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The Stones Development

A new vision for the ultra-deepwater Gulf of Mexico

“Seven percent of today’s conventional oil and gas production comes from deep water, and this proportion is expected to grow to 11 percent by 2040. With major projects having an expected production life as much as 50 years, our estimate of average prices over several decades is more important than near-term market fluctuations. Stones is just such a project. Ultra-deepwater, especially targeting the Lower Tertiary, offers tremendous potential for our industry. While the challenges are great, Shell has a long-standing record of developing and deploying the right technologies to do the job safely.”
Discovery of the Stones Field

Deepest offshore development in the world

Today, the Stones unit consists of nine ultra-deepwater blocks in the Gulf of Mexico, some 200 miles (325 kilometers) southwest of the Louisiana coast. Oil was discovered in the Walker Ridge block 508 in 2005 by a consortium of investors that at the time included Shell (35 percent), Marathon (25 percent), Petrobras (25 percent) and Eni (15 percent).

In 2005, operating in a water depth of 9,576 feet (2,919 meters), Transocean’s Discoverer Spirit drillship pushed the Stones-2 well to a true vertical depth of 28,560 feet (8,705 meters). This second well confirmed the presence of several hydrocarbon-bearing sands in the Lower Tertiary. In 2008, the Stones-3 exploration well reached a depth of 29,400 feet (8,961 meters), to further delineate the reservoir. Stones-3, drilled by Eni, was located about a mile north of Transocean’s initial Stones-1 well.

PROJECT OVERVIEW

Shell announced its final investment decision for Stones in May 2013. That set in motion the construction of the host floating production, storage, and offloading (FPSO) vessel, and the subsea infrastructure to support it.

Stones is being developed in stages. The startup phase includes two wells on one drill center. That part was completed in 2016, with first oil in September 2016. The second phase includes a second drill center and six wells that are either scheduled or being drilled now. To boost production and extend the life of the field, a mud-line-based artificial lift system will be installed in 2018.

By the end of 2017, daily production should peak at about 50,000 barrels of oil equivalent (boe) per day. Shell owns 100 percent of the project and operates the field.
A LEGACY OF DEEPWATER FIRSTS

Only a handful of companies have the financial strength and technical ability to recover oil and gas from the world’s most challenging basins. Shell led the industry in 1978 with its legendary Cognac platform in the U.S. Gulf of Mexico. At a water depth of 1,030 feet (312 meters), Cognac was the world’s first modern deepwater project. After more than 35 years of safe, reliable production, Cognac is still producing.
The Ultra-deepwater Frontier

Helping to unlock the Lower Tertiary

In 2010, Shell’s Perdido development became the first in the industry to recover commercial amounts of hydrocarbons from a portion of the Paleogene known as the Lower Tertiary. Perdido’s success and its spinoff technologies opened the door for more exploration in this prolific geologic zone that many producers refer to as the “final frontier.”

A DIFFICULT TARGET

Much of the oil in the ultra-deepwater Gulf of Mexico is shrouded with thick layers of salt. For geoscientists who rely on high quality seismic data to make their decisions, shooting sound waves through salt structures that are thousands of feet thick is like trying to conduct a conversation across a large noisy room.

Hard as it is to see deepwater targets, they’re even tougher to reach. The Gulf of Mexico is notorious for unpredictable and damaging loop currents that can delay even the most thoughtful development plans. Exploration wells can encounter unexpected faults and pockets of high pressure gas near the surface. Farther down, drillers must contend with nearly-fluid layers of salt. Below the salt, the Upper Tertiary sediments may include low pressure zones that can suddenly swallow up drilling fluid. Finally reaching the reservoirs—which can extend as much as 30,000 feet (9,144 meters) below the seabed—is still not the end of the journey. Too often, the reservoirs themselves don’t contain enough natural gas to make the oil flow for long.

“Stones’ journey has pushed our technological boundaries and tested our resolve to meet the challenges of working in ultra-deep water with a complex subsurface,” says Maria Pena, Stones Business Opportunity Manager.
Developing the Field

Innovation opens new doors

Stones is a phased development that began production in September 2016 from two flowing subsea wells tied back to an FPSO. Full-field development includes six more wells from two connected drill centers, and multiphase booster pumps on the seabed. All eight wells will link to the production vessel.

The reservoir depth in the Stones field is around 26,500 feet (8,077 meters) below sea level and 17,000 feet (5,181 meters) below the mud line. The nine-block development unit covers 72 square miles (186 square kilometers).

A FPSO was selected early on, in part to avoid the expense of laying lengthy oil pipelines at extreme water depths. FPSOs also have the advantage of being relatively quick to build, and it is possible to reuse them for future developments.

Tankers deliver most of the medium-light crude oil from the Stones field to refineries in Texas and Louisiana. The gas is transported by a new 8-inch line that ties the production facility—through its turret buoy—into a larger pipeline some 22 miles (35 kilometers) away.

ENABLING TECHNOLOGIES

The Stones development employs many unique features, including the industry’s first use of lazy-wave steel risers, paired with a disconnectable buoy. Shell led the development of lazy-wave technology more than a decade ago to solve the problem of supporting heavy steel risers.
in ultra-deep water. Rather than running the pipe straight up from the seabed to the production facility as you might do in shallow water, lazy-wave risers allow the pipe to bend naturally to form a very large S shape some 3,200 feet (1,000 meters) or more below the surface of the sea. That S-shaped portion of the riser pipe is fitted with a series of floatation collars that support the tremendous weight of the steel. The natural flexibility of the pipe in this configuration also allows the riser to conform easily to wave- or current-induced movements of the FPSO. Since lazy-wave risers are in almost constant motion, they are designed for an extremely long service life.

HURRICANE SAFE
During normal operations, the FPSO pivots freely around a moored buoy that fits into a large socket in the bow of the vessel. If a heavy storm or hurricane approaches, the vessel can quickly disconnect from the buoy and sail to safety, while the buoy lowers to a safe resting depth that is below the effects of heavy seas and currents. The wells are shut in at the seabed.

KEY CONTRACTORS
Six companies held central roles on the development team. SBM Offshore was responsible for the design, procurement, construction and operation of the FPSO. Heerema Marine Contractors transported and installed the disconnectable buoy. FMC Technologies built and supplied the subsea equipment. Oceaneering fabricated the umbilicals and Subsea Seven was responsible for installing them. Technip installed the pipelines, flowlines and risers.

“We worked together as a single, cohesive unit within Shell, rather than a bunch of individual technical silos,” says Curtis Lohr, Stones project manager. “That made all the difference in terms of cost reduction and safety.”
Most of the leadership team was on the same floor in Shell’s Houston office. The rest of the leadership team was in the Houston area, as were most of the key contractors.

“Team building was important,” Lohr says. “We spent time with Bovo-Tighe, a professional development group that helps companies understand why employees behave as they do and what motivates them to excel.”

Some people, for example, work best in groups. Others need time to reflect.

“Either way, you get the same results,” Lohr adds. “We had over 13 million man hours in two yards without a single recordable safety incident. That is really something special.”

**AN EARLY CHALLENGE**
Complex projects seldom run exactly as planned. At Stones, one hurdle was to add a second drill center.

This addition was driven by early drilling learnings that identified an opportunity to optimize well trajectories. “I’m
very proud of the way our team pulled together to find the best solution,” Lohr says.

THE GAS EXPORT LINE
While most of Stones’ production is oil, there are also commercial volumes of natural gas. To handle it, a 22-mile, 8-inch steel pipeline was needed to tie in to the nearest gathering system. Like everything else with the world’s deepest development, laying the pipeline wasn’t easy. The first issue was the weight of the pipe, which hangs from the turret buoy nearly two miles down to the sea floor.

“There are also furrows on the sea floor,” Lohr says. “That meant we had to design the wall thickness of the pipe to span them without sagging, and add vortex-induced vibration suppression vanes to avoid problems with metal fatigue. The line also had to scale a 2,000-foot (609-meter) escarpment that is just north of the Stones development.”

DRILLING AND COMPLETIONS
In September 2016 the Stones field began producing oil and natural gas from two record-setting wells: Stones-5R and Stones-9. Both were drilled and completed by Noble in 2015. The ultra-deep wells were technically challenging, but two innovations in particular made it possible to build and deliver them safely.

Using a fully-rotating, 350-rpm steerable system that Schlumberger markets as PowerDrive, both wells were drilled from shoe to toe in a single trip. That shaved days off the drilling schedule. It also improved safety for the drilling crew by reducing the number of trips in and out of the hole. Another key technology was the ability to perforate multiple zones of these ultra-deep wells in a single trip.

The same equipment and processes were used on the 5R well with similar results.

LESSONS LEARNED
More than 60 percent of Shell’s deepwater production comes from the U.S. Gulf of Mexico. That experience gives Shell an edge on project efficiency. Lessons learned over the years have led to increasing standardization in the field. In 2015, for example, Shell’s Logistics and Materials Management initiative saved an estimated $60 million. Additionally, Stones features a more cost-effective well design, which requires fewer materials and lowers installation costs. This is expected to deliver up to $1 billion reduction in well costs once all the producers are completed.
In November 2015, the Turritella FPSO left the Keppel shipyard in Singapore on a 15,000-mile journey to its final destination in the Gulf of Mexico.
Building the FPSO

First for Shell in the Gulf of Mexico

The Turritella is the first FPSO that Shell has deployed in the Gulf of Mexico, but not globally. Shell uses them elsewhere, including the Parque das Conchas (BC-10) project off Brazil with co-owners ONGC and Qatar Petroleum International.

Self-contained, versatile and efficient, FPSOs are commonly used by Shell and others throughout the world to produce oil in regions where there is a relative lack of infrastructure. The development concept was a good fit for Stones.

A PROVEN PRODUCTION SYSTEM

The Turritella FPSO, with a deadweight of nearly 160,000 tons, is 900 feet (274 meters) long and 157 feet (48 meters) wide. The vessel has a daily capacity of 60,000 barrels of oil and 1.4 billion cubic feet of natural gas. Up to 800,000 barrels of oil can be stored onboard. During the first phase of the Stones development, tankers will arrive every few days to transport crude oil from the FPSO to US refineries along the Texas and Louisiana coast. The associated natural gas is transported by pipeline into the closest gathering system.

SBM Offshore provided the FPSO and is currently operating the vessel on Shell’s behalf. Shell is now leasing the Turritella...
under a 10-year contract from a consortium that includes SBM Offshore (55 percent), Mitsubishi Corporation (30 percent) and Nippon Yusen Kabushiki Kaisha (15 percent).

“The Stones FPSO is one of the most challenging designs, customized for conditions in the Gulf of Mexico where hurricanes pose a real threat,” explained Bernard van Leggelo, SBM Offshore’s FPSO Product Line Director. “Working as one with the Shell Stones team, SBM integrated teams around the world rose to the challenges of the project finding innovative solutions using cutting-edge technology.”

Viewed from above, the FPSO has a huge circular hole in its bow. On a drill ship or research vessel, such an open-
ing would be called the “moon pool.” On the Turritella the opening is about 82 feet (25 meters) in diameter, and it extends down from the deck through the bottom of the hull. To moor itself in the field, the Turritella manoeuvres directly above the submerged turret buoy, then pulls the buoy up into the hole, like putting a cork in a bottle.

As many FPSOs are designed to do, the Turritella weathervanes freely around the buoy as winds change. But unlike most other systems, the buoy itself is part of the ship. That is a major safety feature, since it eliminates the possibility of the FPSO or other vessels colliding with the buoy and risers.

“Stones is the first ultra-deepwater production system to use a turret and disconnectable buoy paired with lazy-wave risers,” says Curtis Lohr, Stones project manager. “This is indeed a groundbreaking project in the Gulf of Mexico.”
THE NAME SAYS IT ALL

The Turritella began life in 2003 and served its first ten years as a Suezmax tanker. SBM Offshore converted the tanker to a FPSO in a two-year project that was completed in 2015 at the Keppel shipyard in Singapore. A contest to name the vessel produced more than 150 creative ideas. The top five were announced, and from them SBM and Shell picked the winner.

Turritella is the name of a common sea snail famous for its elegant, elongated and tightly coiled shell. The name evokes links between the FPSO’s turret buoy, the expertise of SBM and Shell, and the outstanding teamwork it took to deliver this groundbreaking project.
The Turret Buoy and Subsea Kit

A robust and efficient design

Both the FPSO and the turret buoy were provided by SBM Offshore. The technology is cutting edge, but the collaboration goes way back.

“In 1958, Shell and SBM Offshore began working on the first single-buoy mooring system,” said Stein Rasmussen, president of SBM Offshore. “The Stones project is another chapter in the close relationship and successful cooperation that SBM Offshore has shared with Shell for more than half a century.”

THE ROLE OF 3D PRINTING

The Stones project boasts a series of firsts for Shell, including an in-line connector that provides adjustable mooring tension for the FPSO and its internal turret buoy. Shell engineers began developing the technology in 2010, but since the concept is new to the Gulf of Mexico, the U.S. Bureau of Safety and Environmental Enforcement wanted to see a working model first.

Under normal circumstances, building an accurate, working demonstration model would take months. To avoid delaying the project, Shell employed 3D printing technology to produce the complex model in just four weeks.
“The option of 3D printing allowed us to engage with all involved in the design, fabrication and installation sequence, and to safely and productively put it together,” says Robert Patterson, Executive Vice President of Engineering, Projects and Technology, Shell Global Solutions.

The challenge was to design, fabricate and assemble large blocks of syntactic foam that would nest inside the turret buoy. Syntactic foam is high-strength cellular material made of tiny spheres of glass, ceramic, polymer or metal bound together with polymer. The material is widely used for floatation, but never before on this scale. The buoy is roughly the height of a four-story office building. Manufacturing limitations meant that each piece of foam had to be relatively small. To fit inside the turret, nearly 1,000 blocks in a variety of complex, interlocking shapes were made, and they had to be installed in a specific sequence.

“You typically have nothing more than drawings to understand how best to do the fabrication work,” says Blake Moore, Stones’ FPSO manager. “For the Stones buoy, we used a 3D printer to create a model of the structure and all of the syntactic foam blocks that went inside. With that, we could then plan the assembly to make sure the sequence was right, and that we were doing it safely.”

A ROBUST, SAFE DESIGN

The turret buoy was built for SBM at the Keppel Shipyard in Singapore as part of the Turritella FPSO conversion project. Carl Webb headed Shell’s turret and mooring line team, from concept and design through fabrication and installation.
“The turret buoy for Stones is certainly one of a kind,” he says. “Nothing like it has ever been built before, so there were significant challenges.”

Size, for example. The buoy is 82 feet (25 meters) wide at its base and about the same height. The structure needed to be large to support the weight of the ultra-deep umbilical and steel riser system, which includes two 8-inch production risers, one 8-inch gas export riser, and two power and control umbilical lines. Pull tubes are available for two additional risers and two additional umbilical lines. As it is configured now, the top tension on the buoy is about 1,250 metric tons.

The buoy is secured to the seabed by suction piles and nine mooring lines. Each line is a combination of polyester rope and chain arrayed in three groups of three. The mooring operation was completed ahead of the FPSO’s arrival in January, 2016. Inline mooring connectors allow the line tension to be adjusted as needed during operations. The turret buoy and its mooring system were built to survive the worst conditions of a 1,000-year hurricane.
RAISING AND LOWERING THE BUOY

The turret buoy is passive in terms of floatation. There is no ballast to load or unload, but the structure is designed to sink to a safe depth once it is released from the FPSO. The safe resting depth is determined by house trailer-sized flotation blocks on the buoy’s mooring lines.

The FPSO and turret buoy will remain connected during typical winter storms, but disconnect in case of a named storm or hurricane. Depending on the wind and currents, uncoupling the buoy takes a little over two hours. Once free from the FPSO, the buoy will descend on its own to a safe resting depth. The entire process, from the time the buoy is released until it achieves its final equilibrium depth is less than 30 seconds. The ship can reconnect to the buoy in about eight hours, also dependent on sea and wind conditions.
MOORING AND INSTALLATION

The turret mooring system was installed by Heerema Marine Contractors over a three-month period in the fall of 2015. The work was completed on time, despite Nature’s best effort to prevent it.

“For the first three weeks. We were hit by eddy currents of up to four knots,” Webb recalls. “That was extremely challenging.”

Warm water typically flows northward between Cuba and the Yucatan Peninsula into the Gulf of Mexico. A few hundred miles south of the Mississippi, Alabama and Florida coast, the current turns eastward, then south before escaping to the east through the Florida Straits. Once it hits the Atlantic Ocean, the moving water merges with a northward flow known as the Gulf Stream. Sometimes, however, flowing water that normally curves east breaks from its normal path and spins to the west, forming circular eddies that can be more than 100 miles in diameter. These swirling waters, also called “eddy currents,” may wander for up to a year, causing havoc for anyone trying to construct permanent structures in the Gulf of Mexico.

Some years there are none. In other years there may be four or five.

Eddy currents are unpredictable. The best that operators can do is monitor them and try to compensate when they strike. The physics are such that just beyond the eddy, there will be no current at all. There is also no current in the middle, but for 30 or 40 miles around the circumference and 300 meters deep, the circular current can be as much as five knots.

“We made predictions every day and had our monitoring vessels out 24 hours a day, taking cross sections and other readings,” Webb says. “It turned into quite a science project for us. The eddy tended to advance over us, then retreat and give us anywhere from six to 24 hours of easy going, but that was not enough. It put a stop to all our activities. Eddy currents of up to four knots continued for three weeks. You can’t operate a submarine or ROV in a current that is moving at even two knots.”

While continuing to monitor the current, Webb and his team found ways to work around the problem.
“We were able to do some of the subsea work at water depths that were below the strongest part of the current,” Webb says. “We reoriented our vessels to face their bows into the current. In some cases, we were able to do some of the work out of the water. The remarkable thing is that about 90 percent of that re-engineering was done while we were offshore. In my opinion, that ability to respond quickly to each new challenge is typical of the entire project.”

**WELLHEADS**

FMC Technologies is supplying eight 15K Enhanced Vertical Deepwater Trees for the Stones development, along with the subsea manifolds and topside and subsea controls. The 15K wellheads are the same as those installed on the Shell-operated Perdido development, the first in the industry to successfully tap the Lower Tertiary.

In 2014, FMC Technologies entered a joint partnership with Shell and three other major operators to develop standardized equipment and systems to meet the challenges of high pressure, high temperature fields. The goal of standardization is to reduce costs and lead times for subsea equipment, and to enhance the overall safety of companies who install it.

**JOE HOFFMAN**

Lead engineer for the subsea, umbilical, riser and flowline
FLOWLINES AND UMBILICALS

“In 10,000 feet (3,048 meters) of water, we’re dealing with extreme hydrostatic pressure in the range of 4,200 psi,” says Joe Hoffman, lead engineer for the subsea, umbilical, riser and flowline (SURF) portion of the project. “The flowlines are made of many composite layers, each engineered to give the pipe its unique properties.”

The innermost layers include the interlocking carcass. Next are the thermoplastic layers, which contain the pressure and fluid. There are additional layers designed to handle the loop stress, different layers for axial tension, and another layer to prevent water ingress.

“One thing we had to account for, besides the tremendous pressure, was the compositional uncertainty of the production fluid,” Hoffman says. “We had to evaluate the potential impact of a range of fluid compositions on the whole system; not just the subsea kit, but equipment aboard the production facility as well as the gas export pipeline.”

POWERFUL NEW SUBSEA BOOSTING SYSTEM

Although Stones began production with two wells, drilling continues. As part of the second phase of development, OneSubsea (now part of Schlumberger) will supply two 3-megawatt single-phase pumps and two subsea control modules to boost production from the reservoir. Manufacturing and testing continues at OneSubsea’s facility in Horsoy, Norway, with expected delivery in 2018. When the equipment is installed, it will become the first 15,000-psi subsea pump system in the world.
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SBM Offshore sets new industry records with Turritella

Shell and SBM Offshore engineers first began collaborating in 1958 on fabricating the industry’s first single-buoy mooring. Today, the Stones project in ultra-deepwater Gulf of Mexico cements the successful collaboration that SBM Offshore has shared with Shell for over half a century.

Laying the groundwork, SBM Offshore and Shell were engaged in front-end development work for the FPSO for more than two years. By clearly understanding Shell’s needs, this important preparatory phase allowed SBM Offshore to leverage its experience and outline a well-defined design and execution plan.

“Technology and project execution are what SBM Offshore does well—starting from scratch with a blank page and coming up with solutions to client needs,” explained Babu George, Project Director for the Turritella project.

**HSSE successes**

In addition to design, construction, and operational needs, meeting HSSE goals was paramount. “We had a clear and common HSSE charter from the start of the project,” explained Babu George. “All the project participants, including subcontractors and vendors, understood that we were building something special. The Stones project achieved 22 million man-hours with only 1 Lost Time Incident. That’s an incredible record for a project of this scale.”

“Right from the start of the project, we aligned with our stakeholders.
and agreed that safety was our first priority.” says Stein Rasmussen, President SBM Offshore, USA.

Deepwater records
Shell’s mandate for Stones required a state-of-the-art FPSO for the deepest offshore field the world has known and to handle the winter storms and hurricanes that are common to the Gulf of Mexico. SBM Offshore’s FPSO Turritella has resulted in a roll call of world records:

- Deepest production unit ever installed
- Deepest FPSO
- First disconnectable system with Steel Lazy Wave Risers (SLWR)

Worldwide engineering effort
Working as one and in real time, SBM Offshore’s integrated teams around the world rose to the demanding challenges inherent in the Stones project and found innovative solutions. The needs of this project had been anticipated by SBM Offshore for some time with research showing that deepwater fields would play an increasingly significant role in the oil and gas market of the future.

SBM Offshore’s Regional Centre in Houston was responsible for managing the EPC for the Turritella FPSO with input from the company’s other Centres in Monaco, Schiedam and Kuala Lumpur for expertise on key elements such as the pioneering Turret Mooring System. Conversion of the FPSO took place in Keppel’s Singapore shipyard.

“Our contribution to the Stones project highlights SBM Offshore’s reputation in the FPSO market. We leveraged over 60 years of mooring systems experience to supply this pioneering Buoyant Turret Mooring (BTM) system,” says Bernard Van Leggelo, Managing Director FPSOs SBM Offshore.

Unique FPSO design
The FPSO Turritella represents a breakthrough in terms of technology for riser configuration with the design of Steel Lazy-Wave Risers (SLWR). It is the first time this type of riser is being used in a disconnectable production unit. As a consequence of the combination of water depth and steel risers, the syntactic foam buoy has the biggest

Enterprise agreement
In March 2012, Shell and SBM Offshore signed an Enterprise Framework Agreement (EFA) for the supply of medium and small FPSOs on a lease-and-operate basis. The Stones FPSO is the first Shell project to award contracts utilizing EFA.
displacement for a disconnectable buoy ever built to date.

An innovative feature developed by SBM Offshore for this project is the ability to readjust each mooring line tension without any device installed on the FPSO. This technology pioneers the use of an In-line Mooring Connector (ILMC), which gives direct access to the mooring line for re-tension purposes. As a result, there is more flexibility when the need arises to adjust the tension of mooring lines, even during the early phase of system installation.

Disconnectable buoy
A key necessity for the FPSO was to factor in the severe meteorological conditions of the Gulf of Mexico. Using the world’s largest disconnectable buoy (BTM) enables the FPSO to weathervane in normal conditions and to be disconnected from the BTM upon the approach of a hurricane. As a result, the vessel can safely sail away prior to the impact of perilous weather. This detachable capability also allows the FPSO to quickly resume production once the hurricane has passed the location.

In July 2016, SBM Offshore conducted a demonstration of the disconnection and reconnection of the turret for the regulatory authorities from BSEE and ABS. “The system performed flawlessly,” explained Babu George.

FPSO specifications
Turritella is an SBM Offshore Generation 2 design with a total fluid processing capacity of 60,000 bopd and 15 MMscfd of gas treatment and export. The Suezmax hull can store 800,000 bopd and total topsides weight is over 7,500 tons.

The FPSO breaks the existing water depth for all production units. The opportunities for the industry, in terms of growth potential, are significant. SBM Offshore can meet client needs in ultra-deep waters and offer proven, cost-effective solutions.

For the next 10 years SBM Offshore’s Operations team will operate Turritella, leveraging more than 270 years of combined operations experience to optimize production, achieve efficiencies and continue to set the bar higher for safety.
We will improve the productivity of your team, or you pay nothing. Guaranteed.

Your people are talented, but how much of their full value can they contribute? Sixty percent? Fifty? Are there too many e-mails, meetings and distractions? Are your employees able to fully engage in their critical roles? You already pay for their potential. We will help you unleash it. On the Shell Stones project, we worked closely with the project leaders to help the project team build intentional focus on safety and collaborative leadership. We trained the project leaders to fully leverage each person’s unique ability and overcome obstacles to quality decisions and actions. Our process is systematic, engaging, and sustainable. Let us show you how we did it for Stones and hundreds of other organizations.

Transocean’s Deepwater Thalassa’s First Assignment: Stones

Transocean is a leading international provider of offshore contract drilling services for energy companies, owning and operating the world’s most versatile fleet with a particular focus on deepwater and harsh environment drilling.

As a technical leader and innovator, Transocean has a long history of accomplishments and contributions that have gone toward improving offshore drilling. These range from one of Transocean’s predecessor companies pioneering early versions of deepwater drilling methods in the 1950s, to the introduction of the first ultra-deepwater, dual-activity drillship in the late 1990s.

The innovation continues in 2016 with the introduction of the Deepwater Thalassa, featuring the company’s patented dual-activity drilling technology, industry-leading hoisting capacity, Transocean’s designed and patented Active Power Compensation hybrid system, and dual blowout preventers.

The drillship is designed to operate in water depths of up to 12,000 feet and drill wells to a depth of 40,000 feet. It is upgradeable to accommodate a 20,000-psi BOP system. The Deepwater Thalassa is under contract to Shell and currently operating at the Stones field.
Delivery Alliance: Making It Work Right Together

The successful support of multiple aspects throughout the design and delivery of the Stones project represents the latest in a long line of achievements for the GATE Team. This Team has provided ongoing support to Shell deepwater projects since its formation in 2000 and has been integral to the development and delivery of many of Shell’s industry-leading projects and deepwater innovations over this period. GATE’s engineering and project management services are focused on enabling project teams to make informed decisions and to maximize value throughout the life of the project. This is accomplished by providing critical resources that span across traditional project boundaries as well as technical and contractual silos. GATE’s approach has resulted in a recognized history of smoother facility start-ups, reduced risk exposure, and increased whole-life value for existing developments.

Subsea Construction & Marine Engineering
For GATE, contributing to the Stones project was a remarkable experience that called for novel solutions to numerous engineering challenges, which showcased the GATE philosophy to Do It Right The First Time. The GATE Team worked collaboratively with Shell to overcome multiple project hurdles and deliver the safe and effective execution of the project.

Among these various challenges were the notable depth of the field and the geophysical conditions on the seafloor. At approximately 9,500 ft with diverse terrain that presented an assortment of crevasses and slopes that challenged the placement of subsea infrastructure and hardware, the Stones project required the formulation of unique solutions and risk mitigation strategies.

Subsea boosting pumps represent an integral part of the project design. The GATE Team was also heavily involved in the qualification effort for the subsea pumping system; this support extended to the provision of technical support and planning, alongside OneSubsea, in the testing of the hydraulic and mechanical components. The group also engaged with the manufacturing teams for the 1st article to ensure that processes were in compliance with governing technical codes, such as API. The group was also instrumental in providing technical personnel to the greater project team to support the delivery of the umbilical system.

Offshore Installation & Marine Risk Management
A critical segment of the GATE Team was instrumental in supporting the Pipeline, Flowline, and Riser (PFR) division of the project. This part of the Team was focused on delivering Cathodic Protection (CP) design, coatings, and insulation expertise. In addition to onshore site
quality and fabrication oversight support, this Team provided offshore installation technical support and project management for the flowline, risers and pipelines. GATE provided installation support for both of the Stones drill centers.

The GATE Marine Services Team, headquartered at GATE’s Houston location, provided performance enhancing solutions targeting technical, operational, and project management challenges associated with vessel industrial mission and integrity. The objective of this group was to assist in the delivery of incident-free execution for marine activities associated with the Stones development.

To accomplish this, the Team deployed a series of Decision Support Tools (DSTs) targeting critical process safety impact areas including, but not limited to, station keeping, loss of containment and ballast management. By collaborating with the wider project groups, the Marine Services Team successfully managed these critical offshore risk exposure areas and the corresponding consequences of loss of position of mal-operation during vessel activities.

About GATE
GATE is a mid-sized engineering, project management and commissioning services firm serving the energy industry and is an integral member of the GATE ENERGY family of companies. As a uniquely positioned suite of companies, GATE ENERGY continues to capitalize on its well-earned reputation of providing novel, yet realistic, and achievable solutions to complex tasks and challenges found in both onshore and offshore project environments.

GATE ENERGY is staffed and equipped to safely and efficiently supply expertise in the following sectors of the oil and gas industry:

**Upstream**
- Exploration & Drilling
- Design & Engineering
- Construction, Installation & Commissioning
- Operations Readiness & Initial Start-up
- Operations & Troubleshooting
- Environmental Management & Engineering
- Decommissioning & Abandonment

**Midstream**
- Engineering & Construction
- Environmental Management & Engineering
- Barge & Oil Tanker Transportation
- Pipeline & Process

**Downstream**
- Environmental Management & Engineering
- Installation & Hook-up
- Planning & Commissioning
Synergies & Partnerships
GATE recently acquired BlueFin headquartered in New Iberia, LA. BlueFin is a leading energy services company with expertise in pipeline, process, mechanical, and abatement and environmental services providing solutions covering maintenance, integrity and remediation scopes.

GATE’s founder and CEO, Grant Gibson said, “Our industry is currently being challenged to deliver value in a more efficient and streamlined manner. By combining the operational strength of BlueFin with the engineering and commissioning experience of GATE, we are able to reduce project interfaces and provide maximum value to our Clients. A valuable partnership with BlueFin demonstrates the success of GATE’s strategy of providing high-quality services to our Clients and a challenging work environment to our staff. Ultimately, we want to ensure that our shareholders, which now includes our staff, are rewarded for teaming with us.”

BlueFin’s President David “Ducky” Pugh said, “The Partnership with GATE reinforces our commitment to bring additional value to our customers and employees. Our GoM and Midstream clients have been the center of our business, and we are excited to be able to deliver such a comprehensive offering of solutions in a time where value and subject matter expertise consolidation is critical.”

Every day, BlueFin employs and engages the industry’s best people to fulfill their mission. From deepwater upstream assets and midstream transportational pipelines, to Shale gathering facilities and downstream refining processes—BlueFin positions their customers at the center of their everyday business to ensure their promise is delivered. BlueFin provides world-class expertise and solutions in the following areas:

**Equipment**
- Topsides Construction Equipment
- Diving Rental Equipment

**Mechanical**
- Controlled Industrial Bolting
- Cold Cutting & Field Machining
- Industrial Cutting Technologies
- Spark-Free Tooling

**Pipeline & Process**
- Hydrostatic Pressure Testing
- Nitrogen Services
- Flow Assurance & Pipeline Cleaning
- Decommissioning Services
- Pipeline Pigging including Gel Pigging
- Pipeline Deposit Mapping
- SafeHeat for Heating & Fluid Containment Providing 100% Vessel Retainage
- Extended Reach Lancing
- SlipLine for Bi-directional Flow & Secondary Flowline Containment
- Vessel Cleaning

**Abatement & Environmental**
- HVAC Cleaning
- NORM Survey
- Microbial Treatment Services
- System Hygienic Evaluations
- Emergency Decontamination
- Galley Hood & Dryer Vent Cleaning
- Indoor Air Quality
- Mold & Asbestos Abatement
- Chemical Fume Hood
- Velocity Testing

With the BlueFin acquisition, GATE is positioned to provide its global client base with expanded engineering, IRM, decommissioning solutions, and additional mechanical commissioning services. This strengthening of GATE ENERGY’s resources promotes even greater flow assurance, material and integrity, and production optimization capabilities to serve clients.
Deep Down Inc.’s Specialized Expertise Contributes to Success on Stones Project

Deep Down, Inc. (DDI) serves the worldwide offshore exploration and production industry by providing deep-water oil production distribution system components, innovative design, and installation support services. An industry leader in installation and monitoring of umbilicals and flying leads, DDI provided important, specialized services on the Shell Stones project.

Importance of Umbilicals

The Stones field will produce from a world-record water depth of 9,500 ft. Ultimately, a total of eight wells will produce to an FPSO. The Stones field’s subsea wellheads are powered, monitored and controlled using umbilicals, which include hydraulic and fiber-optic lines, as well as low voltage electrical lines. Umbilicals are attached to the FPSO and are connected on the seafloor to umbilical termination assemblies, which in turn are connected to subsea wellheads and other equipment with flying leads that also contain hydraulic, fiber-optic and electrical lines.

DDI’s Contribution to Shell’s Stones Project

Critical aspects of the project include preparing the umbilicals and flying leads for installation, and monitoring their condition during deployment and installation. To assure reliable operation, hydraulic fluid used in umbilicals and flying leads must be free of contamination. On the Shell Stones project, DDI using microscopes and computers, which provided laboratory-quality results on site.

During installation, DDI monitored the umbilicals both hydraulically and electrically — using its proprietary wireless monitoring system, Bytel and Keller software and digital pressure gauges — providing redundant surveillance of umbilical integrity.

During the flying lead installation, DDI provided installation equipment for its deployment, like its flying lead lay chute while the team worked to maintain the fluid integrity of the flying lead inside by maintaining a NAS 6 fluid cleanliness level.

Historic Operation is Successful

All aspects of DDI’s work were completed successfully. “We are delighted to be part of this historic operation,” said Deep Down Inc’s founder and CEO, Ronald E. Smith. “Deep Down looks forward to future opportunities to work with Shell in the Gulf of Mexico.”

Deep Down Inc.’s experienced personnel were key to successful testing and flushing of umbilicals and flying leads on the Shell Stone’s project.
Enabling ultra-deepwater success when the economics are tight

The Stones development in the deepwater Gulf of Mexico poses numerous technical and economic challenges, but Schlumberger technologies combined with an unwavering commitment to safety and protection of the environment are helping to make it work. The wells constructed for Stones are some of the deepest and longest ever attempted. Perhaps the greatest challenge in the Lower Tertiary geologic frontier and other complex plays around the world is to get the job done safely and efficiently to achieve a competitive return on investment, even at low commodity prices. Here’s how.

Drill faster, more reliably, with minimal trips
The Schlumberger engineered approach to drill Stones #9 was based on learnings from Stones #5R. Upon analysis of the drilling data, the engineering team was able to implement changes to the bottomhole assemblies (BHAs), optimize bit/reamer cutting structure, and define optimal drilling parameters through extensive modeling and simulation.

Schlumberger proposed using the fully rotating PowerDrive Orbit® rotary steerable system (RSS), one of the newest members of the PowerDrive® RSS family. Since its introduction in 1998, the PowerDrive system remains the only fully rotating steerable drilling system on the market. Over the years, refinements have continued to enhance tool reliability to increase system life and improve efficiency through precise directional control guided by real-time near-bit measurements.

Capable of operating at speeds up to 350 rpm, the PowerDrive Orbit RSS is faster, safer and more reliable than conventional systems. The high rpm limit improves steering control in the extensive stick/slip conditions endemic to these challenging wells. The system’s six-axis continuous inclination and azimuthal gamma ray inform its unique inclination-hold feature to enable drilling the well’s tangent and vertical sections with only minimal input from the directional driller. Drilling proceeds efficiently, with less interruption and more accurate well placement, while self-steering also delivers a smoother bore. Near-bit extended-range gamma ray measurements provide further well positioning data for improved real-time decisions.

The new pad actuation system of the PowerDrive Orbit RSS features metal-to-metal seals that can handle corrosive drilling fluids and demanding hydraulics.

The PowerDrive Orbit RSS expands the operating envelope of rotary steerable technology by extending system life, delivering precise directional control, and increasing drilling efficiency. (Courtesy of Schlumberger)
The PowerDrive Orbit RSS readily met the challenges of the Stones #9 production well, drilling shoe to total depth in a single efficient trip. Its high rpm capability powered a fast ROP to shave days from the rig schedule.

Optimize the well connection to the reservoir while perforating
Perforating all zones simultaneously saves valuable rig time compared with stacked completions that require separate trips to perforate each zone. Conducting the entire perforating job at once is also safer for the rig and gun crews, as they spend less time running pipe.

To address these challenges, Schlumberger engineers worked with their counterparts at Shell for more than a year to formulate completion plans for the Stones wells. In each case, Shell elected to use the 30,000-psi-rated Schlumberger IRDV* intelligent remote dual valve, INsidr* perforating shock and debris reduction technology and 30,000-psi Signature* quartz gauges.

In both Stones #9 and #5R, all zones were perforated simultaneously resulting in reduced rig time.

Increase productivity and recovery with subsea boosting
After perforating and installation of the completion hardware, the remaining connection for fluid flow—between the wellhead and the host production facility—is established with subsea equipment. The placement of modern subsea developments in ever deeper water depths and at increased distances...

Examination of the spent 6 5/8-in. perforating gun incorporating INsidr perforating shock and debris reduction technology shows that the shaped charge cases do not break but remain in one piece, resulting in only negligible debris out of the gun. (Courtesy of Schlumberger)

INsidr technology was specified because it both manages perforating gun shock and minimizes the amount of debris left behind compared with conventional gun systems. Excessive perforating gun shock can cause significant damage to the lower assembly or completion tools. The proven PURE Planner* perforation job planning application is used to predict the peak incremental dynamic loads that can produce mechanical damage. Once the peak loads are identified, the software is used to modify the design of both the gun string and BHA to lower the peak loads to force values that are manageable.

Debris from perforating can pose problems during tubing-conveyed perforating and well cleanup operations. Using INsidr technology significantly reduces debris volume, as confirmed with official API 19B Section 5 debris tests. PowerFlow Max* 6618 slug-free big hole shaped charges were specified for deployment with INsidr perforating technology in the Stones wells to lessen the amount of debris created in the first place because their steel cases remain practically intact after the gun fires. Minimizing debris maximizes the area open to flow after perforating for the best possible production.
between the well locations and the host facility introduces pressure losses and temperature changes that can lead to flow assurance problems. Adding energy to the flow with subsea booster pumps overcomes the pressure losses and reduces the temperature losses by speeding up the flow. Although there are many examples of successful subsea boosting in fields around the world, none is in waters as deep or pressures as high as those of the Stones project.

The high shut-in pressure associated with Lower Tertiary reservoirs was one of the key issues for consideration in designing the boosting system for Stones. In addition, high differential pressure is required to increase both the production rates and the overall recovery factor, which would enhance project economics. Due to the potential for high cost and lost revenue if there is downtime, Shell required equipment with a proven track record and the highest reliability and performance. To meet these specifications, the final selection landed on using seabed pumps.

Shell is collaborating with OneSubsea, a Schlumberger company, to incorporate the company’s requirements and specifications in the pump design. The project is being executed at OneSubsea’s facilities for engineering, manufacturing and testing in Bergen, Norway.

To build the pumps, OneSubsea engineers are working with suppliers on every detail. A significant portion of this effort focuses on metallurgy, welding and manufacturing. To deliver the highest-reliability system, every component must be of the highest quality and rigorously evaluated before incorporation into the final assembly.

A critical step in the initial technology qualification program (TQP) involved the project teams going to individual suppliers to qualify the many elements of the pump system. As part of the final phase of the TQP, prototypes and first-article testing were successfully completed. The TQP was concluded with building, testing and qualifying a full-size pump prior to initiating manufacturing of the commercial pumps.

In the long term, seabed boosting allows producing the reservoir to a lower abandonment pressure, which increases the recovery factor and could extend the life of the Stones field considerably.
Reaching record-breaking deepwater drilling depth with industry-leading equipment and completions services

Frank’s International is an industry innovator and leading provider of highly engineered tubular services to exploration companies in both offshore and onshore environments. For more than 78 years, Frank’s has been making history in tubular running services by anticipating change and meeting the needs of our customers. Today with over 200 U.S. and foreign patents, Frank’s specializes in engineering and manufacturing progressive solutions that unlock the most complex drilling environments while continuing to set the standard in the industry.

Frank’s International recently added to their successful track record of industry milestones with Shell’s Stones project, which set a new world-record for deepwater depth. Frank’s supplied a variety of casing, landing string and completions equipment and services to the various rigs utilized in the drilling of wells within Shell’s Stones field.

**Casing services**

On the Thalassa rig, Frank’s provided an array of extended range spiders, elevators and wide-track systems, and ran casing strings on two wells.

**Landing string services**

On the Danny Adkins and Jim Day rigs, Frank’s supplied 1,250-ton landing string spiders and drill pipe elevators to handle heavy landing strings. Frank’s also conducted a landing string analysis on all strings to ensure safe running of heavy landing strings and to facilitate optimal utilization of the rig’s drillpipe inventory. This combination of innovation and expertise resulted in the safe running of hook loads weighing nearly or in excess of two million pounds.

**Completions services**

On the Jim Day and Thalassa rigs, Frank’s technicians executed both upper and lower completions runs using Frank’s RS family of completions spiders and control-line manipulator arms. Additionally, Frank’s

Frank’s International’s Fluid Grip® tong is a patented and proprietary non-metallic and truly non-marking gripping system for running CRA tubulars. Complementary Frank’s equipment includes the Collar Load Support system for a completely non-marking tubular running and handling system.

Frank’s International’s 1250-ton Drill Pipe Elevator is equipped with Frank’s patented elevator/spider interlock system and is designed without latches or doors, eliminating pinch points and improving safety. Frank’s developed the industry’s first 1250- and 1500-ton handling equipment.

International’s patented Fluid Grip® tong technology enabled the make-up of delicate assemblies within the strings.

Frank’s International applies engineering expertise and customized solutions to bring the most complex wells into production more efficiently. Frank’s longevity as a leader in tubular running services and as an expert in corrosion-resistant alloy positions Frank’s as the top provider of well completion, intervention and recovery services.
Oceaneering International, Inc. demonstrated its expertise in ultra-deep water by providing custom-designed umbilicals and overcoming significant challenges to install subsea lines and equipment for Shell’s record-depth Stones project.

During offshore operation on Stones, Oceaneering crews recorded no LTI or other HSE incidents.

Custom-Engineered Power Umbilicals
As the deepest dynamic power umbilicals ever installed, the umbilicals for Stones required extensive engineering. Oceaneering developed dozens of candidate designs before arriving at a technically feasible umbilical that met the requirements of this challenging application. Oceaneering invested more than 11,000 hours of engineering and analysis to ensure that the umbilicals would perform as intended.

Manufactured at Oceaneering’s Panama City, Florida, facility, each umbilical includes three 20-kV medium-voltage triads to power the subsea pumps; 16 steel tubes rated to 15,000 psi for hydraulics and chemical injection; low-voltage power cables; and fiber optic signal lines.

Installing the two wellheads at Stones was a particular challenge because the crane on the available service vessel did not have the capacity to safely lower them to 9,600 sfw using a full line of steel cable. To meet this challenge, Oceaneering replaced 3,000 ft of cable with neutrally buoyant synthetic rope and modified a spool to handle it, reducing total weight and enabling efficient wellhead and tubing head spool installation. Oceaneering also manufactured six jumpers and installed them, along with several flying leads, using ROVs.

Successful ROV Operation in Strong Currents
The ultra-deep water and persistent eddy currents complicated ROV operations, especially during wellhead installation. Three-knot currents at the surface and one-knot currents on the seabed required carefully planned vessel movement and special procedures to compensate for drift while lowering and installing equipment. The high specification Oceaneering® Millennium® Plus heavy work class ROVs worked at full capacity at these great depths, successfully completing all operations with only minor modifications.
Custom-Engineered Electrical and Fiber Optic Connectors from TE Connectivity

Enable detachable turret mooring buoy concept for Stones FPSO

Royal Dutch Shell’s innovative concept for the Stones FPSO includes a detachable buoy turret mooring (BTM) that can release production risers and umbilicals in advance of extreme weather conditions and reconnect afterwards. This capability required custom-designed electrical and fiber optic connectors on the umbilicals and turret stab plates that could disengage and reconnect reliably, safely and repeatedly. TE Connectivity’s (TE) SEACON and DEUTSCH combined portfolios were able to meet this unique challenge.

TE offers one of the widest range of dry- and wet-mate connectivity solutions available in the market and has developed innovative technologies to support FPSO applications such as this since the early 2000’s. For the Stones project, Royal Dutch Shell relied on TE to provide the low voltage and high voltage electrical connectors and fiber optic connectors for the stab plate intersection between the FPSO and BTP and used similar low voltage and fiber optic connectors for the BTB monitoring system.

Demanding Application
The dry-mate EX-Mate LV electrical connectors and wet-mate HydraLight fiber optic connectors had to be certified as explosion proof because they would be installed in a Class I, Zone I hazardous location on the vessel. Connectors had to be designed to mate correctly under all possible stab plate misalignment conditions. The robust design ensures that the connectors function and maintain their integrity under high load conditions while connected to the 180-ton, 3,000m-long umbilical cables. When disconnected from the FPSO, the BTM will be submerged.

Both the EX-Mate and EX-HydraLight connectors were supplied in super duplex material. Within the HydraLight connector, engineers used a new compensation fluid with no flash-point and changed the pressure compensator to withstand higher thermal expansion. A portable oil fill station was developed for connector maintenance, and test connectors were designed to verify fiber optic channel performance.

Extensive Testing and Certification
TE worked closely with Royal Dutch Shell and ExVeritas Limited to create a comprehensive connector qualification test program to certify the fiber optic and electrical connectors for use in a Class I hazardous area. TE also qualified two separate Royal Dutch Shell-provided cables and their integration with connector assemblies through extensive physical testing.

TE also supplied SEACON connector/cable assemblies for the top stab plate for installation at the turret supplier’s location. TE’s DEUTSCH technicians worked at the umbilical supplier’s facility to install the connectors to the cables using a proprietary moulding process.

Collaboration and Support
At the outset of the project, TE worked with Royal Dutch Shell to create a comprehensive functional design specification to capture all engineering requirements. TE’s SEACON Engineering, R&D, production and supply chain groups supported the project from initiation to final installation. Amidst the technical complexities and pioneering requirements, the project was expertly administered. TE’s broad experience across all connectivity mediums and technologies serving Marine Oil & Gas applications — including seven previous FPSO projects — served as a critical asset toward the project’s success.

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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 32,500 people are constantly offering the best solutions and most innovative technologies to meet the world’s energy challenges. Present in 45 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.

Technip was responsible for the fabrication of the flowlines and steel lazy wave risers and installation of the world’s deepest subsea production system and lateral gas pipeline at a water depth of 2,900 m (9,500 ft).

Through a second contract, Technip has secured the fabrication and installation of two subsea production lines to tie in the new Drill Center Two (DC2) to the existing Drill Center One (DC1). The contract covered engineering of the required second-end Pipeline End Terminations (PLETs), fabrication of the PLETs and piles, and installation of the subsea production system, inclusive of associated project management, engineering and stalk fabrication.

Technip leveraged its integrated approach in the subsea business by conducting the overall project management from its operating center in Houston. The flowlines and risers were welded at Technip’s spoolbase in Mobile, Alabama. The first phase of offshore installation for DCI was performed and the second phase of DCI completed by Deep Blue, Technip’s deep-water pipelay vessel.

“With greater depths come greater challenges for our clients,” said Raymond Semple, Technip North America Chief Operating Officer, Subsea & Offshore Business Unit. “With this high-profile project, Technip confirms its subsea leadership and keeps differentiating itself through innovation to remain at the forefront of frontier projects.”
Reliable rigging for the world’s deepest field through custom design, superior rope construction, and rigorous testing

As the world’s deepest production facility, Shell’s Stones project presented innumerable challenges for rigging requirements. Focusing 100% on synthetic rope, SWOS provided high-performance rigging solutions through custom design, superior rope construction, and rigorous testing. The result is excellent operational performance.

Full-service rigging
Based in Houston, SWOS is a leading supplier of high-performance rigging systems to oil and gas companies operating in the Gulf of Mexico and offshore sectors throughout the world. SWOS mastery includes industry-specific rigging applications, including winch lines for subsea installations, node connections for custom seismic streamer lines, customized riser protection nets and engineered lifts for offshore construction. A full-service rigging shop, SWOS has the largest selection of cordage in the U.S., and has gained a reputation for the fastest turnaround times.

Master fabricator and distributor
Since its inception in 1985, SWOS has been a distributor of Samson, the leader in fiber-rope technology. Starting as a Regional Service Center for Samson, SWOS has progressed to become a Master Distributor, and then one of three Master Fabricators worldwide. Working with Samson’s industry leading R&D, engineering and technical services department, SWOS has gained the confidence to provide the best rope products and reliable service.

Custom-designed lightweight solutions
Over the years, fiber-rope rigging solutions have evolved from hemp to nylon, from polyester to Aramids and HMPE. SWOS designs and fabricates rigging solutions utilizing a wide variety of neutrally-buoyant fibers and rope constructions. Custom buoyant rope solutions can be used at most depths without propensity for breakage, because they weigh virtually nothing. SWOS synthetic rigging systems are lightweight, easy to handle, and require fewer operators, and less deck space.

Rigorous testing
For customers needing certification to prove the overall strength of their lines, SWOS provides break-strength testing. SWOS in-house testing facilities also perform internal destructive testing on prototypes for synthetic rope suppliers.

Stones project
SBM Offshore first brought in SWOS to supply a tapered buoy pickup line. “This was SBM’s first use of a synthetic rope system,” explained Andrew Clancy, SWOS Project Manager. “Even before we received the contract, we
provided SBM with technical information on rope performance and submitted designs for sheave design, layout and routing, working hand-in-hand with SBM engineers, and answered many questions about heave compensation. A buoy pickup line needs to float and have unique density requirements. Together, with Samson, we designed a pickup line that was tapered from 140 mm to 80 mm, resulting in significant size reduction and weight savings, and smaller winch package than possible with a wire-rope system.

“The riser pull-in rope required an extremely heavy rope with a specific density target in seawater,” explained Clancy. “There were no off-the-shelf rope products available,” added Justin Gilmore, Samson Technical Sales Manager: “SWOS and Samson worked together to develop three custom-built options. In order to get the highest density possible, Shell ultimately selected a 12-strand VectranTM rope with a twelve-strand lead core. We have used lead in ropes before to add weight, but had never put this much lead in a rope.”

After successful MBS (minimum breaking strength) test regimen on the prototype rope, SWOS, and its testing partner Versabar, built a full-scale test frame to test the rope’s reaction to bending over the sheaves and routing in the course of a number of different cycles. The tests stressed the rope to the maximum estimated dynamic load of a flooded riser: “The customer support continued offshore with a SWOS technician onboard during the first riser pull-in,” said Clancy.

Project success
“The takeaway from the project was that we took the client’s problem, applied our knowledge and expertise to develop a successful solution when no off-the-shelf option was available,” said Clancy. “We appreciate the confidence our clients entrusted in us to develop an optimal solution.”

“We expect the synthetic rope systems to yield significant advantages over wire-rope systems throughout the life of the project, including long operational life, absence of corrosion, and protection of riser tube coatings,” added Gilmore.

Samson: Leader in high-performance ropes
For over 130 years, Samson has been recognized as a worldwide leader in the development and manufacture of high-performance ropes. Among its many innovations, Samson invented the double braid and pioneered the first high-modulus polyethylene fiber ropes. Today, Samson engineers continue to pioneer the use of new fiber technology and the development of innovative coatings and constructions to produce ropes with unprecedented performance characteristics. Samson’s research and development team is meeting an ever-expanding market need for products with exceptional performance in critical applications. Samson is part of Wind River Holdings™ portfolio of operating companies. For more information about Wind River Holdings™ visit www.windriverholdings.com.

Samson’s state-of-the-art facilities in Ferndale, Washington and Lafayette, Louisiana are Quality Assurance ISO 9001 certified, utilizing LEAN manufacturing. Both facilities are located near major sea ports.

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Samson’s state-of-the-art facilities in Ferndale, Washington and Lafayette, Louisiana are Quality Assurance ISO 9001 certified, utilizing LEAN manufacturing. Both facilities are located near major sea ports.
Yokogawa delivers subsea control solutions for Shell deepwater projects

With years of pioneering offshore experience, Yokogawa has kept pace with the industry’s increasing requirements for technology and safety. Yokogawa’s subsea control system, proven to be robust and extremely reliable, was ideally suited for the world’s deepest subsea facility.

About Stones Subsea
Stones is an ultra-deep oil and gas development in the Gulf of Mexico, about 200 miles southwest of New Orleans at a water depth of 9500 feet, making it the world’s deepest production facility. Stones subsea wells deliver oil and gas to Shell’s first FPSO in the Gulf of Mexico (GOM).

Why Yokogawa for Stones Subsea?
Yokogawa CENTUM VP subsea and topsides integrated controls and safety systems are operating on Shell Perdido, Gumusut-Kakap, and OLYMPUS TLP/ West Boreas projects.

The high quality CENTUM VP system, with proven availability of 99.99999%, is a natural fit for the most challenging offshore environments. In addition, Yokogawa has worked with Shell on numerous projects to improve efficiency and standardize control systems. Based on the quality of its systems and these efforts, the Stones Subsea Master Control System (MCS) was awarded to Yokogawa in October 2012.

Contractor toolkit
Stones Modular MCS subsea controls platform includes Yokogawa’s flagship control system, the CENTUM VP, with modular programming that complies with Shell’s engineering standards and programming toolkit.

By standardizing the programming toolkit for subsea controls, the MCS could be streamlined, resulting in a higher quality control solution and a simpler change management solution, at a lower overall cost.

Yokogawa has standardized the HMIs, alarm management and subsea modules (objects and functions) for simple replication of the wells. This reduces the engineering and testing time of the Master Control System compared to a traditionally programmed PLC or other MCS Solution.

Technological Developments
In the quickly evolving offshore industry, changes and additions to the control system have become mandatory. Yokogawa’s latest CENTUM VP control system provides a user friendly and easy-to-maintain application to easily accommodate changes.

Remote Monitoring and Control
Yokogawa’s subsea control system can be monitored remotely via a secure system, allowing Yokogawa
to provide technical support from an independent location.

**Subsea Historian**
The Subsea Historian (SSH) system provides seamless integration with the subsea control system. The highly reliable SSH collects and stores well data. This system enables continuous monitoring of the well operation and the subsea infrastructure. The SSH provides a special user interface to collect valve signatures, downhole and acoustic sand detection data. This feature is used to perform valve diagnostics to aid in planning for interventions and to prevent well damage.

**Safety**
Yokogawa has been successful in inculcating safety as the go by rule. Through the various steps of the Stones project – FEED, Design, Engineering, FAT, EFAT, equipment pre-commissioning at Singapore and the subsea well commissioning at Gulf of Mexico, every activity was carried out with safety being the first priority.

**Value Drivers**
- Ease of Integration with key 3rd party topsides and subsea systems.
- Standard subsea toolkit solution package to reduce engineering and testing cost.
- Provide effective change management system to streamline change and release process.

**Conclusion**
Standardizing the subsea controls application as a solution suite is one of Yokogawa’s main initiatives for the upstream industry. This standardization provides for continuous cost reduction and increases vigilance for safety.

Providing the MCS for the Stones project is a great milestone for Yokogawa. Yokogawa met the challenge by delivering a safe solution while providing advanced technology for the next generation of deep water developments.

**About Yokogawa**
Yokogawa provides integrated control and monitoring solutions that maximize the productivity of subsea, marine, and topside operations while maintaining a safe and secure environment.

Yokogawa’s global network of 92 companies spans 59 countries. Founded in 1915, the US$3.7 billion company engages in cutting-edge research and innovation. Yokogawa is active in the industrial automation (IA), test and measurement, aviation and other business segments. The IA segment plays a vital role in a wide range of industries including oil, chemicals, natural gas, power, iron and steel, pulp and paper, pharmaceuticals, and food.