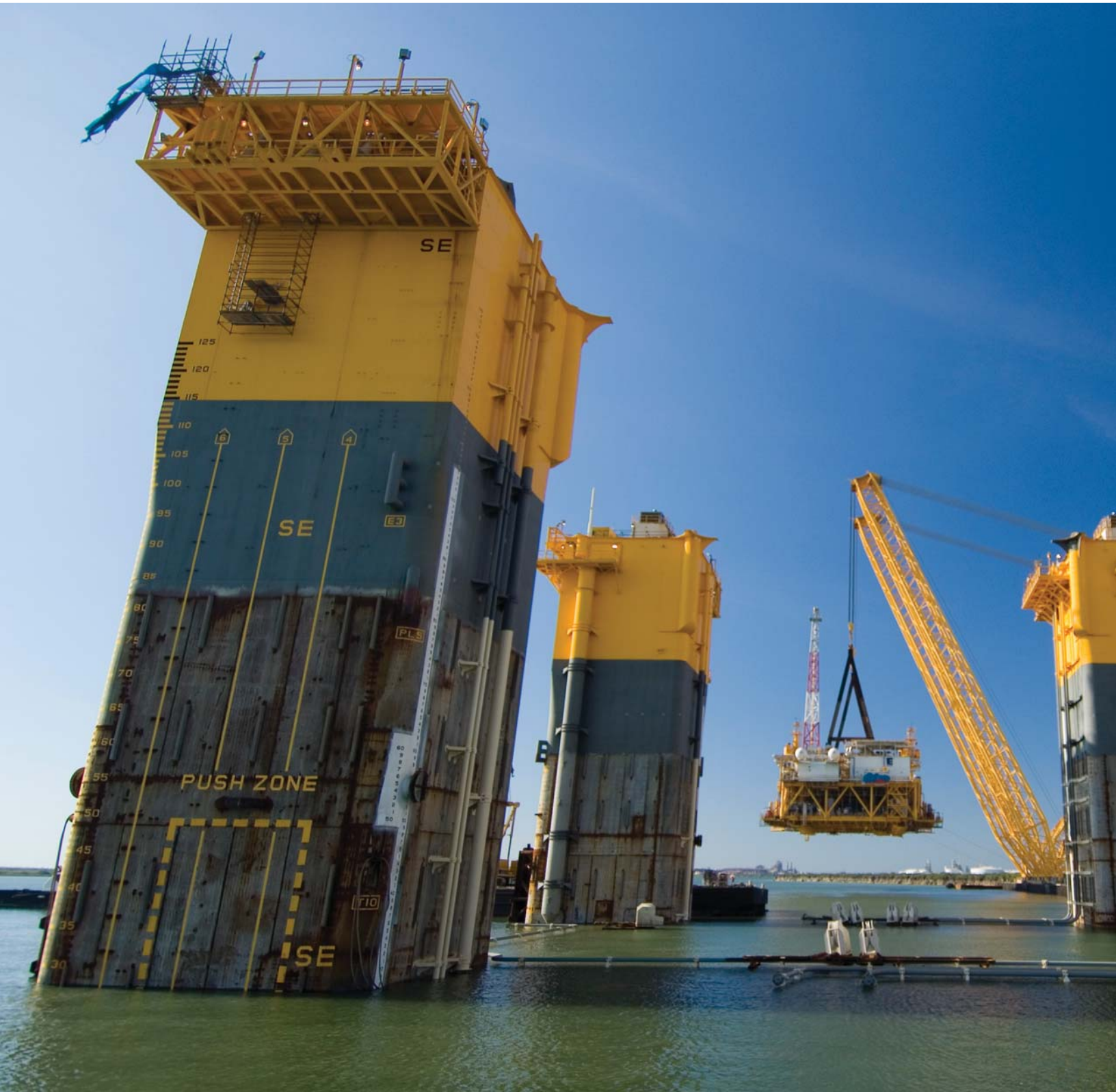
*Development Work Enters Final Stages . . .*

# Milestone Independence First Production From



# Project Approaching Ultradeepwater Fields


## By Tim Beims

HOUSTON—The countdown is on to first production from a collection of 10 fields in the Eastern Gulf of Mexico that take the water depth threshold for oil and gas development to an unprecedented level. The project includes the state-of-the-art Independence Hub platform stationed in 8,000 feet of water, 220 miles of subsea tiebacks, the dedicated Independence Trail pipeline, and sophisticated technologies such as multizone intelligent completions and subsea wet gas meters. Consolidated as a single multioperator development, the fields are expected to boost the total daily volume of natural gas produced in the Gulf by 10 percent!

But for all its technical marvels and its impressive production output, no one had heard of the Independence project only 48 months ago. That is because the project—one of the largest and most complex offshore developments ever undertaken—will have gone from the initial concept stage to first gas within scarcely four years when the platform commences operations later this year, points out Bob Abendschein, vice president of exploration and production worldwide services at Anadarko Petroleum Corporation, which operates eight of the 10 fields and holds a 61 percent majority interest in the project.

The story begins in late 2003, when a handful of independent oil and gas companies came together to form the Atwater Valley Producers Group. The companies had made natural gas discoveries in newly opened blocks in the Eastern Gulf, but because all the fields were in water depths between 7,500 and 9,000 feet, none appeared large enough to warrant stand-alone development.

"Each field holds from 35 billion to 350 billion cubic feet of reserves, which sounds like a lot of gas, but they all were in very deep water in a remote part of the Gulf where there was no infrastructure," Abendschein says.

So the companies decided to work together to try to accomplish what no one could do by itself. They dubbed their project "Independence," which was a play on the fact that all the members of the original Atwater Valley Producers Group were independents, but simultaneously served notice that they intended to break with conventional approaches to chart a new course for commercializing ultradeepwater fields, Abendschein reflects.

Four years later, their collective journey is almost complete, and those same "marginal" ultradeepwater properties are about to be brought on line as part of a 15-well project that produces 1 billion cubic feet of gas a day. However, Abendschein confesses that when the Atwater Valley Producers Group convened for its inaugural meeting, there was considerable concern about the commerciality of the project.

"There was simply no solution that would have allowed us to economically develop one or two fields in isolation of the others," he explains. "The partners recognized early that we all needed one another if we were to figure out a way to convert these stranded reserves into producing assets."

As independents are accustomed to doing in the deep and ultradeepwater Gulf, the Atwater Valley Producers Group found a way. And when the Independence Hub platform receives first gas in a few months, history will score one for the independents–and it's a big one.


**Independence Hub belongs in the category of the megaprojects. Spanning an area 30 miles wide by 60 miles long, if the maze of subsea equipment that ties all the wells to the platform were moved onshore to the Houston area, it would stretch from north of the Woodlands to south of Galveston.**

"We certainly view it as a crowning achievement," Abendschein enthuses. "The project will produce 1 Bcf a day from some of the deepest producing wells in the world through one of the largest subsea systems ever engineered to the world's deepest production platform with the Gulf's largest gas processing facility."

A lot of things make the Independence development project in the deep reaches of the Eastern Gulf stand apart, he observes, but one of the most striking is the sheer volume of gas that will soon start moving into the production system and down the line to a hungry U.S. market. "When was the last time a project came on stream that would produce 1 Bcf/d in the United States?" Abendschein poses. "This single development will boost total U.S. natural gas supply by almost 2 percent."

It also creates an all-important tieback point for future discoveries in the Eastern Gulf, adds Susan Holley, general manager for the Eastern Gulf at Anadarko. "The timing of first production at Independence Hub coincides with the opening of additional acreage in a region where exploration and development activity has been limited. The first of these blocks will be offered for lease in 2007," she points out. "The Independence Hub is well positioned to service future discoveries, and sets the stage for moving even farther into the Eastern Gulf."

**Real Record Setter**

Abendschein has taken to inserting the modifier "record setting" before the project's name, and for good reason. In each segment of the Independence Hub development work, and with almost every piece of equipment installed, he says the partners have established new water depth records. "We have broken all kinds of water depth and deepwater lift records, but the project also has set records with respect to its size, such as the world's largest subsea umbilical order and the largest monoethylene glycol (MEG) system," he states. "It is a real record setter."

Independence Hub belongs in the category of the "megaprojects," Abendschein suggests. Everything about it is supersized. He says the maze of subsea equipment that ties all the wells to the platform spans an area 30 miles wide by 60 miles long, and includes 220 miles of flowlines, 125 miles of umbilicals, 155 flowline jumpers and flying leads, and tieback distances up to 45 miles. "If you could pick up this project and move it onshore to the metropolitan Houston area, the Independence subsea system would stretch from north of the Woodlands to south of Galveston," Abendschein notes. "It covers a large chunk of seafloor."

What makes tackling a multifield, multioperator project in up to 9,000 feet of ocean all the more remarkable, he continues, is that Independence is being developed very quickly and safely. "From our first discovery (Jubilee in April 2003 in 8,800 feet of water at Atwater Valley 305/349 and Lloyd Ridge 265/309) to scheduled first production will take a little more than four years, and less than three years from project sanctioning," Abendschein states. "This is a very important project for Anadarko for a number of reasons, not the least of which is that it will be our largest producing field area the moment it comes on line."

The commercial concept behind the Independence project can be traced to a meeting between midstream energy services provider Enterprise Products Partners LP, Kerr-McGee Oil & Gas (since acquired by Anadarko), and BHP Billiton. After Kerr-

**The Independence Hub is scheduled to receive first gas later this year from 15 wells in 10 fields in water depths to 9,000 feet. The semisubmersible platform is shown here on location in 8,000 feet of water at Mississippi Canyon Block 920 with Heerema's DCV *Balder* during installation work.**

McGee announced the Merganser Field discovery in late 2001 in 7,900 feet of water at Atwater Valley Blocks 36/37, and BHP Billiton made its 2002 Vortex discovery in 8,344 feet of water at Atwater Valley 217/261 and Lloyd Ridge 177/221 (Anadarko later acquired BHP's interest in Vortex), Enterprise–fresh off an agreement with Anadarko to install a deepwater platform at the Marco Polo Field in the Central Gulf–approached the companies in 2003 about the possibility of installing an Enterprise-owned hub to produce the fields, Abendschein recounts.

"The water depths and size of the reserves associated with those first two fields were not sufficient to justify installing a dedicated facility," he explains. "But then came more discoveries as the partners worked through the blocks they had acquired at Lease Sale 181 in December 2001, which opened Eastern Gulf acreage for leasing."

In quick succession between April 2003 and December 2004, he recalls, Anadarko made a string of six discoveries: Jubilee in 8,800 feet of water at Atwater Valley 305/349 and Lloyd Ridge 265/309; Atlas in 9,000 feet of water at Lloyd Ridge 5/49/50; Spiderman in 8,100 feet of water at DeSoto Canyon Block 620/621; Mondo Northwest in 8,340 feet of water at Lloyd Ridge 1/2; Atlas Northwest in 8,810 feet of water at Lloyd Ridge 5; and Cheyenne in 8,987 feet of water at Lloyd Ridge 399. In addition, Abendschein notes, Dominion Exploration & Production brought in the San Jacinto discovery in 7,850 feet of water at DeSoto Canyon 618/619 in early 2004, and Spinnaker Exploration (since acquired by Hydro) announced in June 2005 the Q discovery in 7,925 feet of water at Mississippi Canyon Block 961 (Figure 1).

### Getting The Green Light

The members of the Atwater Valley Producers Group had suddenly proven up enough reserves to give the green light to full-scale commercial development, Abendschein recalls. In the fall of 2003, Enterprise officially submitted a proposal to the group for a gas gathering semisubmersible platform with a daily capacity of 700 million cubic feet, using subsea tiebacks to link the fields to the platform in a daisy-chain scheme. "The original planned capacity of the Independence Hub facility had to be expanded as the partners made more discoveries," Abendschein says.

Under the terms of its agreement with the field producers, the platform is owned by Independence Hub LLC (owned 80 percent by Enterprise and 20 percent by Helix Energy Solutions), and is operated by Anadarko, while the Independence Trail Pipeline is 100 percent owned and operated by Enterprise. "A key enabler from a commercial perspective was bringing in the Enterprise and Helix partnership to install and own the hub and pipeline facilities," says Abendschein. "As an independent, we want to spend our dollars exploring for and producing hydrocarbons."

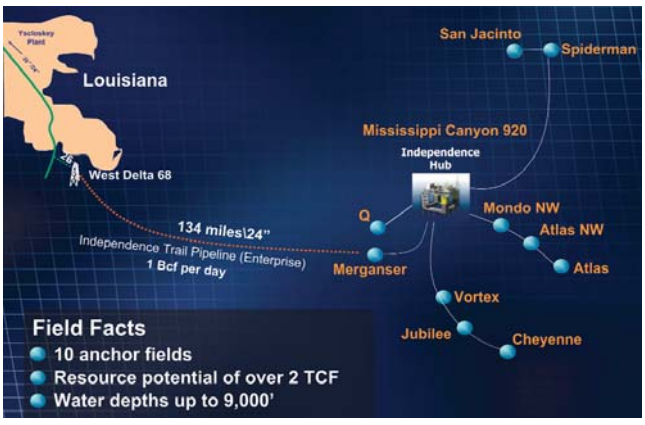
A secondary enabler was cooperation among the partners under the umbrella of the Atwater Valley Producers Group. "We were all bound by the desire to work toward the common goal of bringing the stranded reserves to market," Abendschein relates. "There were initially no legal documents or even a formal agreement among the producers. It required a great deal of trust to make this type of informal arrangement work. We all knew the fastest–and perhaps only–path to production was to work in partnership. We are all in it together, and that helped drive alignment right down to the bottom line."

According to Abendschein, collaborating with the other partners accelerated the project schedule to get to first production sooner, aggregated reserves to meet the commercial threshold for development, improved project economics, and allowed the companies to pool their combined deepwater expertise. "By aligning everyone's interests, we were able to leverage technical expertise and skill sets we otherwise would not have been able to access. That is one reason we decided to partner with Enterprise and Helix on the facilities. It was not an economic decision alone; they brought a great deal of platform and pipeline expertise to the project," he comments.

James Lytal, executive vice president for Enterprise's Offshore Services group, echoed the importance of teamwork in making the project a reality. "While Enterprise and Helix brought to the table the financial backing and technical expertise required to build the platform, the commitment of the producers group to supporting the initiative with fixed demand charges and volumetric fees was a critical element in bringing all the pieces together. With the success of Marco Polo and now Independence,

**FIGURE 1**

**Independence Project Overview**



**The 24-inch Independence Trail pipeline stretches 135 miles to a new shallow-water platform at West Delta 68. Allseas USA Inc.'s dynamically-positioned *Solitaire*–the largest pipe-lay vessel in the world–installed the pipeline after undergoing modifications required to lay the pipe and steel catenary riser in such deep water. Here, pipe leaves the *Solitaire's* stinger, with a vortex induced vibration (VIV) strake attached to improve stability.**

the Enterprise/Anadarko team has proven the effectiveness of the hub concept and the ability of the upstream and midstream sectors to work together to deliver valuable sources of domestic energy supplies."

Partnering with other producers as well as third-party facilities owners also reduced the risks associated with developing ultradeepwater fields, Abendschein continues. "This is a very large ($2.5 billion) capital project, and being able to share capital risk, timing risk and reserves risk across multiple companies was critical in moving it forward," he allows. "Plus, by working collaboratively, we tended to push each other along at a faster pace. That was a big factor in rolling the project scheduling up to get to first production quickly."

### Managing A Megaproject

But even with a pervading spirit of "all for one and one for all," ultradeepwater projects can veer off track and way over budget. To that end, Abendschein credits an effective project management strategy with keeping all the partners' individual goals aligned with the broader objectives. "We worked very hard upfront to understand what risks each company was willing to accept and what everyone's value drivers were," he remarks. "Then as we developed and executed the project schedule, we made sure the communication lines stayed open and everyone had a say."

Every decision related to engineering the project and performing the work was filtered through a three-level project management structure that included an integrated project team of technical experts from the operating companies as well as Enterprise and Helix, a steering committee of managers from the operating companies and facilities owners, and an executive advisory board consisting of executive-level representatives of the partners, facilities owners and all the major contractors, according to Bob Buck, Anadarko's production engineer overseeing the Independence project.

"The members of the integrated project team were selected based on their experience and technical skill sets, and were responsible for developing a detailed design basis and cost estimates, organizing the project schedule, approving the engineering work, overseeing the installation and commissioning work, and preparing monthly reports for the steering committee," Buck explains, noting that the project team is located in a dedicated office off Beltway 8 in Houston.

"Even though all the team members are employees or contractors reporting directly to one of the partner companies, the role of the team is to do what is best for the project," Buck relates. "Everyone recognized that the team had to be able to function independently with the project goals in mind, so we decided to house the project team off site."

The steering committee meets every six weeks, and is charged with monitoring all phases of the project and ensuring that costs and work schedules remain on track. Meanwhile, the executive advisory board meets quarterly, according to Abendschein, and its function is largely to monitor the big picture of equipment and services scheduling and delivery.

"Imagine a meeting of 30 executives representing all the companies involved, with each member standing in front of his peers on the advisory board to discuss his company's progress on the project," he says. "That has been a strong motivator in making certain we have buy-in at all levels and that everything continues to move forward. No one wants to be the guy who shows up at one of these meetings with bad news."

### Creativity And Teamwork

Abendschein says the project consists of four main elements: the 10 natural gas fields, the subsea system, the Independence Hub platform, and the Independence Trail export pipeline. As of late May, the platform and pipeline had been installed and

**The Independence project is on track to become one of a few megaprojects to come in on time and on budget. It also creates a blueprint for developing remote fields in deep water–including perhaps the Lower Tertiary play in the ultradeep Central and Western Gulf–particularly for independents, which have operated nearly eight of every 10 deepwater discoveries made in the Gulf in the past five years.**

field work was under way to finish connecting the completed wells to the hub, he says, commenting: "Each phase of the development has required creative technical solutions and cooperative teamwork from all the parties involved. It has been a tremendous challenge, but it is very exciting to bring gas from a new ultradeepwater frontier to production."

The $300 million, 24-inch Independence Trail pipeline stretches 135 miles to a new shallow-water platform at West Delta 68, where it ties into the Tennessee Gas Pipeline system. Allseas USA Inc. has completed the pipeline installation using the *Solitaire* and *Lorelay* vessels, says Frank Kluwen, general manager of Allseas USA Inc., adding that the *Solitaire* had to undergo modifications during a three-month conversion to meet the requirements for installing the pipeline and steel catenary riser in such deep water.

"It was necessary to increase the stinger strength and length to four sections and 460 feet, strengthen the aft ship by adding buoyancy with a capacity of 8,800 kips, double the tension capacity to 2,300 kips, and upgrade the abandonment and recovery system capacity to 2,300 kips," Kluwen details. "The spinoff of the investment in Independence Trail is huge for the industry. New rules were created and boundaries were redefined, setting the next step in the evolution of deepwater pipeline installation, and in the meantime, creating opportunities for everyone."

The $400 million, 10,000-ton Independence Hub deep-draft semisubmersible has a designed daily capacity of 1 Bcf of gas, 5,000 barrels of condensate and 3,000 barrels of water. Stationed in 8,000 feet of water at Mississippi Canyon Block 920, the platform measures 232 feet long by 232 feet wide by 160 feet high, and has a 45,827-ton displacement. The topsides are equipped with a two-level deck with an operating weight of 10,300 tons

Abendschein says the hull (including the hull and topside main steel) and mooring system were engineered by SBM Atlantia Offshore Ltd., a member of the SBM Offshore Group. The topsides facilities–including the decks, detail steel, process equipment, control center buildings, living quarters and MEG system–were designed by Alliance Engineering. Abendschein notes that the hull and topsides were mated last fall at Kiewit Offshore Services' facility in Ingleside, Tx., establishing a world lift record using Kiewit's Heavy Lifting Device.

Chuck Kindel, SBM Atlantia's project manager for Independence Hub, says the facility uses a motion-optimized design with steel catenary risers (SCRs) to import and export the gas production. "Independence Hub was our first Deep Draft Semi™ project," he relates. "We borrowed some of the technology we had developed for our tension leg platform designs, particularly the ballast control system. We had a few technical issues, but at the end of the day, all systems performed to the design requirements."

It also was SBM Atlantia's first experience with polyester mooring technology, Kindel continues. The platform is moored to suction piles by 12 chain/polyester/chain mooring lines that each measure 2.4 miles long. "The advantage of using polyester rope is the weight savings over chain, which can be used elsewhere on the platform," Kindel explains. "However, there had only been two other applications of polyester moorings in the Gulf of Mexico, so we had to educate ourselves on the issues associated with the technology. In addition to all the other records set at Independence Hub, I am sure it also has the world's largest polyester mooring system."

**The Independence project used a three-level management structure that included an integrated project team of technical experts, a steering committee from the operating companies and facilities owners, and an executive advisory board consisting of executives from the operators, facilities owners and major contractors. Here, Anadarko's Bob Abendschein, left, consults with a coworker aboard the Independence Hub while it was docked in the shipyard.**

**Having A Little Faith**

From SBM Atlantia's perspective, Kindel says, the most challenging aspect of the project was related to the compressed schedule. "Our general philosophy is to make sure everyone involved in a project is on board from the beginning because the interfaces between the topsides/hull engineering and the topsides/installation contractor can have significant impacts on the design," he notes. "Because of Independence Hub's aggressive schedule, however, we did not sign a contract until several months after beginning work, and we ended up doing much of the detailed engineering related to installation almost a year after we started," he comments. "We were well into the design process while Enterprise was still negotiating with the operators and contractors. That took a lot of trust."

Anadarko's Holley agrees, saying that all the parties had to have faith in the project in the early going. "A lot of the technical work in the initial stages was being conducted prior to and during the time that commercial negotiations were taking place," she recalls. "There had to be a certain level of trust and an element of risk taking on everyone's part to make sure work was progressing and that capital was being committed before the final commercial negotiations were completed."

Kindel adds that the trust and cooperation extended to contractor-to-contractor relationships as well. "This was a very complex facility design for a number of reasons, yet it had come off pretty much without a hitch. Part of that was the willingness of the contractors to work together to get the job done," he avers. "We worked in close coordination with Alliance on the topsides. In fact, we designed the topsides main steel at SBM Atlantia because it was such an integral part of the entire system. We also did a considerable amount of review/design work with Heerema Marine Contractors to integrate the installation requirements into the hull's design."

The hull was towed to location and installed last February by Heerema's DCV (deepwater construction vessel) *Balder*. Cor Verdult, senior project manager at Heerema Marine Contractors in The Netherlands, says the *Balder's* work duties began in 2006, when it set the 12 suction piles that form the an-

chors for the Independence Hub.

The hub was connected to the suction piles with the polyester mooring lines. In March, the steel catenary risers for the flowlines from the fields and the export line that connects to Independence Trail were hung-off, Verdult states. "We still have a few flowline SCRs to go, but our work on the project is nearly finished," he updates.

Before the vessel sails from location for the final time, it will have notched a number of technical achievements, according to Verdult. "The 20-inch SCR for the export line was the heaviest deepwater SCR lift ever performed, and in 8,000 feet of water, we also set a number of water depth installation records, including for the suction piles, flowlines and SCRs, as well as the longest mooring lines," he elaborates. "It has been quite an accomplishment by all the parties involved. We faced a number of extremely big challenges, and it was only by having good relationships with the operators and other contractors that we were able to come up with solutions."

One of the biggest issues for the partnership was simply getting the DCV *Balder* on location when it was needed, Abendschein explains. "The *Balder* is one of the only vessels in the world that could install the export pipeline because of the lifting requirements and the water depth," he says. "Because there is only one *Balder*, we always identified access to the vessel as one of the risks we would face during installation. We had to work with Heerema Marine Contractors as well as other operators to make certain we had access to it at the right times."

**The Independence subsea system uses more than 125 miles of umbilicals–the world's largest single subsea umbilical order. It also includes 220 miles of flowlines and 155 flowline jumpers and flying leads.**

### Equipment Availability

And in the deepwater Gulf these days, it is not only construction vessels that are in high demand. Abendschein says the single biggest challenge in managing the project has been getting equipment on site. "There is only so much space in the shipyards, a limited amount of fabrication capacity for trees and umbilicals, and only so many vessels available to do the work. For that reason, equipment availability drove much of the project schedule, particularly after the 2005 hurricanes, when everyone had immediate needs for the same equipment and vessels," he states. "We had to move on a certain schedule, with certain things happening at certain times, or face delays waiting for equipment to become available again."

Compounding the situation was the fact that the project is located in a part of the Gulf where loop and eddy currents can be severe, Buck points out, which means that once a vessel arrives on location, it may not be able to accomplish the task at hand. "We try to figure out ways to work around loop and eddy currents because they are very disruptive to any kind of surface vessel activity, but they are also very unpredictable," he offers.

In that regard, the size of the Independence project works to the partners' advantage, according to Buck. "The large span of operations means that if we encounter strong loop currents in one area, we have the ability to move to another location without having to put a vessel on standby," he says. "The problem is, there may be another vessel already working at that location, which means it has to be moved to another field as well. Loop currents create all kinds of headaches in managing vessels and work schedules."

Loop currents have certainly made their presence felt in the well completions program in Anadarko's fields, according to Kevin Renfro, senior engineering adviser, deepwater completions/production. The plan initially called for completing all the southern wells first and then working back toward the north, but when strong currents hit the southern part of the project, he says the rig moved to the Spiderman Field at the far northern end.

"We had to be able to move to avoid loop and eddy currents, and sometimes even pipe-lay and construction vessels. Rigs are expensive," Renfro notes. "Our challenge was to have equipment ready in advance and make sure it was interchangeable and could move from well to well as needed. Having that flexibility is what I would consider the biggest benefit from a project management standpoint."

Despite the difficulties, Buck reports, loop and eddy currents have not slowed progress. "We have managed to work around them so far, and they are forecast to subside over the next few months, so we hope to complete the rest of our work program without having currents impact the overall schedule," he says.

### Assuring Production Flow

Once first gas begins to flow, the biggest operational challenge will shift from currents at the surface to the seafloor, where hydrate formation poses an ever-present risk to pipelines and equipment, Buck says. "With very long subsea tiebacks in very deep water, hydrates will obviously be a constant concern," he remarks. "The worst problem will be in the riser, because as the production travels though the flowline, it will take a significant pressure drop and cool to ±18 degrees by the time it reaches the platform. Arrival temperature at the facility is actually one of the limiting factors in how much production we can flow."

To control blockages of frozen water and condensate in the long-reach subsea system, the platform contains a monoethylene glycol reclamation unit scaled to unprecedented dimensions. INTEC conducted the conceptual engineering and front-end engineering design of the subsea and flow assurance systems, says Vince Vetter, INTEC Engineering's business manager of offshore field development and the company's project

manager for Independence Hub.

Although the MEG unit is the biggest ever designed, Vetter notes, "It is appropriately conservative to provide high reliability over the life of the project. It allows for continuous injection to prevent hydrates from forming, as well as recapturing and recirculating monoethylene glycol."

The flow assurance system is designed to accommodate 750 barrels of wet MEG storage returned to the facility, and 750 barrels of dry MEG storage after processing, using a vacuum flash system with distillation to remove entrained water, according to Vetter. "With the number and length of flowlines, there is a tremendous amount of storage capacity in the subsea system, so it is important to keep the wet MEG moving back to the facility so the system does not run low at any point," he says.

Most of the 15 fields use FMC Energy Systems' enhanced horizontal trees, connected to the flowlines and 112 miles of Aker Kvaerner Subsea carbon fiber rod enhanced steel tube umbilicals (Figure 2), Vetter details. Subsea production control modules are mounted on all the trees, and two more are installed on the subsea manifolds. Another integrated control system is dedicated to well intervention and workover functions, he adds.

"The subsea system, like the flow assurance design, primarily involves scaling up proven technologies. But with a multiplicity of daisy-chained fields, very deep water and long tieback distances, this system is anything but simple," Vetter holds. "Part of our task was making sure everyone worked with a common operating philosophy and shared a total system view. Resolving different technical issues required coordination among the operators and equipment providers to find the right technical solutions–typically off the shelf–that would serve the best interest of the entire group."

### Wet Gas Metering

Some of the most sophisticated technological components in the subsea system are Roxar wet gas meters and sand monitoring systems, according to Buck. He says each horizontal tree jumper is equipped with a wet gas meter and a sand monitor–the largest application of subsea wet gas meters in the Gulf of Mexico to date, and in the deepest waters.

"Wet gas metering is critical to this development. The meters will be used not only to allocate production, but also for flow assurance," he offers. "The meters are capable of measuring dry gas, condensate and an aqueous fraction (water and MEG), so we will be able to tell when we start cutting water to know when to start increasing the MEG dosage. We also will know how much MEG and fluid are left in the flowlines by measuring the volumes that have passed through the meters versus the volumes received at the hub."

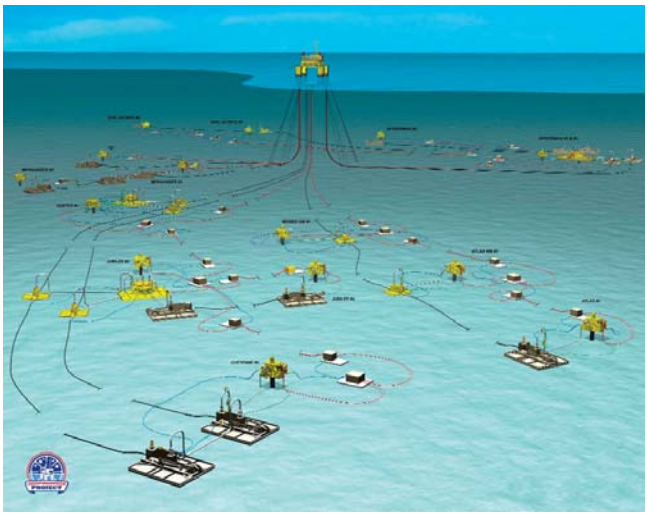
Sandy Esslemont, Roxar's chief executive officer, insists that Independence Hub is equally critical to wet gas metering technology. "We very much measure Independence Hub's success as Roxar's success," he reveals. "Wet gas metering and sand monitoring are enabling technologies for this project, and we are acutely aware of the need for the technology to perform to specifications. We think it will undeniably demonstrate the benefits of wet gas metering in subsea production going forward, particularly in deep water with long tiebacks. We immediately saw that the technology could add value to this project, so we pressed the go button at the start and have pretty much held it down the entire way."

As important as production allocation is to the partners, wet gas metering is absolutely vital in monitoring well performance and preventing hydrate slugs and corrosion in the flowlines, pipelines and subsea equipment, Esslemont says. "If they see water at the platform, the operators have to know where it is coming from so they can take remedial action by injecting MEG, choking back a zone in a particular well, or some other measure."

The subsea sand monitors provide an early distant warning of sand entering the production system to avoid blockages and erosion problems, and eliminate the need for sand clean-outs. "They also allow the operators to produce wells at their maximum sand-free rates," Esslemont points out. "As soon as they detect sand from a well, the operators can wind back production to where sand is no longer being detected. That is essentially the maximum rate at which the well can produce without making sand."

Esslemont says the wet gas meters and sand detectors are designed for 30-year run lives, although as a relatively new technology, the earliest installations have been in operation only for a couple years. "Our design criterion is to install them and never have to intervene until the field is no longer able to produce," he avers. "I do not know how long the initial Independence Hub wells will be on line, but we anticipate the wet gas metering and sand monitoring equipment being there to the very last day."

**FIGURE 2**
**Independence Project Subsea System**



### The Great Enabler

From polyester moorings to wet gas meters to intelligent completions, Holley stresses that technology has proven the great enabler time and again on the Independence project. "It was not that many years ago when we could not even have conceived of producing gas in 9,000 feet of water," she muses. "The project uses some pretty sophisticated technologies, but it also builds on countless technical advances that have become more or less standard in the deepwater Gulf. Those advances had to happen in order for Independence to become a reality."

For Anadarko, the first technological stepping stone to commercializing the reserves was geophysical tools deployed in the reservoir evaluation phase. Holley says the company applied prestack depth migration algorithms combined with seismic inversion, to convert 3-D data to delineate the reservoir, predict

reservoir quality independent of well control, estimate reserves, and maximize well bore positioning.

"Advanced seismic processing and visualization techniques gave us new insights into the subsurface structures we were seeing during exploration in the 3-D data," Holley elaborates.

Although the 12 Independence wells Anadarko operates or holds interests in were drilled in an area with few offset analog wells and that was prone to loop and eddy currents, Abendschein reports rig operations from Transocean's *Millennium* shaved 25 percent from average deepwater drilling times.

"I cannot give the crew of the *Millennium* enough credit. We had a small, integrated team of Transocean and Anadarko personnel, and the teamwork really paid off. We kept getting faster and better at drilling the wells," he praises. "Managing the technical drilling challenges came down to upfront planning, having redundant systems in place, playing through all the possible outcomes, and applying what we learned in post-drilling appraisals of previous wells."

### Completions Program

After drilling and sidetracking, the wells were turned over to Anadarko's completions team, led by Renfro. He says the completed zones are at subsurface depths of 8,000-9,000 feet (16,000-20,000 feet total depth), and all the wells are frac packed and fitted with downhole gauges for monitoring during production. Seven are completed in a single zone, four are two-zone intelligent completions, and one is a three-zone intelligent completion, he details.

"We installed intelligent completion technology so we can cost effectively switch zones as they deplete without rig intervention," Renfro explains. "We can shift between completed intervals remotely in the wells with multiple zones, which saves on capital costs and allows us to keep production up the entire time."

On the dual-zone wells, Renfro says the plan is to begin by producing only the lowest completed interval. "We have the option to produce both zones at the same time and commingle the production, but the key variables are reservoir behaviour (depletion drive versus water drive), flow assurance, and tubing capacity above the smart completions," he states. "If the lowest zone is capable of maxing out the tubular capacity above it, we will produce it to depletion and then move to the upper zone."

The strategy is essentially the same for the three-zone well, with production beginning in the deepest zone and moving upward, except that a slick-line or coiled tubing intervention will be required when the time comes to open the middle zone. "We can commingle production from any two zones or produce any zone in isolation, but we can only control two zones at one time," Renfro relates. "The third zone is already frac packed and completed, but to produce from it, we will have to enter the well to open the sleeve on the third zone and close a sleeve on one or both of the other two zones."

Renfro reports that the majority of the wells flow tested at rates of more than 50 million cubic feet of gas a day, and were limited by flow testing capacity constraints on the rig. "The Cheyenne Field tested at the highest rate, making more than 70 MMcf/d at only 150 psi drawdown, so the rate capability of those zones is probably much higher. But again, with multiple wells going into the flowline system, we will have limits on how much gas can be produced from each zone and each well at the same time. On the plus side, that provides a longer, broader decline profile."

**Teamwork and technology are both on the critical path to success for Anadarko and its partners on the Independence project. Shown here, from left to right, are Anadarko's Kevin Renfro, senior engineering adviser for deepwater completions/production; Susan Holley, general manager for the Eastern Gulf; and Bob Buck, production engineer overseeing the Independence project.**

Renfro says Anadarko worked with BJ Services to continually optimize the frac pack design as the program unfolded, as well as with Baker Oil Tools to increase the size of the intelligent completion sleeves and flow valves installed on 9⅞-inch casing (from 3½ to 4½ inches).

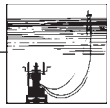
"Our number one issue is sand control, and with so many wells, we learned a lot that allowed us to maximize frac pack performance as work progressed. We have seen excellent results, with good tip screen-outs and net pressure builds," he reports. "For the intelligent completions, we essentially had to adapt existing technology to make it larger to accommodate high-capacity flow rates with large pressure drops, yet still have the reliability of a proven system."

As planned, the completions program called for well work to span through two hurricane seasons, but Renfro says Anadarko was able to beat the schedule by several months. "We worked closely with our contractors and vendors to focus our collective expertise on coming up with the best completion at the lowest cost in the least amount of time," he holds. "Because we reduced the time required to complete the wells, we not only saved a significant number of rig days, but we were also able to avoid a second hurricane season."

### Setting A New Standard

And, of course, like virtually every other aspect of the Independence project, Anadarko established a long list of "firsts" during the completions program, Renfro notes. "It seems like we set new water depth records in almost everything we did, whether installing a subsea tree, frac packing a zone, setting a subsurface safety valve, or testing a well–we hit them all," he concludes. "We kept breaking our own records as we went along."

Until the completions operations moved on location at the Cheyenne Field No. 2 well, that is. In 8,960 feet of water, the Cheyenne No. 2 set a new standard for nearly everything associated with completing a well in deep water, but Abendschein says Anadarko has approached that well just as it has any of the others.



"There are obviously a lot of challenges associated with these wells, and we had an admittedly ambitious schedule from day one. But we have been careful to never get ahead of the industry's learning curve or put ourselves in a situation where we had to depend on radical new technology in any part of the project," he offers. "We have figured out ways to make these fields commercial mainly by pushing existing technologies and engineering concepts into deeper water with more extreme operating pressures and temperatures."

And in doing so, the Independence project may also be drafting a blueprint for developing remote fields in deep water, particularly for independents, which have accounted for nearly eight of every 10 new deepwater Gulf discoveries made since 2002 (almost 40 percent of them in ultradeep waters of 5,000 feet or greater), according to data from the U.S. Minerals Management Service. "We believe the commercial model established for the Independence project is very important to the Gulf's future, so as to allow producers to partner with other companies to group fields, upsize facilities, reduce risk, and move new discoveries to the production phase," Abendschein evaluates.

That includes the growing list of discoveries in the Lower Tertiary oil trend that spans a large area in the ultradeep Central and Western Gulf planning areas, and where Anadarko has participated in multiple discoveries, he adds, noting, "The challenges related to the permeability of the reserves, the size of the reservoirs, and the cost of installing facilities to get the oil to market–whether using a semisubmersible or a floating production, storage and offloading vessel–will likely require multiple companies working together to make Lower Tertiary discoveries commercial."

INTEC's Vetter agrees. "Despite its complexity and size, Independence Hub has been a great project with very few snags–either technical or commercial–and has fundamentally been a 'win' for everyone involved," he states. "Above all, the project demonstrates that bringing a consortium of companies together to maximize synergies in the collaborative development of a group of fields in ultradeep water holds great benefits, but it takes a lot of forward thinking and good people to make it work on a practical basis. Success on this project was no accident."

No one appreciates that sentiment more than Anadarko, Abendschein concedes. "Thanks largely to an innovative commercial model, solid engineering, appropriate technology selection, and a tremendous amount of hard work from countless people, the Independence project is progressing as planned and is meeting all expectations," he concludes. "We are on schedule and cost is right on target. It looks like Independence will be one of the very few 'megaprojects' that will actually come in on time and on budget. Everyone involved should take a tremendous amount of pride in that." ❐