solutions also will provide a range of related engineering, project management, and installation services for the execution of marine and offshore projects, according to ABB.**

**"This collaboration will enhance the range of projects we can undertake in the specialized and growing market of subsea power cables," says Per Haugland, head of ABB's Grid Systems business.**

The Goliat cable will be based on ABB's high-voltage XLPE (cross-linked polyethylene) design, claimed to exhibit low electrical losses, good resistance to oil, solvents and abrasion, and high strength.

Detailed design is under way. A major challenge is the dynamic section which hangs in the water column between the platform and the seabed, and which will be subject to fluctuating loadings from ocean currents, waves, and the movement of the platform. This section of the cable will be about 1.5 km (0.9 mi) long, and with a weight of some 90 kg/m, will have a total weight in air of around 135 metric tons (149 tons). To reduce the loadings, it will be hung in a wave formation with the aid of buoyancy elements.

Lead will be applied as protection against water ingress in the static section which lies on the seabed, but lead cannot be used in the dynamic section due to the latter's sensitivity to fatigue loads. Instead, ABB has developed a copper sheath application for this purpose. A prototype section will undergo six months of flex testing to ensure it can withstand the loads foreseen during the cable's 30-year design life.

The hang-off from the platform will also be different from ABB's earlier experiences. The Goliat platform will be a Sevan Marine cylindrical FPSO, with the cable passing through an I-tube within the deck structure.

The cable, which will be manufactured at ABB's Karlskrona plant in southern Sweden, will transmit power to Goliat from a transformer station on Norway's northern coast near the town of Hammerfest, where the Goliat operations base will be located. Here, power will be taken from the local grid and stepped down, probably to around 110 kV in the initial period. On arrival at the platform it will be further stepped down to 11 kV.

Two fiber-optic cables will be integrated into the cable. These will make it possible to monitor the temperature of the conductor at the most important locations, close to the platform and close to shore.

*For more information contact Magnus Larsson-Hoffstein, ABB AB High Voltage Cables. Tel +46 455 55 949, fax +46 455 82 245, magnus.larsson-hoffstein@se.abb.com, www.abb.com*

SWEDEN

# Crane simulator designed with teamwork focus

Antycip Simulation and CMLabs have teamed to develop offshore crane training simulators for the PNI Training Centre in Norway. The simulators, installed at PNI's Stavanger base in June, will help the company address increasing demands for the training of personnel in offshore lifting operations.

The delivery incorporates Canadian company CMLabs' Vortex simulation technology, which has been used in the development of training programs for the oil and gas, marine, construction, mining, and port sectors.

Antycip, a subsidiary of ST Electronics (Training & Simulation Systems) Pte, provides modeling and simulation tools, projection systems, and related engineering services, and is also CMLabs' representative in Europe.

A priority for PNI was that the program covers the needs of the entire team involved in lifting operations – not just the crane operator, but also the banksman (signaler) and slinger. Incorporating teamwork in a simulated training program is a new departure, according to Malin Hallbeck, account manager at Antycip's office in Gothenburg which was responsible for this project.

Working to detailed specifications supplied by PNI, Antycip gathered wide-ranging input for the simulation program, including capturing extensive visual imagery and procedures on offshore drilling rigs and contacting crane suppliers for the exact crane specifications and operating procedures for the various types of offshore cranes – pedestal-boom cranes, knuckle-boom cranes, and pipe-handling systems.

**Antycip and CMLabs' simulator delivery to PNI for training crane and lifting crews.**

The resulting simulation program offers a realistic immersive environment which is displayed on five large screens and includes authentic crane controls, machine and ambient sounds effects, plus variable weather and sea-state conditions. A wide range of in-depth training exercises cover a variety of situations – rig and supply ship lifts, internal lifts, subsea lifts on intervention vessels, and even tandem lifts with two simulated cranes – in accordance with the leading sets of lifting standards.

"You need as much realism as you can get," says Hallbeck. "It can be dangerous if trainees get into a real crane cab and it doesn't correspond to the training they've had."

The point is backed by CMLabs vice president Arnold Free. "The main cause of offshore crane accidents is human error, and the main cause of human error is lack of knowledge and experience," he says.

*For more information contact Marilou Poupon, Antycip Simulation. Tel +46 31 707 7471, fax +46 31 704 2210, marilou.poupon@antycipsimulation.com, www.antycipsimulation.com.*

# Asymmetric plates block wax build-up in Oyo heat exchangers

Tranter International faced an unusual challenge when asked to supply heat exchangers for Eni's field FPSO offshore Nigeria.

The field's crude has a waxing point of 37 °C (98.6 °F), well above the usual temperature of 30 °C (86 °F). This meant the wall temperature of the heat transfer plates had to be maintained at a temperature of 37 °C or more to prevent wax build-up fouling.

Normally the two media between which the heat is transferred flow in opposite directions to facilitate efficient heat exchange. For Oyo, however, the decision was taken to use a co-current flow, flow in the same direction, to maintain the wall temperature at the required level at the expense of some loss of efficiency, explains areas sales manager for oil and gas, Stefan Gavelin.

Heat transfer is a function of pressure drop – in this case, the application of Tranter's patented asymmetrical plate technology allowed the maximum permitted pressure drop, regaining some of the efficiency lost through use of co-current flow. Through providing high shear rates on both sides, asymmetrical plates also prevent the build-up of fouling layers.

**One of several FPSO heat exchangers supplied by Tranter. Its latest delivery is Eni's *Oyo* production ship off Nigeria.**

Another benefit of this technology is that it allows the overall heat transfer surface to be reduced, compared with symmetrical plates. Also, the asymmetric plates are made of a high-cost titanium alloy, which is resistant to the corrosive effect of sea water coolant.

The solution was embodied in two GX-51 heat exchangers, Tranter's plant in Vänersborg near Gothenburg, where most of its offshore orders are manufactured. Through its Singapore office, Tranter is also well connected with the Far East yards where many FPSOs are built or converted. For the Oyo delivery, the customer was Eni's FPSO contractor, Bumi Armada Berhad.

*For more information, contact Stefan Gavelin, Tranter International. Tel +46 8442 4998, fax +46 8 442 4980. Stefan.gavelin@se.tranter.com, www.tranter.com*

## People

**Simen Lieungh** has stepped down as president and CEO of Aker Solutions.

Solomon Associates has named **Felicitas Global** its India and Southeast Asia representative, and **Michael Hileman** VP for Asia.

**Lasse Amundsen**, Statoil's chief researcher, has won the Conrad Schlumberger Award 2010 for outstanding petroleum geophysics research. Amundsen publishes articles on seismic data processing and imaging. Many of his methods are in use for exploration and improved oil and gas recovery.

Greene's Energy Group has named **Frank Mathews** president of its subsidiary Devin International, and VP of the Devin Business Group.


Jewell

Xodus Group has appointed **Steve Jewell** as subsurface director.

McMoRan Exploration Co. has appointed **A. Peyton Bush III** and **William P. Carmichael** to its board of directors. Bush is president and CEO of Hibernia Homestead Banccorp. Carmichael is a retired executive with more than 35 years of experience in finance.


Sollid

Devon Energy has appointed **John Richels** as CEO. He will remain the company's president.

Ulstein Design & Solutions has appointed **Frode Sollid** as design manager for offshore support vessels.

Origin Energy Ltd. has appointed **Helen Hardy** as company secretary. She succeeds **Bill Hundy**.


Wegener

Signal International has appointed **Carl F. Wegener** as VP of strategic planning, and **Joe Mayhall** as director of sales and marketing for the company's signal ship repair division.


Mayhall

Hydratight has appointed **Paul Hughes** as connectors product manager, and **Juergen Schimohr** as account manager. Hughes will be responsible for the company's Morgrip mechanical pipe connectors. Schimohr will be responsible for promoting the wind products.

Lincoln Electric has appointed **Peter Pletcher** as director of global consumable development, and **Ferry Naber** as director of global machine development. Both are new positions in the marketing and product development organization.


Jordan

ASCO Group has appointed **John Jordan** as CEO of its operations in the Americas. He will be responsible for the company's North and South American logistics operations, and its international freight forwarding business.

INTECSEA has appointed **Dr. Mike Paulin** as operations director of Canada.

FMC Technologies has appointed **Johan F. Pfeiffer** as VP of global surface wellhead, effective June 1.

**Arne Austreid** has resigned as president and CEO of Prosafe.


Leblanc

Fenstermaker has appointed **Steve Leblanc** as pipeline market leader.

ExxonMobil has elected Peter **Brabeck-Letmathe** and **Jay S. Fishman** to its board of directors. Brabeck-Letmathe is chairman of Nestlé S.A. Fishman is chairman and CEO of The Travelers Companies Inc.


Bowyer

Senergy has appointed **Mike Bowyer** as its first COO.

Husky Energy has named **Asim Ghosh** president and CEO effective June 1.


Morris

InterAct has appointed **Bryant Morris** as general manager for the Gulf Coast region and **Megan Hayes** as business development manager.

CNOOC Ltd. has named **Li Fanrong** non-executive director.

Hess Corp. has appointed **Robert Biglin** as VP and treasurer effective Sept. 1.


Hayes

Paradigm has appointed **James Lamb** as executive VP of sales operations.

**Ron Boyd** moves from business line manager for rock drilling tools at Atlas Copco to project manager for its oil and gas products. **Gene Mattila** becomes business line manager for rock drilling tools.

RMSpumptools has recruited **Doug Harwell** as VP of western hemisphere operations. Asia Pacific manager **Eddie Moore** has been promoted to VP of eastern hemisphere operations.


Williamson

UTEC Survey has appointed **Steve Williamson** as CFO. He was previously VP of finance for Helix Energy Solutions.

ACE Winches has appointed **Derek Penny** as head of group sales and business development.


McKay

Marine Subsea has appointed **Tony McKay** as new projects manager for marine projects.

As of July 1 at Beach Energy Ltd., **Neil Gibbins** will be COO, **Steve Masters** will be chief commercial officer, and **Gordon Moseby** will be general manager. **Hector Gordon**, currently Beach CEO, will continue as an executive director of Beach and acting managing director of Sopmerton Energy Ltd.

Expro has promoted **Chris Mawtus** to COO. He will be responsible for the group's operations in North America, the Middle East and North Africa, Asia, Europe CIS, Latin America, and southern and West Africa.

NACE International has named **Chris Fowler**, global director - corrosion at Exova, president of the association for corrosion.

Offshore cargo transportation group Swire Oilfield Services has named **Rupert Bray** as COO. Bray was director and general manager of the company's UK division.

Offshore engineering consultancy CSL has named **Neil Knowles** as managing director in succession to Mark Gillespie, who left the company in January.

Cosalt has promoted **Carine De Weirdt** to product sales manager to look after its Single Point Mooring (SPM) and offshore rope business. In her new role she will focus on servicing accounts in Europe, the Middle East, and Asia, while developing Cosalt's expanding product range in partnership with wire rope manufacturer Bridon.

Samson has promoted **Kris Volpenhein** to Asia technical sales manager.

DOF Subsea Asia Pacific has appointed **Mike Apathy** to head its new business unit in Darwin, Australia.

**Jerry Howard**, senior VP of corporate affairs for Marathon Oil Corp. plans to retire effective June 1, after 35 years with the company.

Peritus International has appointed **Thyl Kint** as global director of Floating Systems and Asia-Pacific field developments.

Clough Ltd. has appointed **Roger Rees** as deputy chairman.

Seadrill Ltd. has named **Esa Ikaheimonen** as CFO and senior VP of Seadrill Management AS.

HB Rentals has named **Tim Murphy** as technical sales and marketing manager.

## Company News

EMS Energy Ltd.'s subsidiary **Oilfield Services & Supplies Pte Ltd.** and **Tianhe Oil Group Co. Ltd.** have established **Tianhe Oil (Singapore) Pte Ltd.**, a Singapore incorporated joint venture. The JV will trade in Tianhe Oil Group's drilling and tools and related equipment. Oilfield Services & Supplies holds 20% interest, and Tianhe Oil Group holds 80%.

**Total Marine Technologies** has contracted **Perry Slingsby Systems** to supply a 3,000-m (9,843-ft) capable Triton XLX ROV system.

**Dana Petroleum** has agreed to acquire **Petro Canada Netherlands** for around $393 million. Canadian E&P company Suncor Energy merged with Petro Canada in 2009. The sale is in line with Suncor's strategy to divest certain upstream offshore interests.

**Statoil** has signed a Memorandum of Understanding with China's **Sinochem** group to promote cooperation between the companies. This follows a recent transaction under which Sinochem bought a 40% interest from Statoil in the Peregrino oil field development due to enter production early next year offshore Brazil.

**AWE Ltd.** registered office and principal place of business is now: Level 16, 40 Mount Street North Sydney, NSW, 2060 Tel: +612 8912 8000, Fax: +612 9460 0176, www.awexplore.com.

**Ranger Offshore Inc.** says it has completed acquisition of **Tiburon Divers Inc.**

**Barclays Private Equity** has taken a minority stake in the **Wilton Group**, a provider of project management services in the UK. Wilton has three main business units – **PD&MS**, **Wilton Engineering Services**, and **Universal Coatings** – together offering turnkey packages to the offshore and onshore engineering sectors.

The **Dynamic Positioning Centre** has celebrated its 10th anniversary.

**Seadrill** says it has acquired further shares in **Scorpion Offshore**, taking its total holding in the drilling contractor to 50.11%.

Representatives of **Eni** have met Kazakhstan's president, Nursultan Nazarbayev, to review progress on hydrocarbon projects. Eni CEO, Paolo Scaroni and E&P COO, Claudio Descalzi, were in Astana, mainly to follow up on an agreement signed in Rome last November, in the presence of Nazarbayev and Italy's Prime Minister Silvio Berlusconi.

**Clough Helix JV** has contracted the *Normand Clough* for a well decommissioning project in the South China Sea.

**Petrobras International Braspetro** (PIB BV) has acquired a 100% interest in block 2 in the Raukumara basin, offshore New Zealand.

**Expro** says its Asia South division has achieved ISO 9001:2008 accreditation for Quality Management Systems. That ISO tag covers delivery of well testing, subsea safety systems, and wireline intervention across Indonesia and Malaysia.

Analysts at **Deloitte**'s welcome proposals to widen access to the UK's offshore production infrastructure, which were announced by the UK's new coalition government.

**Baker Hughes** reports acquisition of **Oilpump Services**, an electrical submersible pump service company in western Siberia. Baker Hughes says Russia has 60% of all global ESP systems and that this acquisition adds three full-service bases and four remote field bases to Baker's Noyabrsk operation.

**ACE Winches** has established a new division in Dusavik, Norway — **ACE Winches Norge** — to serve Scandinavia. The new operation will provide spooling, equipment rental, vessel bollard pull testing, and showcase ACE's product range.

**PTC** has established its international business development and operations headquarters in Aberdeen. The company also has offices in Stavanger, Norway, and Houston, Texas.

**Chevron North Sea** has awarded **RBG** a three-year contract worth $1.7 million. Under the contract, RBG will deliver electrical rope access services and provide electrical inspections and upgrades for the Alba, Captain, and Erskine platforms on the UK continental shelf.

**BG Group** has official consent from the United Republic of Tanzania to farm-in blocks 1, 3, and 4 offshore southern Tanzania. Upon completion of the agreements, BG will acquire 60% of **Ophir Energy Plc's** current 100% holdings in the blocks.

**Barclays Natural Resource Investments** has formed **Hydra Energy**, an oil development company focusing on undeveloped discoveries, marginal oil fields, and late-life assets offshore Australasia.

**Ensco** has opened a new global headquarters in London.

Secretary of the Interior Ken Salazar has issued an order to divide the **Mineral Management Service** in three parts – **Bureau of Ocean Energy Management**, **Bureau of Safety and Environment Enforcement**, and **Office of Natural Resources Revenue**.

**Tullow Oil** has found non-commercial gas while drilling the Noix de Coco prospect offshore Gabon. Noix de Coco-1, drilled in the Azobe permit 45 km (28 mi) northeast of Port Gentil, encountered wet gas within the Cretaceous interval. However, sandstones in the main objective were of poor quality at this location, so the well will be P&A'd.

**Aminex** says a delegation from North Korea is in London negotiating a new production-sharing agreement (PSA) covering activity in the East Korea Bay basin. **Chosun Energy** has become a 50% shareholder in **Korex**, Aminex's subsidiary for the region, and will become increasingly involved in management of this project. Assuming agreement for the PSA can be reached with the North Korean government, work will start as soon as possible on the next phase of exploration in the area.

**Iran** and **Brazil** have signed a memorandum of understanding to cooperate on energy, including exploration and production of hydrocarbon resources. According to Iranian news service Shana, the memorandum was signed in Tehran by Iran's Petroleum Minister Dr. Masoud Mirkazemi and Harold Lima, director of Brazil's National Oil and Gas Agency, ANP. The two countries have agreed to set up a joint energy committee which will hold sessions every six months.

**Navegantes Maritime Construction and Services**, a subsidiary of Keppel Offshore & Marine, has entered into an agreement with Brazil's **TWB Group** to acquire the Estaleiro TWB shipyard in Navegantes, 110 km (68.3 mi) north of Florianoplolis in Santa Catarina.

**Aberdeen Harbour Board** has started work on its $46 million Torry Quay redevelopment. The initial stage of the three-phase project should take 18 months to complete and will involve demolishing existing upstream berths, replacing them with 300 m (984 ft) of realigned, deepwater quays.

**Halliburton** and **Boots & Coots** have entered into a definitive merger agreement, whereby Halliburton will acquire all of the outstanding stock of Boots & Coots in a stock and cash transaction. A new product service line within Halliburton will be created to include Halliburton's existing coiled tubing and hydraulic workover operations and Boots & Coots' intervention services and pressure control business.

**Seadrill** has acquired further shares in drilling contractor **Scorpion**, lifting its holding in the company to 40.1%. It now plans to make a cash offer for the remaining shares.

**Santos** has agreed to sell its working interest in NT/P 48 (Evans Shoal) in the Bonaparte basin offshore Northern Australia to **Magellan Petroleum Australia** for up to $200 million.

Santos has a 40% interest in NT/P 48 and is the operator. The other participants are PETRONAS (25%), Shell (25%), and Osaka Gas (10%).

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# ADVERTISERS INDEX



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# Cross-industry knowledge sharing improves mooring integrity

It has often been commented that the offshore hydrocarbon industry is particularly bad at sharing lessons learned – both with respect to successful solutions and what has proven to be more problematic. However, re-inventing the wheel is expensive. For safety critical systems, not learning from experience can repeatedly place personnel and infrastructure at risk. To avoid this, there is a need to improve knowledge transfer and distribution throughout the industry.

As the industry has moved toward deepwater and complex reservoirs, bottom founded, fixed steel, and concrete platforms of the past have been replaced by more flexible floating units held in place by compliant moorings. Although the chain, wires, and fiber ropes used to moor production and drilling units are strong, they also often have to operate in dynamic environments. Over time fatigue (tension, bending, and torsion), wear, and corrosion (including microbiological activity), all take their toll.

Hence, for example, any material inconsistencies, design approximations, or unexpected loading effects all can result in premature degradation and aging. In fact, engineering experience suggests we should not expect any mechanical system to withstand 20 or more years of field service life without inspection, repair, and maintenance.

Initially in the early 1990s it was expected that brand new bespoke mooring systems for floating production facilities would be much more reliable than those of drilling units, which can be damaged during their regular recovery and relay operations. Although permanent mooring systems have been more reliable than temporary mooring systems, in practice there still have been significant problems, some of which have occurred relatively early in the field life.

Because of this GL Noble Denton (formerly Noble Denton) launched a Joint Industry project (JIP) on Mooring Integrity in 2002 to try and identify the extent of the issues. This attracted 23 participants and reported at Offshore Technology Conference (OTC) in 2005. Following on from this work a Phase II JIP was launched in 2006 to try to tackle the most pressing issues. The Phase II JIP has attracted 38 participants with the principal findings having just been reported in May at OTC. This makes it one of the best supported JIPs in recent years.

Perhaps the most significant factor associated with the Mooring Integrity JIPs, from a pan industry perspective, has been the extent of information sharing at the twice yearly Steering Committee meetings held as part of the FPSO Forum/JIP Week (www.gl-nobledenton.com/fpsoforum or www.fpsoforum.com).

The JIP Steering Committee consists of operators, class societies, regulators, equipment providers, and service companies. Some of the participating companies are in direct competition with each other. However, despite these constraints, participants to the JIP have been prepared to share their experiences to the mutual benefit of the entire industry. For urgent issues that have implications for more than one production facility, this information exchange has included the use of safety bulletins distributed within the Steering Committee. As well as the actual attendees at the meetings there is a much larger virtual correspondents group who are kept informed about latest findings and contribute to the discussion process.

The Mooring Integrity JIPs have demonstrated the importance of a group of experts getting to know each other and regularly meeting up to review developments in their field of expertise. However, JIPs typically only run for a couple of years and once the particular subjects of interest are completed the group typically disbands. GL Noble Denton is currently reviewing the format of a typical JIP to see if a new structure can be established which will promote information sharing on a longer-term basis. If this can be established, it should help in some way to overcome the industry's poor reputation for sharing information and by so doing help to improve safety.

**Martin G. Brown**
*Consultant Naval Architect, GL Noble Denton*

This page reflects viewpoints on the political, economic, cultural, technological, and environmental issues that shape the future of the petroleum industry. Offshore Magazine invites you to share your thoughts. Email your Beyond the Horizon manuscript to Eldon Ball at eldonb@pennwell.com.

Offshore West Africa is now in its 15th year of providing a platform for technology exchange and new business development, Offshore West Africa is the region's premier technical forum focused exclusively on West Africa's offshore Oil and Gas market.

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These companies include operators such as Anadarko, ExxonMobil, Shell, TOTAL, Chevron, and others, as well as Chinese National Offshore Oil Co. (CNOOC), Petronas, Petrobras, Nigerian National Petroleum Co. (NNPC) and others that have attended and taken part in past OWA conferences.

Offshore West Africa, is sponsored by Offshore Magazine and Oil & Gas Journal, is the only conference and exhibition dedicated to the offshore oil & gas industry in the region, more than 1,500 offshore professionals are expected to attend the three-day conference and exhibition.

## Call for Papers

The Advisory Board for Offshore West Africa is now accepting abstracts for the Offshore West Africa 2011 Conference. We invite you to submit an abstract for Offshore West Africa 2011 and share your knowledge, experience and solutions with industry colleagues from around the world. To have your presentation considered for the technical session programme, please submit your 100 - 400 word abstract on one or more of the technical focus areas listed by 3rd August 2010.

Please submit your abstract online at:

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## Deadline: 3 August 2010

# Offshore West Africa 2010 saw over 350 conference attendees

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## Submittal Guidelines

To submit an abstract for consideration by the Offshore West Africa Advisory Board, please follow the procedures below:

- Go to www.offshorewestafrica.com
- Click on submit abstracts in the left navigation bar
- Complete the required fields
- Press submit or send
- Relax, its now all done

Please submit your abstract ONLY ONCE and wait for the automatic e-mail that confirms your submission was successful. Abstracts must have a title and list all authors. Please provide full contact information for the primary contact and speaker (company affiliation, telephone, mobile number and email address). Please designate which author will be the speaker. Presentations must be of interest and of practical value to executives, managers, engineers and operations personnel engaged in the offshore oil and gas industries. Papers will be selected based on a review of abstracts by the Offshore West Africa Advisory Board. Papers must not be commercial in nature.

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