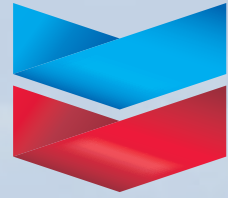


Chevron



# Jack/St. Malo

Expanding Chevron's Reach  
in the deepwater U.S. Gulf of Mexico



A SUPPLEMENT TO

OIL & GAS  
JOURNAL

Offshore

OIL & GAS  
FINANCIAL  
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## Jack/St. Malo

### Expanding Chevron's Reach in the Gulf of Mexico

"Jack/St. Malo is the result of the collaboration of hundreds of suppliers and contractors and many thousands of people across nine countries over a ten-year period. This project highlights our long-term commitment to safely developing the natural resources of the U.S. Gulf of Mexico, where Chevron is one of the top leaseholders. For the life of the fields, operating and maintaining Jack/St. Malo will continue to contribute to the nation's economy and support hundreds of local jobs."

— Jeff Shellebarger, president,  
*Chevron North America Exploration  
and Production Company*







# The Project

## Two of the Gulf's largest fields

**T**he Jack/St. Malo development, which includes the Walker Ridge Regional host facility, in the deepwater U.S. Gulf of Mexico is a key part of Chevron's plan to boost its global production. Along the way, the project has safely extended the industry's deepwater capability well beyond what it was when the St. Malo field was discovered in 2003, and the Jack field the following year.

The reservoirs are 25 miles apart, some 280 miles southwest of New Orleans, Louisiana. Water depths in

both fields are around 7,000 feet (2,134 meters). The reservoirs lie some five miles below the water surface. With today's technology about 500 million barrels of oil is recoverable, but that estimate may increase as we continue to improve our tools and learn more about the resource.

Jack and St. Malo are being developed simultaneously with subsea completions flowing back to a single semi-submersible floating production host platform located between the two fields. Electric seafloor pumps boost the produced fluids to the host.

The Walker Ridge Regional host production platform can handle as much as 170,000 barrels of oil and 42 million cubic feet (1.2 million cubic meters) of natural gas per day, and there is room onboard for expansion. The platform—built for an operating life of more than 30 years—is the largest semi-submersible floating production unit in the Gulf of Mexico. It also serves as the host production facility for the Julia field and has excess capacity for other nearby operators.



## The Co-owners

### Financial and technical strength

Chevron, through its subsidiaries, Chevron U.S.A. Inc. and Union Oil Company of California, owns 50 percent of Jack, 51 percent of St. Malo, and is the operator of both fields. Maersk Oil Gulf of Mexico Four LLC and Statoil Gulf of Mexico LLC are the co-owners in the Jack field, with 25 percent working interest each. The St. Malo field co-owners are Petrobras America Inc. (25 percent), Statoil (21.5 percent), Exxon/Mobil Corporation (1.25 percent) and Eni Petroleum US LLC (1.25 percent).

Chevron U.S.A. Inc. and Union Oil Company of California also own 40.6 percent of the host facility, with co-owners Statoil (27.9 percent), Petrobras (15 percent), Exxon/Mobil (10.75 percent), Maersk Oil (5 percent), and Eni (0.75 percent). The combined Jack/St. Malo investment, sanctioned in 2010, had an initial development budget of \$7.5 billion.







## Exploring the Lower Tertiary

### Back-to-back successes at the edge of the deepwater frontier

Since the world's first modern offshore platforms began appearing in the U.S. Gulf of Mexico in the late 1940s, the petroleum industry has delivered the energy equivalent of more than 40 billion barrels of oil from the continental shelf, and another nine billion from the Gulf's deepwater basins. Analysts say production from deepwater wells will likely eclipse the total production from shallow-water fields in the coming decades. One of the most prolific systems is what geologists call the Paleogene—more often referred

to as the Lower Tertiary. Still others call it the “final frontier” of deepwater drilling.

#### Industry's greatest challenge

Some analysts estimate that the Lower Tertiary in the Gulf of Mexico holds as much as 40 billion barrels of oil equivalent (boe). The challenge is that most of it lies some five miles deep, below as much as 10,000 feet (3,048 meters) of water and hidden from seismic sensors by thick layers of salt.

Compared to Miocene plays, most of the reservoirs found in the Lower

Tertiary are relatively low permeability. In other words, even though the great depth means the reservoir pressures and temperatures are high, the rock's ability to flow fluids is much lower than the Miocene reservoirs. Without additional assistance from improved completions, artificial lift, and possibly gas or water injection, oil recovery rates may be less than 10 percent. The good news is that what industry is learning today about the Lower Tertiary in the Gulf of Mexico applies to other subsalt deepwater prospects, including those off the coasts of Brazil







**Steve Thurston, vice president of Deepwater Exploration and Projects Business Unit.**

and West Africa. Through the end of 2015, Chevron had drilled more than 30 percent of all the industry's new wells in the Lower Tertiary.

"Our success rate for wildcat wells has been great, resulting in many fields with commercial potential," says Steve Thurston, Chevron's vice president of Deepwater Exploration and Projects Business Unit (DWEPP). "These discoveries do not come easy. Overall, the Lower Tertiary trend requires some of the most challenging wells and development technologies in the world."

Chevron was one of the early pioneers, Thurston notes. "We started buying leases in the late 1990s. By the time we discovered the Jack field, we knew we were on to something big."

Two of Chevron's biggest deepwater discoveries, St. Malo and Jack, were made in 2003 and 2004 in the Lower Tertiary Wilcox trend. At the time, the technology to develop them didn't exist, and there are still significant technical challenges.

"Wells in the Lower Tertiary have to be drilled in water depths down

to 8,000 feet (2,438 meters), and each well extends from 26,000 feet (7,925 meters) to as much as 36,000 feet (10,973 meters)," Thurston says. "The good news is the reservoir intervals are typically more than 1,000 feet (305 meters) thick, which means there is a tremendous amount of oil in place."

The Jack-2 appraisal well reached a total depth of 28,175 feet (8,588 meters) in the second quarter of 2006. A subsequent production test, which delivered a sustained flow of more than 6,000 barrels of crude oil per day, was the deepest ever performed in the Gulf of Mexico. It was also an industry milestone for understanding the potential of the Lower Tertiary, where Chevron is the largest leaseholder.

"Since the mid-2000s, with Chevron's installation of major developments such as the Tahiti field in the Gulf of Mexico, key technologies have enabled our deepwater developments," Thurston explains. "We are also committed to project safety, and Jack/St. Malo is a prime example."







## The Chevron Way

Built on a philosophy developed in the 1990s, The Chevron Way gives every employee and contractor a concise definition of the company's corporate vision, values and strategies. It establishes a common understanding for all of those who work for and interact with Chevron. It can be summed up in the phrase: Get results the right way.

At the heart of The Chevron Way is the vision to be the global energy company most admired for its people, partnership and performance. This vision means that Chevron:

- Safely provides energy products vital to sustainable economic progress and human development throughout the world
- Is an organization with superior capabilities and commitment
- Is the partner of choice
- Earns the admiration of their stakeholders — their investors, customers, host governments, local communities and employees — not only for the goals achieved but how the company achieves them
- Delivers world-class performance





Photo courtesy of McDermott International, Inc.

McDermott's *North Ocean 102* fast-transit construction vessel transported and installed some 65 miles (105 kilometers) of control and power umbilicals in waters as deep as 7,200 feet (2,195 meters).

## Building the Fields

### Advanced technology trims cost per well

Through the first quarter of 2016, Chevron had drilled seven exploration wells and nine production wells in the Jack/St. Malo development. Daily hydrocarbon production from the fields reached 75,000 barrels of oil equivalent per day in March 2016.

Phase 1 development drilling started in November 2011, resulting in nine production wells: four at Jack and five at St. Malo. Development drilling resumed after the production hub logged its first oil in December 2014.

Phase 2 of the JSM development plan includes four additional wells: two each at Jack and St. Malo. The

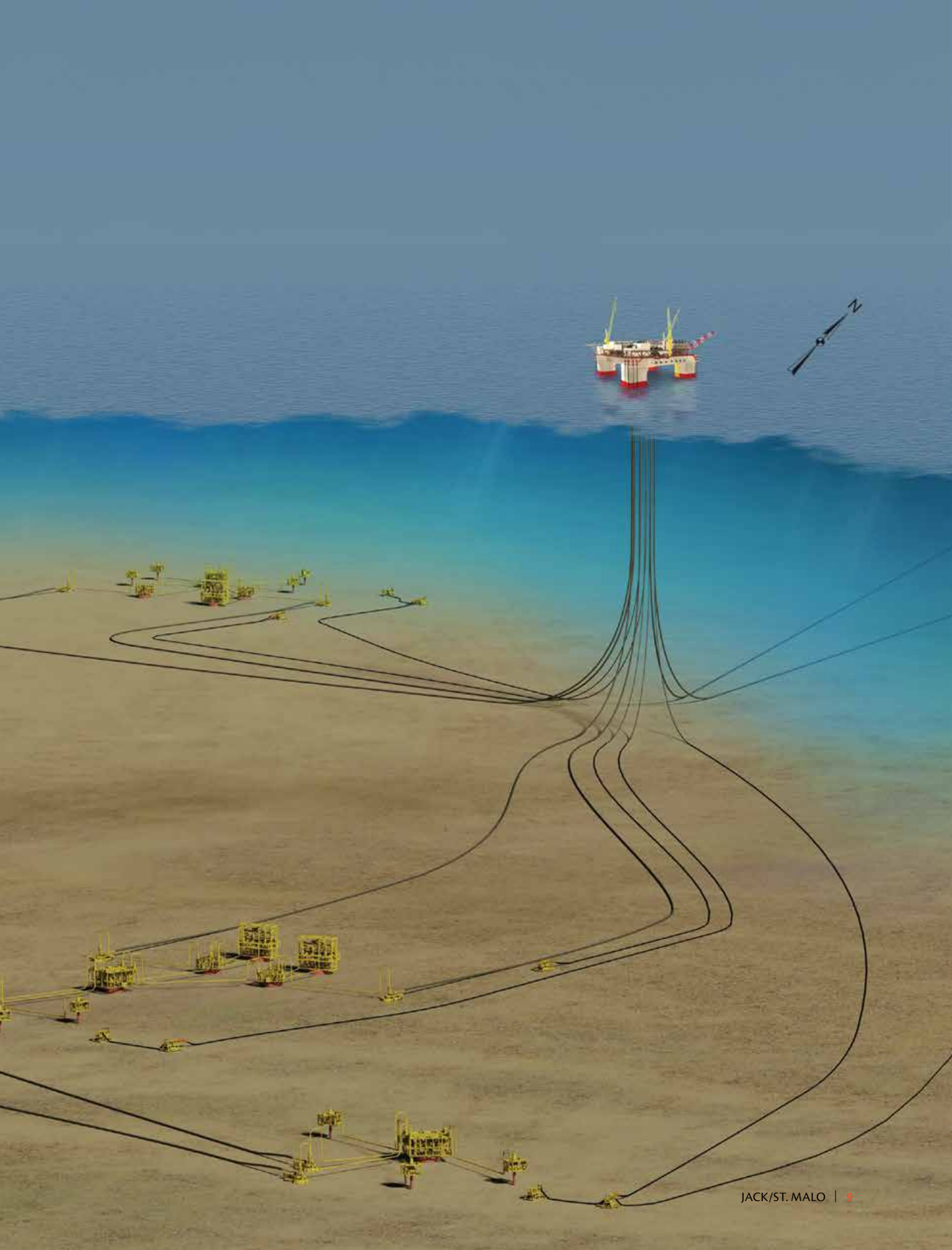
front-end engineering and design (FEED) activities for Stage 2 were completed in September 2015. The drilling that began in October 2015 will continue into 2017. First oil from Stage 2 is expected in 2017.

#### Expected production levels

The fields have an estimated remaining production life of at least 30 years, with recoverable oil-equivalent resources estimated to exceed 500 million barrels. Beyond that, new drilling and completion techniques and advanced production technologies developed in coming years









have the potential to substantially increase incremental recovery from these fields.

### Picking the right target, first time

With the enormous cost of drilling and completing wells in ultra-deep water, operators demand a high degree of certainty before they commit. One of the toughest challenges is creating seismic images that are sharp and accurate enough to make good decisions.

“At these depths, nearly 30,000 feet, the seismic image is quite limited,” says Matt Richards, subsurface geoscience team leader for Jack/St. Malo. “That’s not abnormal, but it takes a lot of work to bring those

images up to a level where you feel like you understand the field. We had to acquire multiple generations of seismic. Fortunately, the technology was advancing rapidly during this time, which ultimately worked to our benefit.”

### Sensors on the seabed

In conventional offshore seismic surveys, ships pull long streamers of acoustical sensors that record the digital echoes of sound waves as they penetrate subsea layers. The deeper the water, the harder this process becomes, since seawater itself muffles the signal. To improve chances of producing high quality seismic models at JSM, the team put

seismic sensors on the ocean floor rather than towing them behind a boat. That costs more initially, but the system is safer, more versatile, and it yields better results.

With ocean bottom node (OBN) technology, remotely operated vehicles deploy a grid of 100-pound receivers (nodes) directly on the seabed. Each autonomous suitcase-sized device—which contains a battery, clock, geophone and other gear—can remain on the bottom for as long as 120 days, allowing for survey acquisition over large areas. There are several advantages. First, placing sensors on the seabed eliminates any signal degradation caused by the water column above.



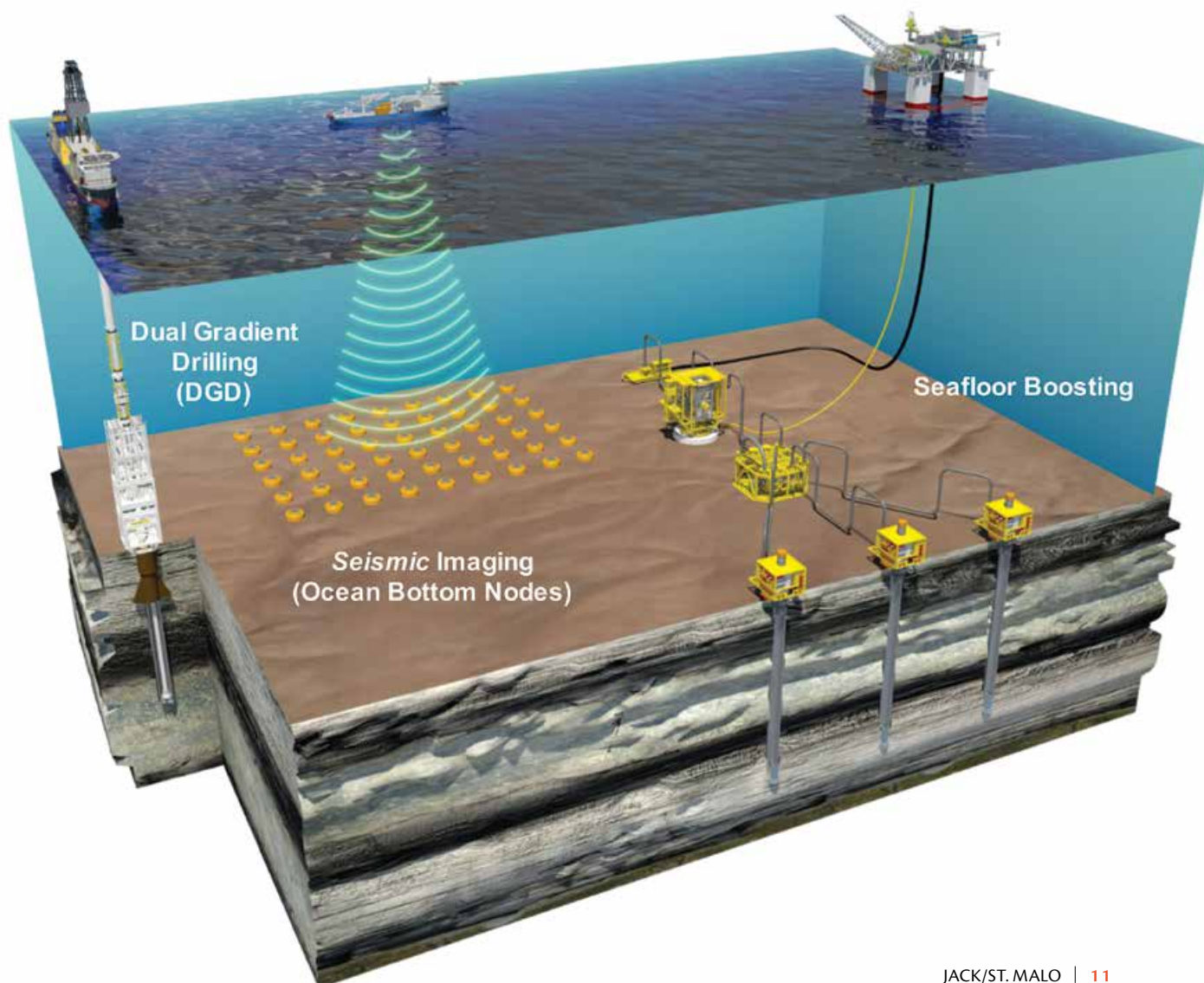
Equally important, these stable ocean bottom nodes catch reflected waves in an orderly grid, enabling the gathering of clean, high-fidelity data without gaps in coverage. They also improve the repeatability of 4-D seismic, which compares surveys made years apart to see how reservoir fluids have moved over time, during development. Over the life of the field, this information helps us decide where to place new wells and how to optimize our facilities. The

bottom line is that OBN data gives Chevron a clearer structural image without the noise of conventional data. It helps Chevron see past barriers of complex geology to better estimate a reservoir's potential.

"The Wilcox Reservoir is very thick here," Richards adds. "It's up to 1,400 feet thick in some places with a lot of oil in place, suggesting very long field lives."

Yet another advantage of OBN technology is that it can be carefully


deployed in congested waters and fields where there is already a lot of equipment on the sea floor. In areas where complex geological features such as salt or volcanic layers hide oil and gas deposits, the source boat may sweep outside the boundaries of the field to collect wide and full azimuth seismic data. OBN technology allows them to safely pass closer to the field's existing facilities than a conventional streamer vessel could with its wide swath of receivers in tow.











Ocean bottom node technology is one of several enabling tools that did not exist when the St. Malo and Jack fields were discovered in 2003 and 2004. To help delineate Jack/St. Malo, 1,100 nodes were placed on the seabed in each field in 2013. The back-to-back surveys lasted 10 months, involving 100 people and two ships. The surveys broke several industry records, including the number of nodes, the longest acquisition schedule, the deepest water, and the largest source area. Besides their use at Jack/St. Malo, Chevron has completed similar ocean bottom node surveys in the North Sea, and off the coasts of West Africa, Brazil and Northwest Australia.

### Single-trip, multi-zone completions

With low-permeability reservoirs like Jack and St. Malo, engineers typically pump a high-pressure slurry of sand, water and treating chemicals into isolated zones to create fractures in the reservoir rock. Pressure drives the sand deep into the newly formed cracks, and the sand grains (or similar manmade material) prop the cracks open once the pressure is released.

This process, called frac-packing, historically represented as much as one-third the total cost of a deepwater production well, and a good bit of

the risk. Part of the expense was the time it took—as much as five days to treat one zone. The risk came from running miles of pipe in and out of the hole over and over again. One well, for example, had five zones to complete. With the technology that was available when Jack and St. Malo were first discovered, the job would have required 14 trips in and out of the well to plug, perforate and fracture. The cost was prohibitive.

Chevron and Halliburton engineers joined forces in 2007 to develop a new single-trip, multi-zone system that could stimulate multiple zones in one operation. Their goals were to increase the maximum pump rate and pressure differential, and to boost the volume of proppant. They got it right. Instead of four or five days, it now takes as little as 18 hours to stimulate each zone. One result is a much safer work environment, since crews now spend less time running pipe in and out of the well. The other benefit is a tremendous reduction in cost.

“This technology is really going to help the development of deepwater Gulf of Mexico,” says Aaron Conte, senior drilling superintendent. “With spread rates well over \$1 million per day, every hour saved is significant. It has delivered more than \$200 million in savings across the Gulf of Mexico.”

At one well in the Jack field, Chevron stimulated a record-breaking six zones and pumped more than 2 million pounds of proppant (sand) in just a few days instead of several weeks. The first of the three wells tested at more than 13,000 barrels of oil per day.

Chevron also successfully tested the technology that Halliburton calls the Extended Single-Trip Multizone (ESTMZ™) Frac-Pack system.

“ESTMZ™ allows more reservoirs to be stimulated in a shorter amount of time,” says Ron Shuman, senior vice president of Halliburton’s Southern and GOM regions. “This system allows us to deliver a very aggressive stimulation with rates up to 45 barrels per minute and volumes greater than 400,000 pounds of high-strength proppant. We deliver this with 10,000 horsepower per interval for up to five intervals, providing a total cumulative proppant volume of more than 2 million pounds per well with one service tool.”

The multizone system was developed for use in the Gulf of Mexico, but has since been deployed in Indonesia, Brunei and elsewhere.

### Subsea boosting

The naturally high reservoir pressures driving Jack and St. Malo during the early stages of development will decrease over time as the fields are

produced. To compensate and maintain production levels, Chevron called on OneSubsea (a Cameron and Schlumberger company) to install three powerful subsea pumps on the seabed to boost fluids from the wells to the host platform. Each pump can withstand pressures up to 13,000 pounds per square inch. The working depths and power consumption—some 3 megawatts each—represent a significant improvement over previous subsea boosting systems. As part of the subsea production and

processing systems for the combined fields, OneSubsea also installed a dozen 15,000 psi subsea wellhead trees, the production controls, four manifolds and their associated flowlines. At the time the work was done in 2011, it included the deepest, longest and highest-pressure tieback in the Gulf of Mexico.

Developing the subsea infrastructure and boosting system for Jack/St. Malo was one of the biggest challenges for the facilities team. Because of their experience with subsea

boosting systems on the Norwegian continental shelf, technical experts from Statoil—Chevron’s co-owners in both fields—were seconded to the Jack/St. Malo team.

“Subsea boosting is not new,” says facilities engineer Chris Hey, “but on Jack/St. Malo, in terms of the water depth, the pressure rating and the power of the pumps, there’s nothing else like this in the industry.”

Many of the technical advances were developed specifically for this project. Some addressed the challenge





of working in water more than a mile deep. Others supported the building of JSM's complex infrastructure and improved the recovery of its oil and natural gas.

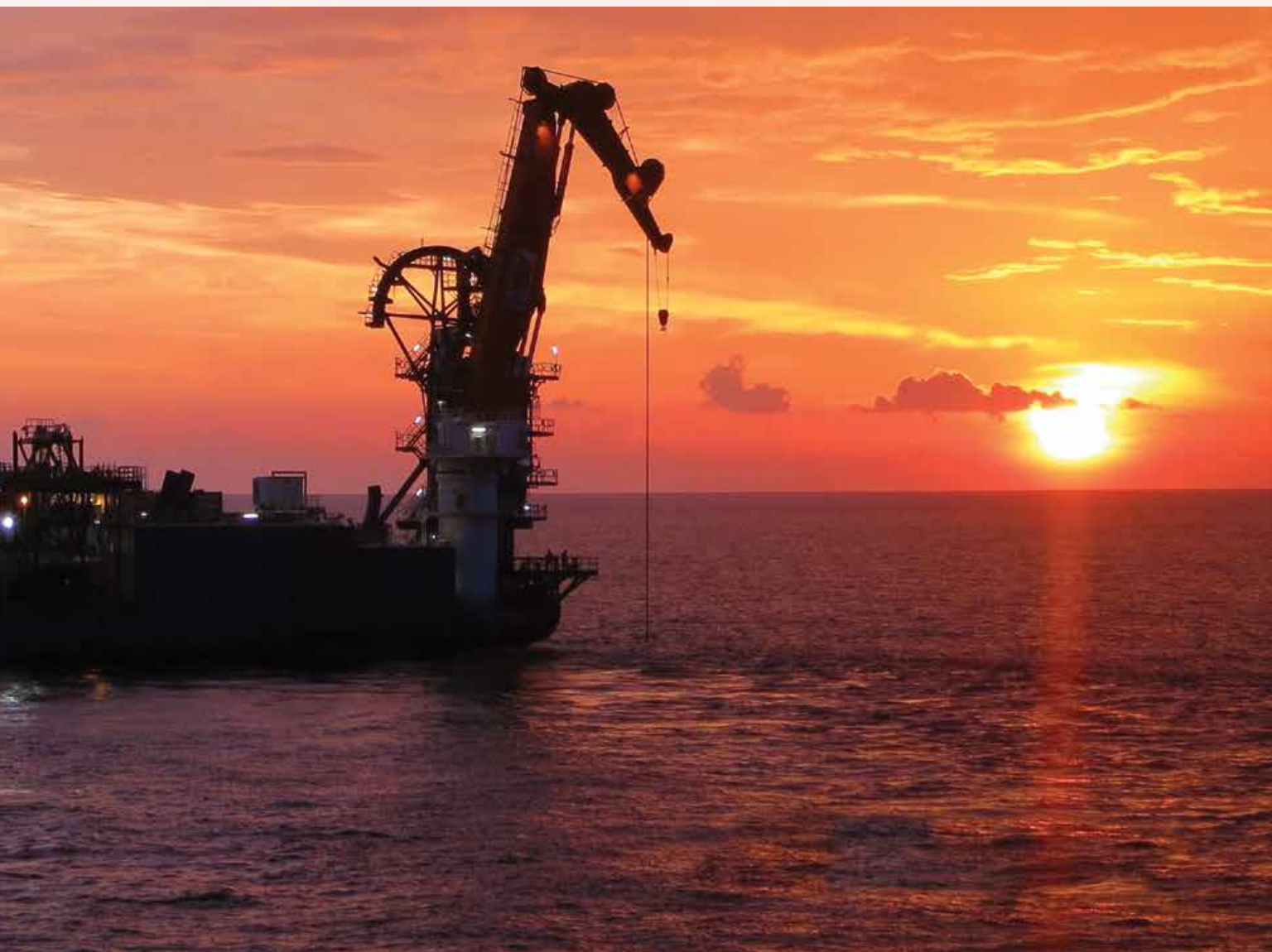
McDermott International installed the jumpers, flying leads, subsea pumps and umbilicals. Much of the heavy equipment, including three pump stations weighing 209 tons each, was installed by McDermott's *Derrick Barge 50*. A second McDermott vessel, *North Ocean 102*, installed the control and power umbilicals.

### An extra level of safety

As the largest leaseholder in the U.S. Gulf of Mexico, Chevron is a principal sponsor of the Marine Well Containment Company LLC (MWCC), a company which was established in 2011 to respond to deepwater well containment emergencies. Available to all deepwater operators, MWCC maintains a system that can stop or cap and flow a runaway well in water depths from 500 to 10,000 feet, temperatures as great as 350 degrees Fahrenheit, and pressures up to

15,000 pounds per square inch.

With the assistance of experts from Chevron and other major energy producers, MWCC upgraded its interim containment system in 2015 to provide increased capacity and compatibility with a wider range of well designs, flow rates and environmental conditions. The company maintains two shore bases on the U.S. Gulf Coast. Regular training exercises keep MWCC's equipment and personnel ready to respond to a well control emergency at any time.











## The Production Hub Largest in the Gulf of Mexico

**W**ith a nameplate capacity of 170,000 barrels per day, the Walker Ridge Regional host floating production unit is the largest such facility that Chevron operates in the Gulf of Mexico. Indeed, it is one of the largest in the world. Building the host platform and moving it around was no easy job.

### Fabricating the hull

The front-end engineering and design (FEED) for JSM's topsides facilities began in the second quarter of 2009. The principal contractor for this part of the job

was Houston-based Wood Group Mustang. Wood Group also managed the commissioning of the production platform. Construction began on the hull at the Samsung Heavy Industry yard in Geoje, South Korea in early 2011. At the time, JSM was the largest semi-submersible hull constructed in terms of displacement, as it displaces 146,168 metric tons (161,122 short tons) of water.

KBR performed the detailed engineering for the floating production unit's hull, deck box, crew quarters, equipment foundations, mooring system and the anchor suction piles.

GVA Consultants, a subsidiary of KBR, worked exclusively on the hull configuration. The deep draft hull design minimizes the motion of the vessel, which in turn reduces stress on the vessel's risers, umbilicals and more than 164,000 feet (50,000 meters) of polyester mooring lines.

### Transporting the hull

The hull was completed in February, 2013. Soon after, it left South Korea aboard the new *Dockwise Vanguard*—the world's largest heavy lift transport vessel—on the ship's inaugural run. The *Dockwise Vanguard* took its 56,000-ton cargo safely around Southern Africa and the Cape of Good Hope to arrive at Kiewit Offshore Services' Ingleside yard near Corpus Christi, Texas, in mid-April.

### Topsides

The host topsides facilities were fabricated and assembled at Ingleside. There are three main topsides modules for production, power generation and gas compression. The completed modules were lifted onto the hull and deck box in May 2013. Most of the integration and commissioning was completed before the facility was towed to the field. Kiewit also fabricated the host's mooring piles. For efficiency and worker safety, most of the integration

and commissioning of the mooring piles was also completed before the facility was towed to the field.

The integrated semi-submersible platform left Ingleside in November, 2013, and was moored offshore and in place by early January, 2014. Offshore commissioning began while the hull was being towed to the field, and the installation of the subsea infrastructure continued through 2014.

### Project economics

Chevron holds a 50 percent interest in Jack, a 51 percent interest in St. Malo, and is the operator of both fields. The company also has a 40.6 percent interest in the production facility, which is designed to accommodate production from the Jack/St. Malo development and third-party tiebacks. Chevron's other co-owners for the hub facility are Statoil, Maersk Oil, Petrobras, ExxonMobil and Eni. The total daily production from the Jack and St. Malo fields in 2015 averaged 61,000 barrels of liquids and 10 million cubic feet of natural gas. Although the project delivered first oil in December 2014, ramp-up and development drilling for the first phase of the development continued into 2015. Production for the Julia field, which is also serviced by the host, began in April 2016.







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DOCKWISE

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DOCKWISE

DOCKWISE VANGUARD









An underwater photograph showing a diver in the center, surrounded by numerous fish swimming in the blue water. The scene is dimly lit, with light rays filtering through the water.

# The Export Pipelines

## Planning for growth in the region

Crude oil from the regional host travels 136 miles to the Shell-operated Green Canyon 19 platform via the Jack/St. Malo Oil Export Pipeline. From there it enters the larger network that delivers crude oil to refineries all along the Gulf Coast. To handle the natural gas, Chevron and Enbridge, Inc. signed an agreement in 2009 for a 170-mile (274-kilometer) southern extension of the Enbridge central Gulf of Mexico natural gas gathering system. The 8- and 10-inch pipeline includes bi-directional points at Jack and St. Malo and similar links to other nearby fields. For the oil and gas export pipelines alike, the combination of extreme water depths, large diameter, high-pressure design, and the system's flexibility for future development have set new milestones for the Gulf of Mexico.

### Largest pipeline at this depth

The JSM oil export pipeline is the first of its kind to address the challenges of installing high-pressure, large diameter pipe in ultra-deep water. The 24-inch (61-centimeter) export pipeline, with a pressure rating of 4,500 psi, was installed in 2014 at water depths greater than 7,000 feet (2,134 meters).

The pipeline's innovative design includes two 92-ton inline modules that allow Chevron or future operators in the Walker Ridge area to connect their development projects to the main export line. The oil export pipeline was designed, built and installed by Amberjack Pipeline Company LLC, a joint venture between Chevron Pipe Line Company and Shell Pipeline Company.

"It was a first for us, especially in dealing with a 24-inch diameter pipeline in 7,000 feet of water and operating at 4,500 psi," says Edward LaCour,



Chevron Pipe Line's asset manager, Gulf Coast Area. "Safety and reliability were our primary concerns, but another feature is that the pipeline includes inline sleds for future tie-ins. It links our upstream and downstream businesses in a supply chain that will also provide competitive solutions for other leaseholders in the transport of crude to the market."

### Installing the crude oil export line

For this project, even the pipe-lay vessel was new. At the time, the *Cas-torone* was the largest such vessel in the world. The vessel and its crew installed up to 1.5 miles (2 kilometers) per day, which translates to more than 120 joints of pipe being laid off the back of the vessel.

"The pipe is brought out in 40-foot segments," explains Jerry Hoose, Chevron Pipe Line's installation engineer for the JSM export pipeline. "Within the vessel's triple-joint factory, sets of three 40-foot lengths of pipe were welded into 120-foot segments. They were then brought up to the main firing line where the segments were welded together to form a continuous pipe."

The pipe is fed in a gentle curve off the back of the vessel and down to the seabed. All the while, a constant tension on the pipeline keeps it from buckling. At the seabed, the pipe curves again until it is lying flat on the bottom.

"A project this size takes years of planning by teams from around the world," Hoose adds. "What we delivered was the largest pipeline ever laid in these water depths."

The success was noted throughout the industry, according to Al Williams, the president of Chevron Pipe Line during the installation and the current vice president of Chevron's San



**Al Williams, the former president of Chevron Pipe Line and current vice president of Chevron's San Joaquin Valley Business Unit.**

Joaquin Valley Business Unit. "Completing this project demonstrated to our co-owners that Chevron Pipe Line has the ability to perform in this challenging environment and can deliver these critical resources to the market. Every Chevron employee can take pride in the way individuals and teams came together to develop one of the company's most technologically challenging and commercially rewarding projects."

### The gas export line

All of the natural gas produced from Jack and St. Malo is sold into a pipeline system built and operated by Enbridge, Inc. To reach the host, Enbridge spent some \$500 million to extend its southern reach into the deepwater Gulf of Mexico.

The Walker Ridge gathering system is a new supply source for the Enbridge Manta Ray and Nautilus offshore pipeline systems, which enhances the company's existing offshore pipeline business and establishes a strategic base for future growth by Chevron and other operators in the ultra-deep Gulf of Mexico. The new line has the capacity to carry 100 million cubic feet of natural gas per day.



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→







# First Oil

## The start of a long run

“There’s nothing more exciting than the startup of a new oil field in the deepwater,” says Steve Thurston, vice president of Deepwater Exploration and Projects. “With the startup of the Jack and St. Malo fields, we were finally able to see what these wells could produce.”

Jack/St. Malo is a showcase of Chevron’s focus on safety and operational excellence, yet for all of the exploration success so far, the Wilcox remains a challenging reservoir. Many questions remain. In the next few years, development drilling at Jack/St. Malo will teach the industry a great deal. One thing that is known is that the Wilcox reservoir is very thick in this area, as much as 1,400 feet (427 meters). There is a lot of oil in place in both fields, which means they should be productive for a very long time.

### Safely delivered on time and on budget

The Jack/St. Malo project was completed on a timeline that began with the discovery of St. Malo in 2003. First oil occurred on schedule on December 1, 2014. Soon after, Chevron’s Gulf of Mexico business unit took over the daily operation of the fields. Within a few months, the project was producing a steady 70,000 barrels per day from five wells. Stage 1, which will continue into 2017, includes nine production wells. Four additional wells are planned in the second stage of the development. Stage 2 development drilling will continue through 2017.

Stage 1 of the investment, which included more than 20 million hours of work, was accomplished with only three lost-time incidents.

“While working on Jack/St. Malo, some of our contractors posted the best safety records they’ve ever had,” says Billy Varnado, the Jack/St. Malo project director. “I think that is good evidence of all the effort everyone put in.”



**Billy Varnado, the Jack/St. Malo project director.**



# Continuing Operations

Innovation, safety and efficiency are the keys

It's only natural for a project as large and important as Jack/St. Malo to become a showcase for the industry's most advanced technology. Given the anticipated life of the fields—more than 30 years—we've also planned for years of expansion and growth.

## Decision Support Center

In 2015, Chevron expanded the capabilities of its Drilling & Completions Decision Support Center. The center is a combination of technology, processes and people designed to help eliminate serious well-control incidents and improve operational efficiency. Working as a team, Chevron specialists monitor in real time

our most complex wells around the world. They are called upon any time Chevron is drilling a complex well. This state-of-the-art center can support as many as 15 drilling rigs on a continuous basis, providing expert backup and advice to ensure safe, reliable and efficient operations.

## Monitoring equipment performance

Within Chevron's Energy Technology Company, the Machinery and Power Support Center (MPSC) uses predictive analytics to monitor machinery performance at a centralized and local level. There, and in several of the business unit





**WORLD CLASS PROJECT  
WORLD CLASS SAFETY  
WORLD CLASS FACILITY**

***CONGRATULATIONS ON***  
**3,000,000 INJURY FREE HOURS**

*Jack*  *St. Malo*





Equipment Decision Support Centers (EDSC), experts remotely monitor rotating equipment to evaluate its performance and safety, ensure the proper maintenance, and to avoid unplanned shutdowns.

Rather than waiting for equipment to fail, the MPSC and EDSC teams feed data into a model that gives advance notice of potential failures or maintenance needs.

This process reduces unplanned downtime, couples work-orders and identifies what spare parts are needed.

### Ready for the next big storm

Chevron and its legacy companies have been exploring for and developing oil and gas resources in the Gulf of Mexico for more than 75 years. As of

early 2016, Chevron has an interest in 466 leases in the Gulf of Mexico, 347 of which are located in water depths greater than 1,000 feet. At the end of 2015, Chevron was the Gulf's largest leaseholder. Over the decades, Chevron brought their people safely through numerous tropical storms and hurricanes, including mega-storm Katrina, when the company evacuated more than 1,000 employees and contractors without a single injury. Offshore installation manager Tommy Boepple knows the drill first hand.

"Jack/St. Malo is more remote than most of our offshore facilities, so we allow extra time to initiate the systems that will ensure the safety of our people and assets," Boepple says. "We rely on a number of resources. Chevron

maintains its own Gulf of Mexico helicopter fleet, for example, which gives us greater flexibility if we need to evacuate a platform prior to a storm."

Jack/St. Malo is also equipped with technology to track a storm's progress and trajectory, as well as detailed computerized crew manifests to keep tabs on who is offshore and where they are.

"Like other fields, Jack/St. Malo is connected to our onshore Decision Support Center (DSC) in Covington, Louisiana," Boepple says. "Covington serves as our 'mission control' during severe weather. To make sure we're ready, we conduct periodic drills that reinforce each individual's role and responsibilities in a weather emergency."





Chevron’s tasks and timelines during severe weather are guided by the company’s hurricane action plan. Storms are monitored as soon as they develop. If they have the potential to impact the Gulf of Mexico, the hurricane evacuation team is activated, and the DSC is staffed 24 hours a day.

“Assets in the Gulf are evacuated and production is curtailed in

phases, based on the track of the storm and information provided by the National Weather Service,” Boepple adds. “The facilities closest to the tropical weather’s most immediate path are cleared first. All available marine and aviation assets are directed and monitored by the DSC throughout the entire evacuation and remobilization process.”

### The role of information technology

Chevron information technology (IT) teams from around the world put their stamp on Jack/St. Malo, providing the technical support that helped this major capital project achieve first oil. Chevron IT experts delivered telecommunications and the infrastructure needed to support





ZZZ-1800  
UNIT SKID



operations at Jack/St. Malo as well as network connectivity on the floating production unit, the pipe-laying vessel, floating accommodation vessel and the drillships.

“One of the big wins was the great collaboration we had,” says Keith Breaux, Chevron’s DWEP Information Technology manager. “We were aligned not only in transition from the project team to the Gulf of Mexico business unit, but on the facility itself. The IT teams from Jack/St. Malo, DWEP and GOM business units were phenomenal. They worked together seamlessly.”

Over the course of the project nine “digital oil field” solutions were also implemented, including new

operator workflows and Chevron’s Production Reliability and Efficiency Program.

“These solutions helped the GOM business unit increase the reliability of the facility, reduce health, safety and environmental risks, and decrease costs,” says GOM Information Technology manager Jennifer Scriabine. “Real-Time Reservoir Management is also providing engineers with the information they need to make faster, better decisions to bring wells on line sooner, reduce downtime and maximize production.”

Linking the facilities required 88 miles (142 kilometers) of new network subsea fiber optic cable on the ocean

floor. The cable runs from Jack/St. Malo to a high-performance network connectivity system made available by BP to oil and gas producers in the Gulf of Mexico. The host also boasts more than 137 miles (220 kilometers) of telecommunications cabling onboard for fast, reliable access to data and systems.

Design, construction and regulatory approval required the processing of more than 200,000 documents and drawings, including regulatory and specifications documentation, process safety, personal safety and environmental management system documentation, as well as operating and installation manuals. The team migrated construction data to a document management system for use during handover and operations and developed a central document archive.

“The IT challenge for a major capital project is staggering,” explained Eric Sirgo, DWEP’s general manager of Major Capital Projects. “IT is integral to all aspects of the project, including document management, telecommunications, security, operational data gathering and control and reservoir management. IT’s role and contribution were critical to the project’s overall success.”



**Eric Sirgo, DWEP’s general manager of Major Capital Projects.**



# Operational Excellence

## Chevron's values and vision

To achieve and sustain projects like Jack/St. Malo, Chevron has developed world-class capabilities and a company-wide culture of operational excellence. It is a process that requires active leadership and the engagement of the entire workforce, employees and contractors alike. At its core is the belief that all incidents are preventable and that “zero incidents” is an achievable goal.

### Workforce health and safety

Every job involves risk. Chevron identifies and mitigates those risks by enhancing technology, tools and competency at all levels. The company gives its employees and contractors the authority and responsibility to stop work if they believe that conditions are unsafe. Chevron is also an industry leader in providing health awareness and educational programs to its employees and their families, as well as to the residents of their host communities.











# The View from Here

## A solid foundation for future deepwater developments

“Jack/St. Malo is the fourth deepwater facility that we operate in the Gulf of Mexico,” says Mike Illanne, vice president of Chevron’s Gulf of Mexico Business Unit. “Chevron is a big operator in the Gulf and the number one leaseholder overall. Our top priorities are protecting people, being good stewards of the environment, and good business partners in the communities where we operate.”

With its numerous technical advancements, Jack/St. Malo serves as an example of what Chevron can achieve and a foundation for its future deepwater developments. To that end, we place the highest priority on the health and safety of our workforce and protection of our assets and the environment. We aim to be admired for world-class performance through disciplined application of our Operational Excellence Management System.

“I believe that the work we’ve done on process safety and environmental protection—ensuring that we had the right design and procedures in place to operate this project reliably—has been outstanding,” Illanne adds. “I am very confident that Jack/St. Malo will have a great record of safety and success going forward.”



**Mike Illanne, vice president of Chevron’s Gulf of Mexico Business Unit.**



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# Jack/St. Malo—a collaborative success

## A winning formula

As with any major development, success hinges on close and continuous collaboration between all parties involved. Chevron's Jack/St. Malo prospect is no exception. This ongoing deepwater frontier development in the Gulf of Mexico began following discovery of the two fields in 2003–2004. With such a major project, Chevron elected to benefit from the 'chain of accountability' for mission-critical services, whereby responsibility for key, linked services was assigned to a single provider.

For Chevron, collaborating with Schlumberger to develop several of these service solutions was a natural choice based on the companies' shared positive experience developing the Tahiti prospect in 2004. Learnings from the Tahiti prospect proved invaluable as it set the record for water depth for a producing well.

The decision to collaborate had dual benefits: first, communication between Schlumberger and Chevron was greatly facilitated by all parties having a common purpose—working with Chevron to construct wells in challenging geology and landing them precisely in reservoir sweet spots. Second, technical expertise was available to all participants up and down the chain of operations. Learnings experienced by operational planning and implementation teams was seamless, resulting in major efficiencies as the project proceeded. Close collaboration ensured that data required for life-of-reservoir decisions was acquired at the most opportune time.

To illustrate, flow assurance, which is typically a completions concern, requires field designers to know precisely where the asphaltene threshold will be reached. The information required to make this calculation is provided by sophisticated logging tools run many months earlier in the development process. Coordination between the information providers and data users fast-tracked resolution of this critical task.

## The challenge

The Jack/St. Malo prospect presented numerous technical challenges in terms of water depth that ranged from 2,100 ft (640 m) to more than 7,000 ft

(2,134 m). Reservoir targets were estimated at more than 20,000 ft (6,096 m) beneath the seabed. They were characterized as low permeability, 30,000-psi ultra-high pressure reservoirs that would require a full portfolio of suitable and reliable technologies to enable Chevron to assess the reservoirs' economic potential toward reaching production goals of 94,000 b/d of oil and 21 MMcf/d of natural gas in the coming years.

## Valuable information for exceptional planning

Chevron's planners were already applying their foreknowledge based upon seismic surveys and other exploration techniques to build dynamic models. These could be easily updated as additional information became available. The early models were promising; nevertheless, each new bit of information helped to clarify and improve Chevron's ability to estimate costs and profits.

In 2006 Chevron commissioned a 3D seismic survey conducted with the Q-Marine\* point-receiver marine seismic system to image the St. Malo reservoir. Information from this survey enabled Chevron to high-grade initial reservoir models and optimize early appraisal and development targets. The positive results of this survey led Chevron to sponsor a multient wide-azimuth (WAZ) project in 2008. The new survey provided better illumination under complex salt bodies and improved structural definition. During 2011 and 2012, Chevron employed a combination of Chevron and



**Figure 1: A collaborative environment between Chevron and Schlumberger teams enables optimal data integration and management throughout operations at Jack/St. Malo.**

WesternGeco imaging technologies to improve the seismic imaging, which then served as the foundation for a collaborative uncertainty analysis study that integrated Chevron’s knowledge of the Earth Model with the WesternGeco WAZ data. Results from the study were integrated into Chevron’s static model for St. Malo reservoir management and used for scenario testing and risk mitigation.

### Drilling technology evolution

The Jack/St. Malo project benefited from application of the industry’s technology advancements. Drilling tools and techniques, drilling fluid development, and logging and well-testing technology were all evolving rapidly at this time to deliver higher efficiency, more precise information, and greater safety.

For drilling at Jack/St. Malo, the PowerDrive Orbit\* rotary steerable system (RSS) efficiently drilled up to 8,000 ft (2,439 m) of complex, salt, shale and abrasive sandstone strata that would have greatly affected the run-life of previous-generation equipment. The highly reliable push-the-bit pad actuation of the PowerDrive Orbit RSS utilizes metal-to-metal seals for enhanced drilling

performance, efficiency, and trajectory control, even when high shock and vibration and other harsh drilling conditions are present.

The system enabled accurately steering through the overlying strata to hit reservoir targets and to achieve Chevron’s ambitious development plan while reducing shock and vibration issues that are anathema for bottomhole assemblies. The drilling system delivered an unprecedented 24% improvement in salt penetration rates, and 208% improvement in the sediment.

*Compared with earlier St. Malo wells, Chevron saved 15.9 days of deepwater drilling vessel time, which is equivalent to a 55% drop in estimated costs and savings of more than USD 14 million.*

One application where innovation directly addressed Chevron’s concerns was underreaming while drilling. Previously numerous trips were required to achieve desired hole diameter, with the costs not in line with the marginal value. Because the Rhino XC\* on-demand hydraulically actuated reamer can

be quickly adjusted via flow activation, 48 hours of trip time was saved.

Continuous measurements transmitted in real time while drilling enabled M-I SWACO, a Schlumberger company, to customize its drilling and completion fluids as needed. Chevron drilling engineers worked with Schlumberger fluids experts to model each section to minimize equivalent circulating density (ECD) and reduce lost returns. Conventional fluid systems were compared with M-I SWACO’s WARP\* advanced fluids technology. This micronized-barite drilling fluid was selected in consideration of its ability to maintain ECD within a narrow band, with a subsequently reduction in overall fluid losses to 144 bbl.

### Reducing risk

Chevron’s mission-critical objectives for wireline logging addressed reservoir compartmentalization and communication, relative position of reservoirs for designing well paths, prospective production potential, and, most importantly, early identification of any production impediments.

Although wireline logging tools provide the most accurate geological and petrophysical information needed to characterize the reservoir, the risk of tool sticking with its subsequent fishing costs concerned Chevron engineers. Accordingly, Schlumberger deployed the logging toolstrings on the MaxPull\* high-tension wireline conveyance system using TuffLINE\* torque-balanced composite wireline cable to provide 40% greater pulling capacity than conventional ultra-strength logging cable systems. The MaxPull system also delivers higher bottomhole wattage to run



**Figure 2: The newly designed pad actuation system, combined with real-time three-axis shock-and-vibration measurements, allows the PowerDrive Orbit RSS to withstand the most difficult drilling conditions and operate at higher rotational speeds than conventional systems.**



complex tool combinations that reduce the number of logging runs.

Workflows were developed to efficiently acquire and analyze the data needed to address Chevron's immediate concerns, but Schlumberger understood that more insight would be required as development progressed. Perhaps the most valuable information was derived from measurements acquired with the MDT\* modular formation dynamics tester equipped with Quicksilver Probe\* focused fluid extraction and the InSitu Fluid Analyzer\* real-time downhole fluid analysis (DFA) system because it enabled real-time decision making by Chevron engineers. The previously mentioned asphaltenes threshold is but one of the critical parameters revealed by DFA conducted with specialized sensors on the fluid at reservoir conditions.

As its name implies, Quicksilver Probe extraction speeds the acquisition of uncontaminated formation fluid. In addition to the real-time insights provided by DFA, fluid samples can be retrieved for laboratory analysis. Both the shorter station time for Quicksilver Probe extraction and the critical reservoir information obtained enable reducing the risk of sticking to save valuable rig time. Where closely spaced fluid samples are not required, the MDT tool is augmented with PressureXpress\* reservoir pressure while logging service to determine pressure gradients that identify gas/oil and oil/water contacts, which is vital knowledge for completions specialists and reservoir engineers.

### The gold standard

Recognized by petroleum engineers as the "gold standard" of reservoir data, the final step in the well evaluation is the



**Figure 3: Engineers discuss the Quicksilver Probe focused extraction which drains off contaminated filtrate from the outer ring while sampling uncontaminated formation fluid from the center port.**

well test, a temporary completion of the well achieved by a string of downhole test tools. Pressure transients, measured by precise downhole gauges, are used by reservoir engineers to calculate reservoir volume and connectivity and place boundaries. These data give critical input to Chevron's 3D reservoir model for economic decisions.

*Well testing at Jack/St. Malo determined that commercial production rates were indeed achievable and, in the process, set a world record for well test depth at more than 28,000 ft (8,537 m).*

As part of the dynamic underbalance management program, wells were prepared for optimal flow using the latest-generation innovation in HP high-shot-density gun systems—the INsldr\* perforating shock and debris reduction

technology. Chevron used the technology to minimize debris fall-out and manage the dynamic underbalance effects in their HP wells, enabling a best-fit completions design.

The development of Jack/St. Malo remains on target due to the continuous collaboration between Chevron and Schlumberger. As the program continues, knowledge of the reservoir—from data integration and management by Chevron experts in the 3D dynamic reservoir

model—will benefit future decisions as well as provide backbone information for completion and production engineers, extending all the way to final abandonment.

Perhaps the ultimate achievement is that the development of the Jack/St. Malo blueprint will guide geoscientists and engineers as they tackle future challenges.

\*Mark of Schlumberger

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# Lower Tertiary success with leading-edge completion and production technologies

The Lower Tertiary trend in deepwater Gulf of Mexico is characterized by older sediments with low porosities, ultra-deepwater depths, and high bottomhole pressures. At the outset, Chevron realized that production from the Jack/St. Malo discoveries was not economically feasible without significant advances in completion and production technologies. To develop the critical solutions, Chevron teamed up with Halliburton to push the technology frontier.

## Enhanced completions

For optimum results in the Lower Tertiary, Halliburton developed the ESTMZ™ Enhanced Single-Trip Multizone system in 2007, based on its highly successful single-trip multizone system. Chevron depended on the ESTMZ system's full 10,000 psi differential pressure rating, which increases the operating envelope for deeper wells and allows frac design optimization.



**Halliburton's Integrated Completions Center in New Iberia, Louisiana, provides comprehensive resources for deepwater completions throughout the Gulf of Mexico region.**



**The Stim Star IV has the frac fluid and proppant storage capacity, blending on the fly and high-volume pressure pumping capabilities needed for Lower Tertiary wells in deepwater Gulf of Mexico.**

The industry's highest frac and proppant ratings enabled pressure pumping to be increased to 45 bbl/min. The volume for 16/30 high-strength proppant increased from 300,000 lb to 3.75 million lb per well with the use of special alloys that have greater erosion resistance. These capabilities enabled the Chevron-Halliburton team to perform single-trip completions on a six-zone well,

saving 14 trips. Compared to conventional completions, Chevron estimates the ESTMZ system saved up to 25 days on average and approximately \$22 million per well.

## State-of-the-art stimulation

During the first completions for the Jack/St. Malo fields, Halliburton used two stimulation vessels in order to meet the high volume stimulation requirements. Through innovative solutions, such as the Offshore Proppant Transfer System, and through the launching of the Stim Star IV in 2015; Halliburton can accomplish these same tasks with just one stimulation vessel.



The Offshore Proppant Transfer System has blown proppant offshore, vessel to vessel, at 1,000 lb/min. The Stim Star IV has storage capacity for 14,374 bbls of frac fluid and 4 million lb of proppant. With 21,500 hhp of high pressure pumps, redundant 75 bpm blenders, redundant power units, and redundant proppant movers, the Stim Star IV is capable of providing more quality assurances than any vessel to date. These technological advances make it possible to place over 4 million lb of proppant in a single trip.

### Real-time visualization service (RTVS)

Halliburton's completion crews can access the InSite® system for real-time visualization of the entire sandface assembly, including the service string. This helps save significant time and money, while increasing the reliability of service tool positioning. During pre-job analysis, the crews can validate the interaction between the completion

string and the service tool by simulating the job using the proposed operational steps. As the job is underway, it is possible to track, in real time, the service tool's movement, position and status. For post-job analysis, the crew is able to use the visualization tools to review all or portions of the job data using the replay feature or log plots.

Wellbore assurance, provided through various critical operations such as wellbore cleanout, completion services, pumping and fluids, also contributes to the success of the wells. This integrated approach in planning and execution mitigates risks, while promoting efficiency, and providing an optimal conduit for the reservoir to flow.

### Collaboration success

The Jack/St. Malo project is a remarkable example of how collaboration between an operator and a service company can achieve step-change advances in oilfield technologies. The technical innovations and lessons learned during the Jack/

St. Malo project have made deepwater economics more favorable by reducing the number of trips needed to complete a well from Lower Tertiary formations.

### Advancing the industry frontier

Halliburton is committed to working with Chevron to reduce completion and production costs for successive phases of the Jack/St. Malo project and apply the efficiency gains to other deepwater and ultra-deepwater E&P projects in the Gulf of Mexico and throughout the world. In fact, Halliburton has worked on more than 90% of deepwater operations worldwide, including every project in the Lower Tertiary.

### Integrated completion resources

In February 2015, Halliburton opened its new Integrated Completions Center (ICC) in New Iberia, Louisiana. Located on 103 acres, the 275,000-sq-ft climate-controlled facility includes a 30,000-sq-ft administration building, an operations command center and several learning auditoriums for training. The ICC will increase the company's resources for deepwater completions, align services, ease equipment maintenance, preparation and job execution for its Gulf of Mexico area customers, all aimed at delivering the highest level of service quality.



Real-time visualization/collaboration centers provide technological elements that facilitate access to information and effective team decision making.

## HALLIBURTON

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# Enbridge WRGS provides gas gathering services for Jack/St. Malo

Enbridge constructed, owns and operates the Walker Ridge Gathering System (WRGS). WRGS currently serves the Jack/St. Malo fields, and will also provide the gas portion of the Big Foot field when it is connected. With an estimated capital cost of \$400 million, the WRGS has a capacity of 120 million cubic feet per day (MMcf/d) and includes 170 miles of 10-inch and 8-inch diameter pipeline at water depths of up to 7,000 feet. The WRGS ties into Enbridge’s Manta Ray and Nautilus offshore pipeline systems. The first phase of the system, serving Jack/St. Malo, went into service in December 2014.

## Integrated Project Team

Soon after the Jack/St. Malo discoveries, Enbridge engaged with Chevron and its project co-owners to understand the requirements of a gas gathering system for the Walker Ridge area.

“It’s important for us to always focus on the needs of the customer,” said Enbridge’s Allan Schneider, vice president of engineering and project execution. “Having a clear understanding of their needs and working with our customer every step of the way ensures a good outcome.”

Once definitive agreements were signed in December 2010, Enbridge and Chevron formed an integrated team, with defined roles and responsibilities, to design and implement the WRGS project.

The 20-person team had members from all aspects of the project including procurement, project controls, quality

control, engineering and project management. Chevron team members participated in technical, commissioning coordination and risk management roles on the Enbridge Project Team. Representatives from Jack/St. Malo and Big Foot, as well as a commercial representative were actively monitoring the project and officially represented Chevron and its project co-owners on interface issues and decisions.

The team conducted biweekly meetings to discuss ongoing issues, make decisions, and carefully document every step of the project. The team consulted with groups working on the Jack/St. Malo floating production unit (FPU) to understand all requirements and develop procedures to tie the pipeline into the FPU in

7,000 feet of water. In addition, the team worked with Chevron to provide a comprehensive progress report annually to the project co-owners on Jack/St. Malo. The integrated team approach worked well and kept the project on schedule.

## Unique Requirements for WRGS

The Walker Ridge Gathering System was designed to meet a number of unique requirements. The WRGS had to transport up to 120 MMcf/day of high pressure gas 150 miles from Walker Ridge 718 to Ship Shoal 332. The system had to safely tie into the Jack/St. Malo FPU in 7,000 feet of water using steel catenary risers (SCR) and terminate in the crowded infrastructure on the shelf around Ship Shoal 332.



**(Below) Ship Shoal 332 platforms (A & B) in the U.S. Gulf of Mexico, (left) Technip’s Deep Blue performed the pipelay work. Photo courtesy of Technip.**





The Jack/St. Malo FPU was designed to be powered by natural gas, so the WRGS pipeline had to be bi-directional, providing import gas for FPU startup operations, and for times when produced gas became insufficient to meet fuel needs during the life of the platform. In order to provide suitable pressure and quality for gas used during import operations, a compressor and dehydration station were installed at the Ship Shoal 332 platform.

The WRGS design also had to accommodate the subsequent tie-in of gas production from other deepwater fields, so the project included installation of several large subsea sled structures with Y connection points.

In addition, by terminating at Ship Shoal 332, the WRGS gave the Jack/St. Malo owners an alternate route to ship gas to market. In the unlikely event of problems on Enbridge's Nautilus pipeline, gas from WRGS could be directed to the nearby Kinetic Energy Express pipeline, assuring reliable gas delivery.

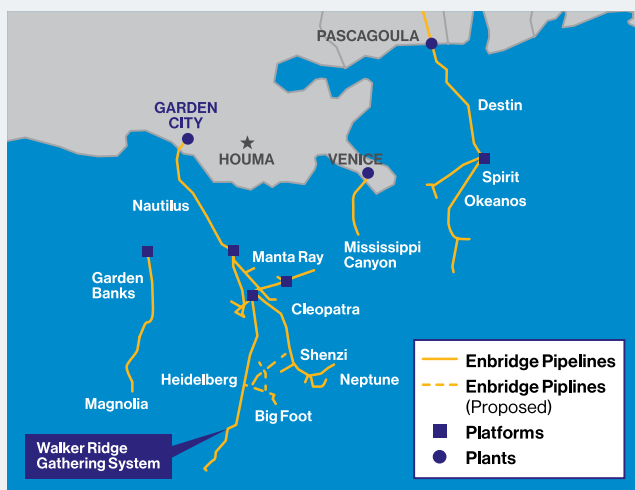
During the front-end engineering and design (FEED) process, the team developed a comprehensive design for the WRGS to address all of these requirements.

## WRGS Implementation

While the Jack/St. Malo FPU was being assembled in Ingleside, Texas, Enbridge began construction of the WRGS, with Technip as the pipelay contractor. Technip's Deep Blue and Deep Energy vessels, which are capable of installing

up to 33 miles of 10-inch diameter pipe in a single voyage, were selected to perform the work.

The WRGS was constructed during peak activity in the Gulf of Mexico. At the time, pipeline contractors were working at full capacity, and Enbridge had to coordinate with suppliers and



several producing groups to schedule WRGS construction and keep the project on schedule. Work proceeded without weather delays, completing the 170 miles of the gas pipeline system in five segments.

As the pipeline was installed, the project team focused on equipment inspection and quality control of system components. Extensive pigging tests were performed on the bi-directional Y connections (provided by Quality Connector Systems, now part of Oil States International), and additional tests were performed to assure pig-ability of the entire system.

Chevron and other project co-owners required the WRGS to have a very robust emergency pipeline repair system (EPRS) in place to minimize downtime in the event of pipeline damage. To

comply with the requirement, Enbridge acquired and tested a complete EPRS package, including lifting frames, clamps, connectors and remotely operated vehicle tools for coating removal, cutting and beveling.

At Ship Shoal 332, Technip's Uncle John vessel was used for spool and

riser installation in 435 feet of water. For redundant protection, installation included a subsea safety shutdown system for the high pressure gas line in addition to the standard surface emergency shutdown system.

At Jack/St. Malo, the gas export line was successfully connected to the FPU through a steel catenary riser, and during initial startup, Enbridge delivered

gas to the platform, demonstrating the bi-directional operation of the pipeline system.

The WRGS delivered first gas from Jack/St. Malo in December 2014. Enbridge completed the project on time and under budget.

The WRGS system is designed for reliable operation, and provides options for Chevron and its project co-owners to keep oil flowing and deliver gas to market.



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## Early delivery of complex production control umbilicals

Over the past 20 years, Aker Solutions has delivered more than 550 umbilicals for some of the world’s most challenging fields, from harsh environment to ultra-deep, high-pressure water conditions.

For the Jack/St. Malo fields, Aker Solutions supplied five subsea production control umbilicals, which provide hydraulic, electrical and fiber-optic service. Totalling 112,403 m, these steel-tube umbilicals have been deployed at 7,000-ft water depth.

Engineering, project management, and manufacturing took place at the

company’s state-of-the-art umbilical facility in Mobile, Alabama. “The JSM umbilical project required extensive coordination with suppliers, the



**Aker Solutions’ umbilical facility in Mobile, Alabama, with its high-capacity horizontal cable, is specially designed to meet the challenges of demanding deepwater applications.**

deployment contractor and Chevron’s JSM team,” explained Aker Solutions’ project manager Graham Jones. “Despite the logistical challenges and complex umbilical construction, which included UV protection for the dynamic portions of the umbilicals that are above the water line and a double closing process to incorporate additional fiber-optic cables and hydraulic lines, Aker Solutions achieved early delivery, before the contractual date.”



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## Success through project performance forecasting and technology qualification

The Jack/St. Malo project posed numerous challenges in terms of performance forecasting, technical risk assessment and qualification of innovative E&P technologies. “DNV-GL is proud to have contributed to the success of this deepwater milestone through our technical advisory services,” explained Graeme Pirie, Vice President DNV-GL – Oil & Gas.

**Performance forecasting.** A DNV-GL team performed an asset risk study, assuring that the Jack/St. Malo facility will meet its intended production targets based on the engineering design and system configuration. The study



included technical risk assessments to ensure that the topsides and loads were within design specifications.

**Technology qualification.** In Bergen, Norway, DNV-GL performed testing on umbilicals and polyester ropes. Laboratory testing was also performed at DNV-GL’s facility in Columbus, Ohio, to ensure that materials under test

were fit-for-purpose in the downhole Lower Tertiary environment.

Chevron has endorsed DNV-GL’s recommended practice (RP 8203) for its Technology Qualification Program (TQP). The TQP is used to qualify any novel or unproven technology that is under consideration.



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# Bevel Tech Group Inc. provides ID Machining of JSM Riser and FSFL pipe joints

Bevel Tech Group Inc. (BTG) provides critical, precision machining on the ID and OD of deepwater pipe and components from 3" to 28" onsite, with CNC precision, in the U.S. and internationally. In 2006 BTG completed the machining on Chevron's Tahiti Project steel catenary risers (SCR), FSFLs, Flow-lines and J-Collars, machining over 6,000 ends to project specifications using our manual counter boring systems.

## Proprietary CNC Machining

Developed in 2006, BTG's CNC machining system was designed to provide CNC quality machined products in virtually any location, no matter how rugged or remote. The system can operate under generator power, is adjustable to compensate for uneven landscapes, and is containerized for shipping overseas. However, BTG's main goal in developing the concept was to provide our fully trained staff a safe operating system for use in any set up location.

For the Jack/St. Malo Project BTG's automated CNC system performed the ID machining on the FSFL and SCR pipe joints on location. More than 3,500 ends were machined to exact ID and WT specifications needed on time, safely.

Entering our 10<sup>th</sup> year of operating our CNC systems, we have completed more than 50 deepwater machining projects without any safety or quality incidents.

## About Bevel Tech Group Inc.

Bevel Tech Group Inc. was established in 1998 as a specialty field and



**Bevel Tech Group Inc.'s machining system provides CNC quality products in virtually any location, no matter how rugged or remote.**

shop machining company with heavy emphasis on deepwater pipe and products. Since then, BTG has become a leader in counter boring SCR pipe and components needed for deepwater projects. Bevel Tech Group Inc. partners with major oil companies and their EPC contractors to develop and provide unique services for the deepwater industry:

- Counter boring (OD and ID) for SCR and flow line piping or other applications
- Specialized coating machining removal/modifications
- Pipe End Measurement Services (PEMS) Laser Metrology
- Pipe cutting and beveling services for all sizes of pipe.

- Bolting/Torquing
- Isolation Testing
- Millwrights
- Field Machining of all Types

**BTG provides proven project management, equipment, and technicians while achieving high standards in Safety and Quality.**

**Bevel Tech Group**.INC

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# Danos Supports Jack/St. Malo Platform Commissioning

Danos provided mechanical hook-up and commissioning support for the Jack/St. Malo floating production unit (FPU). The company also closed out or mitigated more than 2,000 punch-list items to enable Chevron to produce first oil on schedule.

## Onshore and Offshore Support

Danos provided onshore logistics, materials management, fabrication and construction support throughout the topsides integration. Mechanical walkdowns began 90 days before the FPU was towed from the integration yard in November 2013.

Once the FPU was moored at Walker Ridge 718, Danos continued to provide installation, testing and remediation services through January of 2015. One of the challenges of the Jack/St. Malo project was that many operations typically performed onshore—adjustable speed drive (ASD) transformer removals, large valve replacements, and hydrostatic testing—had to be carried out in the offshore environment. Danos managed difficult logistics, as well as limitations for personnel on board, to successfully perform these complex operations on the FPU moored 250 miles from the nearest port.

## Project Highlights

Danos contributed to the success of the Jack/St. Malo project:

- Fabricated and installed a temporary oil export system with two pumps



**Danos owners, from left: Paul Danos, Executive Vice President; Garret "Hank" Danos, President & CEO; Mark Danos, Vice President of Project Services; and Eric Danos, Executive Vice President.**

- and 500 linear feet of pipe, requiring over 300 shop welds.
- Removed and reinstalled five large ASD skids in two buildings, and designed and performed infrastructure modifications needed to complete the task.
- Removed, repaired and reinstalled 106 PetrolValves and actuators, including 52 large, high-pressure valves (rated at 15,000 psi).
- Installed a 66,000-pound H<sub>2</sub>S removal skid below the platform's north bridge. Danos project managers designed a skid-in plan to install the unit from the platform's moonpool, eliminating the need for derrick barge support.
- Completed 160 pressure tests of 34 systems at pressures up to 22,500 psi. Issues found during 14 flow line tests were successfully repaired without delaying line commissioning.

## About Danos

Founded in 1947, Danos is a family-owned and managed oilfield service provider. In addition to project management and construction services, Danos offers production workforce, environmental, instrumentation and electrical, fabrication, coatings, materials management, scaffolding, shorebase and logistics solutions.



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# Heerema transports, installs Jack/St. Malo FPU

Heerema Marine Contractors (HMC) transported the Jack/St. Malo floating production unit (FPU) from the Kiewitt Offshore Services (KOS) shipyard in Corpus Christi 425 miles to Walker Ridge 718. HMC installed mooring lines and steel catenary risers (SCR) to the FPU. In addition, HMC managed design, fabrication and testing of the SCR pull-in equipment, and marshaled chains, ropes and connectors needed to install the FPU in 7,000 ft of water. This large-scale installation required subcontracting with 18 suppliers, as well as deployment of the Balder Deepwater Construction Vessel, a support vessel, a smart buoy, two barges and a total of 14 tugs.

## Suction Pile Installation

First, Heerema transported 16 suction piles and installed them in the ocean floor to secure the mooring lines. Each pile was 120 ft long and 19 ft in diameter, with a dry weight of 353 short tons. The piles were towed on barges from the KOS facility to Walker Ridge block 718. The Balder vessel, which is equipped with two cranes and can lift up to 6300 tons, unloaded the piles from the barge and lowered them to the seabed. Suction pumps were used to drive them into the sea floor. This operation took two weeks, from May 8 to May 22, 2013.

## Marshalling Materials

At its facility in Port Fourchon, La., HMC gathered and organized 13,000 m of chains with associated shackles; 43 reels containing more than 72,000 m of polyester rope; and a variety of subsea mooring connectors and rope connectors.



DCV Balder lifting a Jack/St. Malo suction pile.

## Tow-out and Installation of Mooring Lines

In November 2013, HMC towed the Jack/St. Malo FPU from the KOS facility. The massive FPU, which weighs 55,000 mT, was towed by 11 tugs to a holding area where the push fenders were removed and bunkering took place to increase its draft. Then the FPU was towed to its operating location.

Next, HMC installed the 16-line mooring system to secure the FPU in place. Each of the mooring lines was secured to a mooring pile, and was comprised of an anchor chain, multiple polyester rope segments joined by H-link connectors, and an upper chain connected to the FPU.

## Custom SCR Pull-in System

HMC managed the design, procurement, fabrication and testing of the custom-engineered SCR Pull-in equipment. The system, which includes an SCR module (SCRM), specially manufactured chain, chain locker and work wire winch, has the capacity to pull 1250 mT of riser.

Once the FPU was moored on location, six SCRs were laid down on the seabed in proper orientation, and so their installation would not interfere with the mooring lines. Then the SCRs were recovered in sequence and pulled up by the SCRM. This operation was completed in January 2014.

## About HMC

Heerema Marine Contractors (HMC) is a world leading marine contractor in the international offshore oil and gas industry. HMC transports, installs, and removes fixed and floating structures, subsea pipelines and infrastructures in all water depths. The company is a fully-owned subsidiary of the Heerema Group.



## HEEREMA MARINE CONTRACTORS

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# Self-supporting, open-water umbilical systems for rigless, riserless well control

A world-class provider of subsea technologies, JDR Cables plays a key role in the design, development and delivery of self-supporting, open-water intervention workover control (IWOC) umbilical systems.

**Self-supporting open-water umbilicals.** Custom-engineered, patented and manufactured by JDR, this class of open-water umbilicals utilizes high strength materials and innovative component configuration to support its own weight—and that of the subsea termination assembly. The JDR umbilicals are suitable for riserless, rigless open-water applications. They can be spooled rapidly and immediately upon arrival at the site, and may be deployed through the moonpool or “over the side” from a vessel of opportunity. The Umbilical Termination Assembly (UTA) can be deployed via the umbilical as well. JDR umbilicals have a smaller footprint and reduced need for topside equipment. Risk of exposure for personnel is reduced as well.

**Workscope.** For the Jack/St. Malo project, JDR developed two high-strength, self-supporting, open-water umbilical systems, designed to operate in water depths of 7,000 ft. With patented terminations, the umbilicals enable an extensive range of well control packages to be rapidly deployed from a vessel of opportunity, without the need to clamp the umbilical to a wireline or riser.

The umbilical packages featured JDR’s high-capacity subsea terminations



**Comprehensive pre-deployment inspection and testing ensured successful installation of the IWOC umbilicals for the Jack/St. Malo project.**

and custom-engineered hydraulic reelers for open-water operations. Designed and manufactured in Littleport (UK), the umbilicals were integrated with the reelers before field shipment.

**Comprehensive testing.** In addition to a full API17E qualification program, JDR undertook a series of tests to evaluate and verify the strength and compatibility of the umbilical design under a variety of operational and environmental workloads.

The umbilicals were load tested at 2.5 x SWL with no failure. There was 95% retention in strength of umbilical after fatigue due to continuous reeling (employing a solid turning wheel for uniform load distribution). The umbilicals were suitable for continued operation at its safe working load (SWL) of 30,000 lb for >50 deployment cycles. The subsea termination exceeded the

specified minimum break load (MBL) of 72,500 lb.

JDR’s dynamic and agile approach delivers industry-leading solutions; building long-term partnerships and increasing asset productivity. New technologies, such as JDR’s self-supporting, open-water umbilical systems, have been developed to enable Operators to realize significant cost savings for their intervention operations in deepwater applications.



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# KBR is Pleased to Have Collaborated with Chevron on Successful, Ground-Breaking Jack/St. Malo Project

The opportunity to participate on the Jack/St. Malo floating production unit (FPU) for Chevron positioned KBR at the forefront of deep water field development.

One of the largest semi-submersible production platforms in the world and the first semi-submersible floating production unit designed and built as a low-motion unit for the Gulf of Mexico, the Jack/St. Malo FPU is an example of KBR's ability to offer integrated solutions through combined expertise across all of KBR and our subsidiaries.

KBR performed conceptual engineering and design, pre-front-end engineering design (FEED) and FEED services and KBR subsidiaries Granherne and GVA collaborated on the execution



**Jack/St. Malo's hull arrives in Port Aransas, TX on its way to the fabrication yard in May of 2013**

of the design and engineering support through fabrication for the deep draft semi-submersible including: hull,

deck box, accommodations, appurtenances, equipment foundations, mooring system design, and anchor suction piles. The semi was designed to minimize vessel motion and allow acceptable fatigue lives of the moorings, risers and umbilicals.

With the Jack/St. Malo FPU, Chevron has expanded the possibilities of offshore exploration and production and KBR is pleased to have collaborated with Chevron on this successful and ground-breaking project.



**Jack/St. Malo is the largest semi-submersible in the Gulf of Mexico based on displacement. With a planned production life of more than 30 years, current technologies are anticipated to recover in excess of 500 million oil-equivalent barrels**

# **KBR**

**KBR, INC.**

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# Oil States technology gets SCRs on board at Jack/St. Malo

Oil States Industries, Inc. collaborated on the Jack/St. Malo project, providing pull-in technology for the installation of multiple SCRs as well as FlexJoint™ HPHT SCR flexible joint assemblies.

A cooperative effort between Oil States–Houma and Bardex, the SCR Pull-In System was used to transfer the flow-lines and risers from the installation vessel to the FPU. The Oil States team designed, manufactured, and tested the system’s SCR Pull-In Module; the chain windlass and chain locker assembly; and the work wire and auxiliary winches.

The system offered the ability for the entire system and components to translate 360° around the moon pool on rails and for the SCR module to rotate 360° under load. These capabilities were vital to achieving precise installation into the hang-off porches integral to the FPU hull.

The modules included:

- SCR Pull-In Module with chain jack designed for a 1250 Te nominal capacity and 147mm chain for lifting and positioning the SCRs
- Chain Locker Module for storage of 600m of 147mm chain, including a 40 Te auxiliary winch to manage and store slack
- Work Wire Winch Module designed for 700m of 3” wire with a line pull of 175 Te on all layers; used to install the chain onto the FPU from the support barge

Oil States completed a full-scale dynamic test of the system at its facility in Houma, Louisiana. The installation was completed on time and without incident.

Oil States also designed, qualified and manufactured four 10 ¾” production, one 10 ¾” gas export, and one 20” oil export FlexJoint™ HPHT SCR flexible joints for the Jack/St. Malo

project. The flexible joints provide the required storm safety and fatigue resistance for the SCRs connected to the Jack/St. Malo FPU.

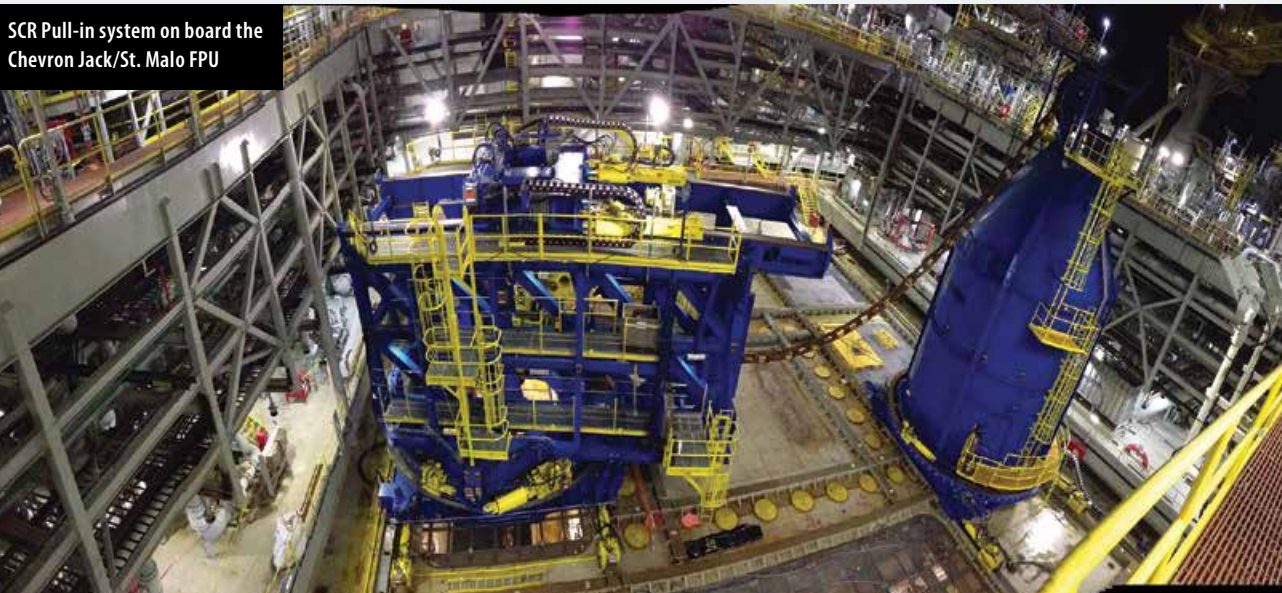
Acute Technological Services (ATS), owned by Oil States, provided specialty welding services for the project and qualified three first-joint girth weld procedures and NDE. ATS also fabricated the first girth welds for each of the six top-of-riser assemblies.

Oil States Houma provided 16 Model UCF-104 7-pocket Underwater Chain Fairleads sized for 165mm chain.



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# Subsea Boosting Systems Contribute to Jack/St. Malo's Success

Seabed boosting technology from OneSubsea, a Schlumberger company, is making an important contribution to Chevron's Jack/St. Malo project by providing the necessary lifting required to produce from the two deepwater fields and enable long tiebacks to the development's Floating Production Unit (FPU).

To date, Chevron has drilled 12 wells in three clusters (one in the Jack field and two in the St. Malo field), which are served by three subsea pumps.

## Importance of Seabed Boosting

The prolific Lower Tertiary reservoirs tapped by Jack/St. Malo's 28,000-ft wells naturally provided enough pressure to lift the hydrocarbons from the reservoir to the seabed, and carry them through the long tiebacks and to the production platform. However, as the original reservoir pressure declined, Chevron chose to deploy subsea pumps on the seafloor to boost the production to the topsides facility. Chevron has stated that by reducing the back-pressure on the reservoir, the boosting pumps have the potential to improve the recovery factor by 10% to 30%. This translates to between 50 and 150 million barrels of additional oil recovery resulting from this leading-edge subsea boosting technology.

## The OneSubsea Solution

OneSubsea, through its Schlumberger and former Cameron roots, has implemented 30 subsea projects over the last 25 years and has unmatched experience in meeting the challenges of deepwater



**The OneSubsea boosting pumps are rated for 13,000 psi design pressure and differential pressures up to 4,500 psi.**

production. After rigorous evaluation, Chevron chose OneSubsea as its supplier for the subsea boosting system on the Jack/St. Malo project.

OneSubsea provided a broad scope of services and products for Jack/St. Malo, including engineering, project management, 12 subsea trees, production controls, and four manifolds. Subsea boosting technology was the most advanced contribution from OneSubsea, including three pump stations with 3.0MW single-phase pumps, subsea transformers, and pump control modules; associated controls and instrumentation; and a complete topside power and control system.

Installed in 2,100 m (7,000 ft) of water, the 3.0MW pumps are the most powerful subsea pumps ever deployed, and are rated for 13,000 psi design pressure and differential pressures up to

4,500 psi. The powerful pumps convey production through two 20-km (12.5-mile) tie-backs and the risers to the topside processing system on the FPU.

## Booster Systems Installed and Commissioned

The subsea boosting systems were installed and tested in 2014, and Jack/St. Malo's first oil was produced in December of that year. In early 2016, the systems were fully operational, lifting 70,000 bopd. Jack/St. Malo production is expected to ramp up to 94,000 bopd and 21 MMCF/day in the coming years.



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# Data-driven solutions across the entire oil and gas value chain

Buzzwords such as “analytics”, “data-driven solutions” and “business intelligence” have entered the lexicon of the oil and gas industry for some time now. With the implementation of oil and gas apps on the TIBCO Spotfire platform, Ruths.ai has transformed these buzzwords from promises to best practices.

## Ruths.ai

An oil and gas data analytics company, Ruths.ai specializes in building solutions that handle the messy reality of today's data. These solutions enable scientists and engineers make informed decisions across the entire oil and gas value chain. Ruths.ai leverages the TIBCO Spotfire platform as the visual analytics and interactive exploratory analysis engine of delivered solutions. Ruths.

ai has over eight years of experience in applying Spotfire to both common workflows and in-depth analyses in the oil and gas domain. Based in Houston, the Ruths.ai team works with technical end users and IT departments to gain valuable insights for some of the largest and most complex oil and gas fields in the world.

The Ruths.ai team is led by Troy Ruths, who is the founder and Chief Data Scientist. Troy earned his BEng in Computer Science from Washington University in St. Louis in 2008. Subsequently, Troy graduated with a PhD, also in Computer Science, from Rice University. He gained his first insights into the oil and gas industry as an intern for Chevron. In recent years, through Ruths.ai, Troy has worked

closely with Chevron's technical and IT teams to design and implement sophisticated analyses for a growing set of global applications.

## Data analytics resources

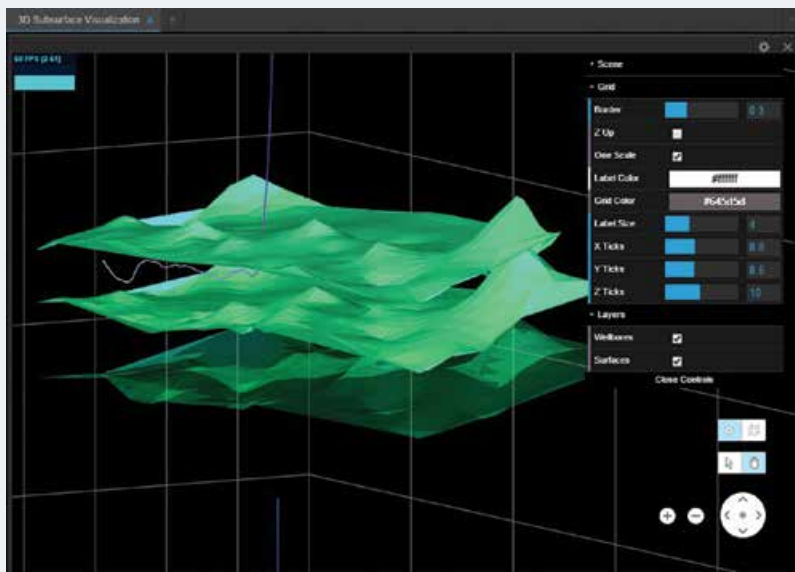
Ruths.ai works with its clients through an analytics retainer. This arrangement provides a comprehensive set of services for an organization to help mature and support its growth in data sciences and data-driven solutions. Specifically, the retainer offers:

- 1) **Exchange.ai Premier Membership** for privileged access to Exchange.ai, a multi-vendor analytics app store,
- 2) **Onsite and Web Support** for day-to-day data analysis questions,
- 3) **Advisement** for access to a Community of Excellence and data science advisors,
- 4) **Training** consisting of a deep course catalog of classes provided at regular intervals.

An exciting part of the Ruths.ai ecosystem is **DataShopTalk**, a collection of curated articles about Spotfire, data, data science, and messages about how the data analytics community lives, works, and plays.

## Oil and gas apps at Exchange.ai

Exchange.ai is the only multi-vendor analytics app marketplace that allows users to browse solutions and download a growing array of templates and extensions across the oil and gas value chain. Templates are guided analytic workflows that provide the users a launching



Ruths.ai's 3D Subsurface Visualization extension adds surfaces, trajectories and seismic volumes for a true, 360°, interactive view of the subsurface environment, bringing together the best data science interface for 3D analytics.



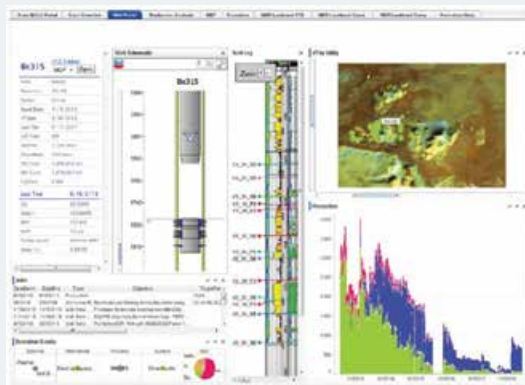
point for their Spotfire analysis. The templates are designed to solve common oil and gas workflows. Extensions provide new functionality to Spotfire by adding visualizations, data connectors, and tools.

Ruths.ai provides modular templates and extensions that can be combined to make powerful workflows. Some of the Ruths.ai products, available through Exchange.ai, include:

- **3D Subsurface Visualization** – an extension for visualizing 3D surfaces, well paths, variables on well paths, wellbore features, geobodies, and seismic within Spotfire,
- **Basic Type Curve Analysis** – an extension for aggregating well declines to determine typical behavior of a well ensemble,
- **Workover Candidate Analysis** – a workflow for identifying potential workover candidates using past field performance,
- **Well Log Visualization** – an extension to create, visualize, and interact with log data.

### Data analysis partnership with Chevron

Ruths.ai and Chevron have had an enduring data analytics collaboration. A recent example is a reservoir management application that Troy Ruths and John Pederson, production manager of a Chevron asset, designed to analyze and monitor oil fields. The software's goal is to integrate and expose



**A visual, interactive experience enables scientists and engineers to discover new and actionable insights into their oil and fields to increase production and reduce costs.**

relevant, oilfield-related data sources to improve the efficiency and quality of decision-making, communication, and data mining in a friendly, visual analytics environment. The application is stable, tested, and deployed across Chevron's global assets.

### Startup monitoring for JSM wells

Ruths.ai delivered several analytics tools that provided advanced Spotfire capability for the JSM engineering team. Specifically, these tools enabled the JSM team to build dynamic plots necessary for startup monitoring. This extension improved the existing toolset for the JSM startup workbench in terms of performance and content, built additional analyses that target tactical workflows, and is supporting ongoing reporting requirements.

"Our application enabled the Chevron engineers to monitor real-time

data feeds from the JSM wells as well as to discern how parameters, such as the productivity index (PI) and reservoir pressure, for the wells compare with simulation data as they were ramping them up," explained Troy Ruths. "We were able to bring up the simulation data side-by-side with the field data for a real-time comparison.

We also ran predictive well integrity models against PI degradation and pressure loss." The JSM stage 1 producing wells data will be utilized in the analysis to provide insights and information to support future JSM wells.

### Analyst Recognition

Gartner has named Ruths.ai as one of the Cool Vendors in Oil and Gas, 2016 for its custom developed data science solutions.



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Gartner, Cool Vendors in Oil and Gas, 2016, May 5, 2016. The Gartner Cool Vendor Logo is a trademark and service mark of Gartner, Inc., and/or its affiliates, and is used herein with permission. All rights reserved. Gartner does not endorse any vendor, product or service depicted in its research publications, and does not advise technology users to select only those vendors with the highest ratings or other designation. Gartner research publications consist of the opinions of Gartner's research organization and should not be construed as statements of fact. Gartner disclaims all warranties, expressed or implied, with respect to this research, including any warranties of merchantability or fitness for a particular purpose.

# Technip leverages its products and services to deliver an integrated subsea system

Technip is a world leader in project management, engineering and construction for the energy industry. From the deepest subsea oil and gas developments to the largest and most complex offshore and onshore infrastructures, our 34,400 people are constantly offering the best solutions and most innovative technologies to meet the world's energy challenges. Present in 48 countries, Technip has state-of-the-art industrial assets on all continents and operates a fleet of specialized vessels for pipeline installation and subsea construction.



**The *Deep Blue* is one of the most advanced pipelay and construction vessels of the subsea industry and the flagship of the Technip fleet.**

## Jack/St. Malo (JSM) subsea project

Technip was responsible for subsea installation services, using the *Deep Blue*, one of the world's largest ultra-deep-water pipelay and subsea construction vessels, to install 55 miles of flowlines and SCRs, eight PLETs, and eight heavy-lift structures over four, continuous offshore campaigns.

Stalk fabrication for the flowlines and SCRs took place at Technip's spool-base in Theodore, Alabama, which also served as the mobilization site for the *Deep Blue*. Fatigue-sensitive flowline sections required buoyancy modules. Strakes and anodes were also part of the flowlines installation. The Technip-designed pipeline end terminations (PLETs) were fabricated in Houston, Texas. Six stab and hinge-over PLETs

were fabricated to initiate flowlines, and two gravity-base, second-end PLETs were supplied for terminations. All stab and hinge-over PLETs were stabbed into pre-installed piles and hinged over to land on the pile top.

The Technip-designed stab and hinge over PLETs were the first of their kind for rigid pipelay applications with the *Deep Blue*. The heavy-lift structures, four manifolds and four tie-in skids, were free-issued by Chevron and loaded out by inland barge, transferred to an offshore barge and transported to the field for offshore installation. All structures were installed onto pre-existing piles. The heaviest of the manifold structures installed weighed 200 tonnes.

## HSE milestones

Consistent with our HSE Pulse program, the health and safety of our employees is a core value and an absolute commitment for Technip. The JSM project completed over one million man-hours without a recordable injury (LTIR=0.00 and TRIR=0.00).



## TECHNIP

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# Wood Group Mustang Puts Experience to Work with the Jack/St. Malo Topsides Design

Since its inception more than 25 years ago, Wood Group Mustang has developed a global reputation for its innovation, technical excellence and project management expertise on many of the industry's most notable floating deep-water projects. As testimony, it has designed and engineered more than 60% of the topsides for floating production facilities currently operating in the U.S. Gulf Mexico (GOM). In just the past decade alone, Wood Group Mustang has designed more than 500,000 metric tons of topsides representing production of over 1.5 million BOPDE.

The complexity of the Jack/St. Malo design was complicated by the need for the facility to host the two co-developed fields, 25 miles (40 km) apart and in ultra-deep 7,000-foot water depths. The design also needed to incorporate additional provisions to accommodate future subsea tie-backs to additional fields. Jack/St. Malo is one of the largest semi-submersible facilities in the world and the largest by displacement in the GOM, with a final topsides weight of 33,000 tons. The initial design throughput was for 170,000 BOPD and 43 mmscf gas. The hub supports 43 subsea wells and is the first such facility to operate in the gulf's high-pressure Lower Tertiary trend.

Wood Group Mustang first completed the front-end engineering design (FEED) phase for the production facilities. Following the project's sanctioning in 2010, Wood Group Mustang was



further awarded the detailed design for the topsides.

Utilizing its very experienced project team, Wood Group Mustang found innovative ways to keep the project on schedule while assuring the necessary quality standards were met. Wood Group Mustang performed process and mechanical designs for the many equipment packages; procured valves, instruments and other equipment for the topsides, as well as some hull and subsea packages; then provided construction management for the topsides assembly by the selected fabricator. This procedure allowed the detailed piping design to be expedited, greatly reducing the time normally allotted for packaged equipment vendor data. An example was a highly complex subsea chemical distribution module that had to fit in a compact deck footprint. Wood Group Mustang's experienced designers

provided the layout for the equipment, which was installed without incident.

The project was delivered safely, within budget and on schedule.

Wood Group Mustang's sister companies also made significant contributions to the success of the Jack/St. Malo project. Wood Group Kenny performed detailed design for the 137-mile oil export pipeline and Wood Group PSN provided services relative to the planning, management and execution of onshore and offshore hook-up and commissioning services.



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# McDermott delivers integrated subsea solutions

The ability to fabricate jumpers in house, and the combined strengths of its off-shore construction vessels, enables McDermott to deliver integrated subsea solutions for challenging deepwater projects.



**McDermott's North Ocean 102 installed umbilicals totaling 65 miles.**

For Jack/St. Malo's first-stage development, McDermott completed in September 2014 the installation of jumpers, flying leads, subsea pump stations and umbilicals, and achieved subsea landings for some of the industry's largest and most complex umbilical-end terminations. McDermott performed in-house fabrication of 21 high-specification rigid flowlines, manifold and pump jumpers, and installed the structures using the *Derrick Barge 50*, with its specialized deepwater lowering system.

Three control and two power umbilicals, totaling 65 miles, were installed

by the subsea construction vessel, *North Ocean 102*.

In March 2015, Chevron awarded the company a contract to support the brownfield expansion of the Jack/St. Malo fields. The transportation and installation of 30 miles of umbilicals is expected to commence in the second quarter of 2016.



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