Drilling Automation: A Catalyst for Change

Stephen Rassenfoss, *JPT/JPT Online* Staff Writer

Shell's autonomous drilling control system, known as SCADAdrill, during testing in the Netherlands.

EMERGING TECHNOLOGY

Seabed Rig is a small company named after its audacious vision: creating a device able to drill a well on the bottom of the ocean. The company, 20% owned by Statoil, is using what it learned from a prototype to build a rig capable of drilling on land, or an offshore platform, with no workers on site.

"You command it, you don't control it," said Kenneth Søndervik, vice president of sales and marketing at Seabed. Rather than a person controlling machines putting together pipes, an automated system will respond to a command, such as "pick up 3,000 meters of pipe," from the computer program controlling drilling. The ability of these machines to work together on their own is essential for Seabed because Statoil needs a rig capable of drilling in the Arctic, and other environments that would put workers in harm's way.

This semantic distinction points to a fundamental change in the drilling business, and the people who work on the rigs. Seabed is building a rig like no other, using components supplied by oil and automation companies. "The big thing is we are not an inventing company. We are an engineering company taking all that's out there," said Søndervik.

Seabed is working on creating a confined rig floor—the footprint is 9 m by 9 m—with robots programmed using software developed for NASA by Energid Technologies. The US company's software is also being used to control the next generation of lunar rovers. For the drilling, Seabed will be choosing from a growing number of major oil and service companies developing software that does the job.

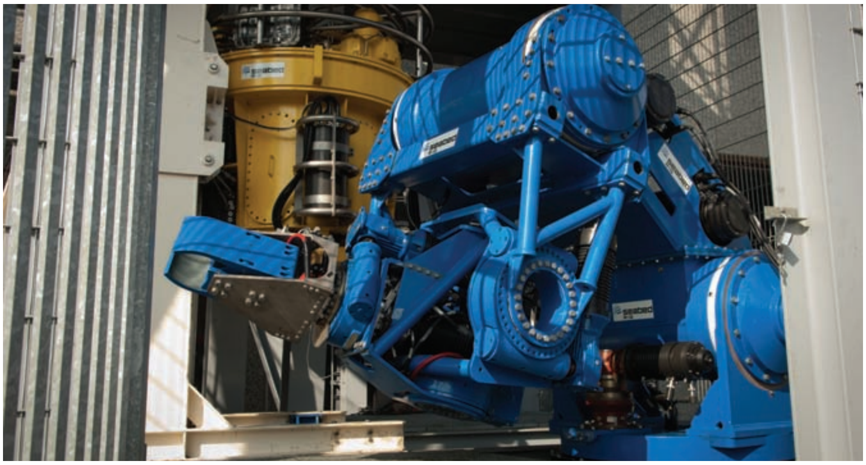
Statoil, ExxonMobil, Petrobras, Schlumberger, National Oilwell Varco (NOV), and Baker Hughes, represent a sample of the technology leaders seeking ways to program all or parts of the drilling process.

Shell appears to have taken it the furthest, with an automated program that has drilled multilateral wells. "It is not science fiction, it is what we have done," said Peter Sharpe, executive vice president of wells at Shell. Its SCADAdrill System has been demonstrated in Canada and the Netherlands, with testing in progress in two US shale plays, the Marcellus and Haynesville.

Shell has shown its confidence in this work in progress that it has created a joint venture with the China National Petroleum Corporation (CNPC) to create and operate a new generation of automated drilling rigs designed to efficiently develop unconventional fields requiring thousands of wells. That has been the biggest step toward taking a technology that has been gradually changing the state of the art in drilling, and shoving it into the mainstream.

Drilling contractor Helmerich & Payne (H&P) was one of the first to equip rigs with automatic drilling programs that can take control of drilling, and competitors such as Nabor's Canrig have followed suit. Others are embracing computer controls as a way to create systems that show what they have learned about drilling.

Useful knowledge, such as how to reduce the vibrations that can slow drilling and prematurely wear out drill bits, is converted into mathematical formulas. For example, if there is an increase on the weight on the drill bit, an algorithm determines if the change will mean more or less, efficient rock cutting. If the result is positive, the algorithm determines at what point the change will no longer improve performance and then it says, stop doing that. Such algorithms are the basis for programs to control drilling functions that also take advantage of the stream of downhole data.



This robot was created to work on the deck of the automated drilling rig being built by Seabed Rig. It can lift and move a variety of tools weighing up to 3,000 kg, making it the world's strongest industrial robot.

"The number of companies with significant automation efforts under way is growing rapidly," wrote Fred Dupriest, chief drilling engineer at ExxonMobil Development, in an email. He did not offer details, but said the company is working on an automation update expected in March.

With so many companies working to turn their knowledge into working programs, NOV is redesigning its rig control system. The goal is to create an open system that will facilitate deploying new drilling programs, said Andrew Bruce, vice president of controls at NOV. The approach is similar to the way iPhones runs a growing number of applications, better known as apps.

The Unconventional Case for Automation

Computerized control systems, which have been used for decades in factories and airplanes, are emerging as a way to manage a costly challenge: developing unconventional oil and gas reserves that will require enormous numbers of wells.

For Shell, the added drilling will push its spending for drilling and completing wells from 30% of its exploration and production budget—about $9 billion in 2011—to about 50% in 2020, Sharpe said. With natural gas prices relatively low and drilling costs on the rise, there is pressure to do things differently.

"If you are drilling 5,000 or 6,000 wells next year, there is a need for serious cost control in every aspect of the drilling program," said Fred Florence, product champion of automation and drilling optimization at NOV.

Adding to the interest is the limited supply of skilled drillers. The rapid expansion of drilling in certain US shale plays has resulted in local shortages in directional drillers. And many of the best ones are reaching retirement age. In many other countries with large shale potential, people with directional drilling skills are a rarity.

And there is the promise that automation technology will reduce the risk of injuries by reducing the number of workers on site, and ensuring safe procedures are followed consistently.

In Search of Savings

The early work suggests automation can reduce costs by drilling wells faster. But the available results are based on limited experience. In the interviews for this story, a commonly cited estimate was automation can reduce the time needed to drill a well by around 25% compared with a driller.

In a presentation, Shell showed an example where its automated system reduced the drilling time by 25% and the cost of the well by 17%. The total cost included fixed costs not affected by faster drilling.

H&P offered an example showing how the efficiency of its rigs more than make up the higher day rates it charges to drill. However, it had not done a study to separate the benefit of its automated driller from the value of other features that increase productivity.

One study of offshore drilling found that over the past decade, advances in rig designs, which promised cost reductions, failed to deliver.

The study by Michael Behounek, senior drilling adviser for worldwide drilling at Apache, found that industrywide there were little or no gains in productivity during the period. The presentation delivered at the International Association of Drilling Contractors technical meeting in April was based on a variety of cost measures gathered by Rushmore Reviews.

"We had some great technology developed. It has allowed us to drill wells we couldn't do in the early 1990s. But on the cost curve, we didn't bend it," Behounek said. His prescription: radical technological change.

Cooperation vs. Competition

For H&P and Shell, making a change required going it alone.

In the late 1990s, when the US drilling business was in a slump, H&P began designing and building new rigs. Its rigs represent more than 40 percent of all the US rigs wired to handle drilling automation and are among the most active.

The decision by Shell to move forward with commercialization may serve as a catalyst in an industry where most companies seek to be "close followers." Adding to the challenge is the complex structure of the drilling business.

Sharpe said it also shows how the splintered, competitive oilwell services business can impede development of a technology with far-reaching consequences. To explain, he drew a diamond-shaped diagram of the drilling business. At the four corners were equipment makers, drilling contractors, large service companies, and E&P companies.

As he explained the role each plays in drilling a well, Sharpe drew lines with

A worker monitors the progress of a well drilled by Shell's automated drilling system.

arrows highlighting the symbiotic relationships with lines that crossed in the middle of the diamond. Then he drew an X at that intersection, as he pointed out how those competing interests make it harder to change. Sharpe said the barriers to automated drilling begin in the control room. "Who wants this change on the rig?" he asked. "A directional driller will do everything he can to make sure it doesn't work, and the driller isn't keen on this working."

The rush to create drilling programs challenges the normal relationship between a driller and the companies that hire them. A program from the oil company that manages drilling by controlling the weight on the drill bit and the revolutions per minute goes beyond the company man setting parameters for the well.

Shell's plan to create a joint venture with CNPC that will build and run rigs drilling in a select group of extremely large fields does not avoid the issue altogether. For the many fields where less drilling is required, including Shell's US shale plays, Sharpe said Shell will look for ways to use its drilling control system in situations where it hires a driller. He recognizes that may require an unusual agreement, where Shell would exercise control over the drilling and the equipment needed to make its automated system work.

For a rig owner it is a significant change. When the customer takes control of equipment of a business built on selling a valuable service, there is the risk that a drilling business will

The Path to Automation

SPE paper 119884 cited Professor Thomas B. Sheridan's 10 degrees of automation, which range from all decisions made by a human with no machine assistance to decision making by the control system.

1. Offers no assistance: driller must take all decision and action.
2. Offers a complete set of decision/action alternatives.
3. Offers a set of alternative and narrows the selection down.
4. Suggests a single course of action.
5. Selects and executes that suggestion if the driller approves.
6. Allows the drill a restricted time to veto before automatic execution.
7. Executes automatically, then necessarily informs the driller.
8. Executes automatically and informs the driller only if asked.
9. Executives automatically and informs the driller only if it, the computer, decides to.
10. Decides everything and actions autonomously, ignoring the driller.

become more like an industrial equipment rental company.

Bridging Gaps

The technical and business challenges presented by drilling automation have spawned a pair of professional groups seeking to bridge the gaps. SPE's Drilling Systems Automation Systems Automation Technical Section (DSATS) has worked to identity and overcome barriers that limited the use of downhole automation, as has the IADC's Advanced Rig Technology Committee.

One indication of the rising interest has been the swelling attendance at DSATS events. An overflow crowd filled a ballroom at the IADC/SPE Drilling Conference in Amsterdam in March, said Florence, who is the chairman of DSATS.

The discussions have covered what standards should be used for data communication and commands, how will automation change the driller's job, and whether there are ways to resolve the business issues raised in this competitive business.

When DSATS held an automation workshop in Galveston in March, participants were encouraged to offer solutions to the technical and business issues raised by drilling automation. Florence said the business issues generated the fewest responses.

Based on a survey at that gathering, there is time to work out these issues: 46% of respondents said the day when a rig can be operated without people is 20 years off, if ever.

"Some folks say it will never happen. Some say it has to happen. Some people see autonomous drilling machines," Florence said, adding: "Some level of autonomy will be there."

Ten Degrees of Automation

The path to total machine control was broken down in an SPE paper by Florence and others into 10 steps. They ranged from a driller making all the decisions with no assistance from an automated device, to a machine deciding everything and ignoring the driller.

Currently what is out there, such as H&P's automatic driller, or the drilling management programs developed by Schlumberger, is around the middle of the scale, with drillers able to review and veto drilling recommendations, or just turn the device off.

Shell's push to move the driller out of the process adds a layer of complexity because tradeoffs are required among the multiple subprograms. Achieving one priority, say rapid penetration, can work against the goal of drilling a clean hole. To drill fast, the program will have to see how dirty a hole is acceptable when it is time to complete the well. Sharpe described the process as "a little more complicated."

A mass movement into drilling automation requires an investment beyond software development. Modern rigs, with control systems wired to communicate and respond to a digital system, are needed. These are most often variable frequency drives (VFD), or alternating current (AC) systems.

Only 25% of the active rigs working on land in the US are AC equipped, according to H&P data. Its chart, drawn from H&P and industry data, showed 72% of the existing US onshore drilling rigs were built between 1942 and 1982. "Retrofitting 30-year-old land rigs isn't likely to make economic sense," said Clinton Chapman, drilling automation program architect at Schlumberger. "It will cost less to scrap them and do new ones."

Automation also requires rigs with compatible equipment that is consistent from job to job. To drill a well, Schlumberger had to develop algorithms to control drilling, and the interfaces needed to ensure its instructions are delivered and executed properly by the equipment on the rig.

Writing algorithms for every possible rig and equipment setup would be prohibitively costly and time consuming. One example of the differences: a command setting the drill bit revolutions per minutes rate would need to go through the control system on one rig, while another would require setting up a system to control the throttle on the top drive.

There is no standard for communication and commands among drilling devices. To fill that gap, DSATS recommended a communication protocol widely used in industrial automation—OPC UA—based on the consensus among its members with expertise in the area.

Creating drilling equipment that works flawlessly with a computerized control system also raised questions for DSATS. The fear was the standards needed to ensure uniform performance could prevent equipment makers from adding value with unique new features. Equipment makers do not want to be trapped in a business making something that is selling a low-cost commodity.

"We have to find a way to deal with all these limits in a way that makes technical sense and business sense and is secure and reliable," Florence said. "I hope you see more of it five years, it may take more like 10 years." **JPT**

For further reading:

SPE 119884 *• "Drilling Automation: Technologies, Terminology, and Parallels With Other Industries" by John Thorogood, Drilling Global Consultant LLP, et al.*

SPE/IADC 140114 *• "Interoperability: An Enabler for Drilling Automation and a Driver for Innovation" by Andreas Sadlier and Moray Laing, Baker Hughes*

SPE 134580 *• "Borehole-Quality Design and Practices To Maximize Drill-Rate Performance" by Fred Dupriest, ExxonMobil Upstream Research Company, et al*

SPE 143899 *• "Drilling Automation: An Automatic Trajectory Control System" by Dimitrios Pirovolou, Clinton D. Chapman, Schlumberger, et al*

SPE/IADC 139897 *• "Increased Rate of Penetration Through Automation" by J. Dunlop, Schlumberger, et al*

Automated Drilling Raises Control Issues

Stephen Rassenfoss, *JPT/JPT Online* Staff Writer

Anadarko averaged 12.6 days to drill 59 Eagle Ford Shale wells during the second quarter of this year. Its best took 8.5 days from the day drilling began to when the rig was released.

Mark Sundland, drilling engineering manager of Anadarko's Southern Region, credits the rapid pace of the 10 rigs—with times less than half of some competitors in the South Texas play—to consistent use of modern rigs and long-standing ties with top directional drillers and consulting company men. Some of those hands learned their trade working on the first big horizontal drilling play in the Austin Chalk play back in the 1990s.

The rigs are equipped with automatic drillers and equipment that replicates the skill of skilled directional drillers. Sundland said he sometimes questions the high cost of those options, which are built to do what Anadarko's experienced drillers can do. But with so many veteran hands nearing retirement, and drillers hard to find in some places, he admitted there is a clear and growing need.

The people developing automated drilling equipment are thinking along the same lines.

"What we are trying to automate are the best practices across directional drillers so you can take one with two years' experience and they can drill as well as someone who has done it for 20 years," said Clinton Chapman, drilling automation program architect at Schlumberger.

The oilwell service company has developed a pair of programs. One speeds the drilling penetration rate, and the second controls the trajectory of drilling. The benefits come in the form of faster drilling, which lowers costs, and more predictable results, which is critical in satisfying the terms in drilling contracts. Both are aimed at performance that exceeds what is now available elsewhere. Shell has gone a step further with a device capable of managing the entire drilling process.

Many companies in the industry are seeking to turn what was once an art based on the experience and feel of a person, and turn it into a science using computer programs based on mathematical formulas. "We can do this much more predictably with a series of algorithms," said Peter Sharpe, executive vice president of wells at Shell. He pointed out that a machine's ability to instantly react to downhole data allows it to do a better job than a person at keeping a drill bit steadily engaged on the rock face.

While automation is often seen as machines replacing people, the reality is more complicated. The growing range of digital control is changing the way workers interact with drilling rigs. Electronic systems have had a visible effect on how drillers do their job. On modern onshore rigs, drillers on newer rigs work in air-conditioned control rooms with a joystick in hand, flat screen displays in front, and an automatic driller.

Next generation technology—such as Shell's SCADAdrill (Supervisory Control and Data Acquisition) system—takes a far greater role. It raises the question: In the future, will there be someone called a driller? Sharpe's response was "I hope so."

The Shell system is designed to limit the number of workers at the well site. A person in a remote monitoring center will follow its progress and will intervene if things are not going according to plan, problems are expected ahead, or the team in charge sees the need to do so.

A worker in the control seat of a Helmerich & Payne FlexRig can control drilling, or turn the operation over to an automatic driller.

Fred Florence, product champion of automation and drilling optimization at NOV, compared it to commercial jets: "We can fly from here to LA without a pilot. The problem is you are not getting Fred Florence on that plane."

Getting More From Drillers

The drilling automation found on rigs today has been well received. The Schlumberger program designed to maximize the rate of penetration has been popular, said Chapman, noting: "There are a lot of them asking 'Please, can I run it,'" because it helps them do their jobs better.

Helmerich & Payne (H&P) was a pioneer in building rigs with variable frequency drives and automatic drillers. Juan Pablo Tardio, vice president and chief financial officer of H&P, said the system more precisely controls everything from the weight on the drill bit to drilling fluid flows. Drillers appreciate that because it allows them to focus on other aspects of their job.

H&P designed one of its smaller FlexRig models with automated systems that were expected to allow a reduction in the crew from five workers per shift to four. In practice, the crew size remained the same. "We found that given the huge improvement in productivity, the tasks that had to be done for every well were compressed to the point where the fifth crew member remained productive," Tardio said.

Learning From Experience

Chapman of Schlumberger describes the impact of automation on drillers by saying "their jobs will shift away from the tasks best done using automation to those that require human supervision."

There is general agreement that automation changes jobs. The harder question is how this should be managed to be sure people focus on what is important when the automated driller is working.

John Thorogood, who is a drilling consultant, the recipient of SPE's 2011 International Drilling Engineering Award, and a pilot, studied the lessons learned by airlines as they moved into automation. He said the oil industry needs to take a more structured look at what can be automated, why it should it be automated, and what happens if it is automated.

Lessons learned from past designs of the cockpit displays in fighter jets have figured into the development of the screens for the next generation control system from National Oilwell Varco (NOV). The common link between a fighter jet and a drilling rig is that the available data can overwhelm the person at the controls. The risk of data overload is a factor in the design.

"It is not about data; it is about information" that a driller can use to safely and effectively manage the operation, said Andrew Bruce, vice president of controls at NOV. The needs of the person in the drilling chair, and those monitoring it online, may well be different. System designers need to know: How do you analyze what is going on and get the relevant information to the right people?

The rise of machine control could lead to a greater emphasis on drillers playing a role in finding ways to improve the process.

In a presentation on ExxonMobil's fast drill program, the company's chief drilling engineer, Fred Dupriest, focused on the value of training and motivating drillers to involve them in the work of finding faster, safer ways to drill. "We teach drillers some physics. They have got to understand why you fundamentally have changed how things work," said Dupriest during a panel discussion at the International Association of Drilling Contractors annual technical meeting in April.

He was followed by Eric van Oort, onshore gas technology manager at Shell, who agreed that workers are motivated by the desire to be good, true, and noble. But, he added, they are also fallible. "You can teach people anything, but they forget. They have good days and bad days," said van Oort, adding: "The future will include a fair degree of automation."

Thorogood said the lessons learned in the fast drill program are "a classic case where automation is essential because organizational motivation and willpower eventually fades or gets distracted."

Shell's automated approach is expected to halve the size of drilling crews. Sharpe said he does not see the reduced number of observers hampering Shell's drilling improvement program. "The existing rig cadre is not contributing to continuous improvement. They are optimizing connection time and tripping time and rig moving time," Sharpe said. "It is supervisory level people that are looking at that." **JPT**

Joint Venture Challenges Drilling's Status Quo

Stephen Rassenfoss, *JPT/JPT Online* Staff Writer

Shell is facing up to fast-rising future drilling costs by taking control, with a venture that will build, own, and operate drilling rigs. The company has created a joint venture with China National Petroleum Corporation (CNPC) to build a new generation of special-purpose automated drilling equipment.

There is a back-to-the-future quality about the strategy. Oil companies once owned many of the rigs used to drill their wells, but largely got out of the business in the 1970s and 1980s as they pared back to focus on the more profitable business of finding oil and gas.

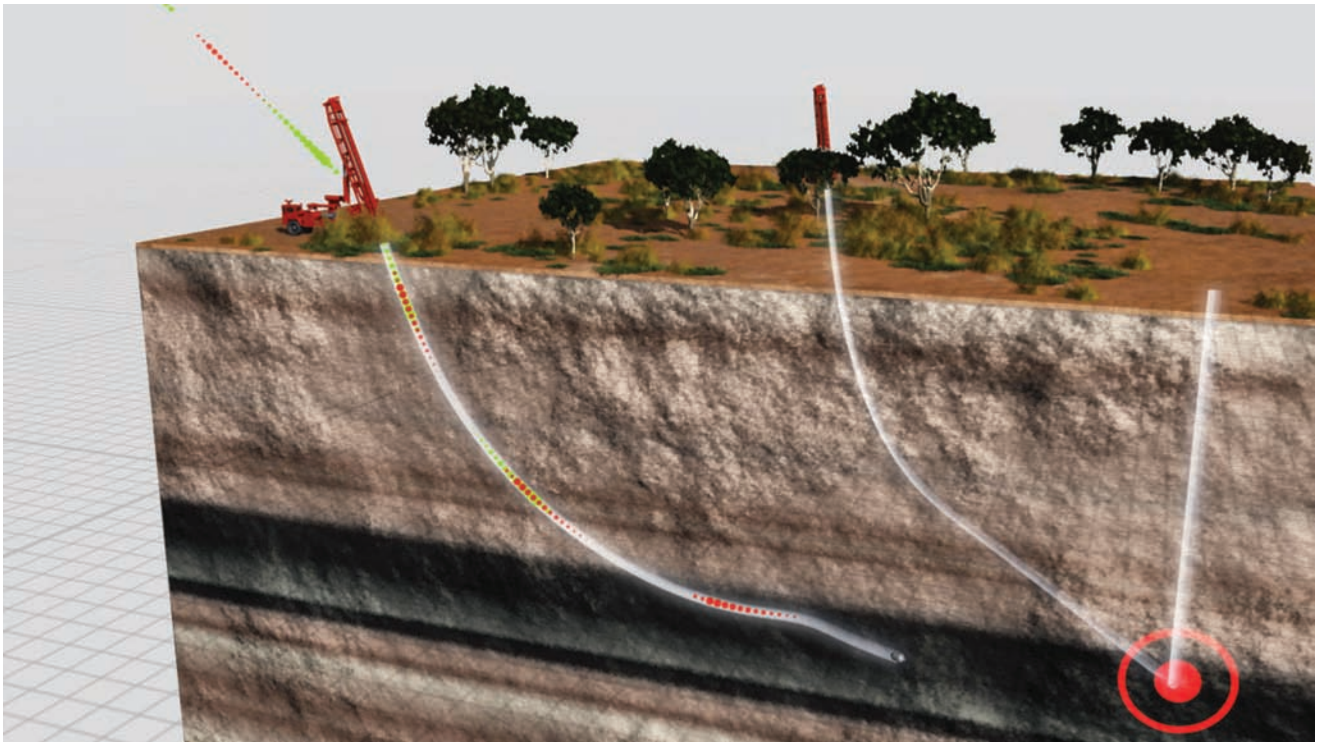
Shell is changing its strategy as the number of wells it drills soars to take advantage of unconventional reserves. For example, rather than drilling 10 highly productive wells to develop an offshore field, Shell expects to drill about 10,000 wells to produce natural gas from a single coalbed methane project

"The well manufacturing joint venture is an opportunity to redefine our costs in an area where we spend a significant amount of money," said Peter Sharpe, executive vice president of wells at Shell.

Shape declined to say how much Shell expects to invest or benefit from the venture. The agreement was signed between the companies in late June. As of late July the two sides were working on a detailed business plan and negotiating details, such as what intellectual property each would contribute. The operation, which has not yet begun design work, expects to begin production in 2013.

Sharpe

The venture is not going to become the driller of choice on all Shell projects.



A new generation of truck-mounted rigs drilling a directional well is shown in this image. Created to perform specific functions, the equipment will be built and operated by Shell's joint venture with China National Petroleum Corporation. Work has not yet begun on the actual design.

It is aimed at fields requiring high-density drilling, with thousands of wells drill over decades. Fields that do not fit into that category include Shell's US shale holdings, where the drilling is not on the scale needed for its high-density field approach.

The business plan for Shell's manufactured drilling program goes after costs in a variety of ways. It combines new technology—drilling automation—with long established cost-cutting strategies: partnering with a low-cost provider, economies of scale, specialization, and cutting out the middleman.

Shell's partner in China, CNPC, is a major maker of drilling rigs in one of the world's largest and most efficient manufacturing economies. While Shell is far better known, Sharpe said CNPC's budget for drilling and completing wells is comparable to its own.

The automated drilling program is expected to lower costs by drilling wells faster with fewer people on site, which should make it safer as well. It reduces the number of rig workers, who are hard to find in some territories. Sharpe said there are countries where "we can't train the people we need at the rate we need them."

Technology Plus Efficiency

Building and owning its rigs is expected to cost less than entering into a long-term contract with a drilling company at a time when costs are rising. Sharpe said too often, the drilling services available exceed what is needed, resulting in higher costs. "When I want a Ford Focus, they are selling me a Ferrari," he said.

The venture that will build and operate equipment tailored to the needs of its owners are:

- Rigs will be designed to efficiently do specific jobs for decades.
- Automated drilling systems built by Shell are expected to allow rigs to consistently attain high productivity levels.
- Drilling rig crews are expected to be half as large.

A Shell animation illustrated its plans. It shows truck-mounted units each with a specialized purpose—some are drilling vertical gas production wells and others horizontal wells to produce water. Automation will be used to control the wells. Sharpe said its technology will allow it to drill directional wells that precisely intersect with vertical ones, which is difficult to do now.

Rigs operated by the joint venture will be far more specialized than the average rig, which Sharpe likened to a Swiss Army knife. While drilling crews will shrink, he predicted the number of people working will rise because more efficient drilling "will allow us to unlock resources in place that are not economic to unlock today." **JPT**