New Technology magazine
JULY/AUGUST 2015
THE FIRST WORD ON OILPATCH INNOVATION

THE CYBERSECURITY THREAT



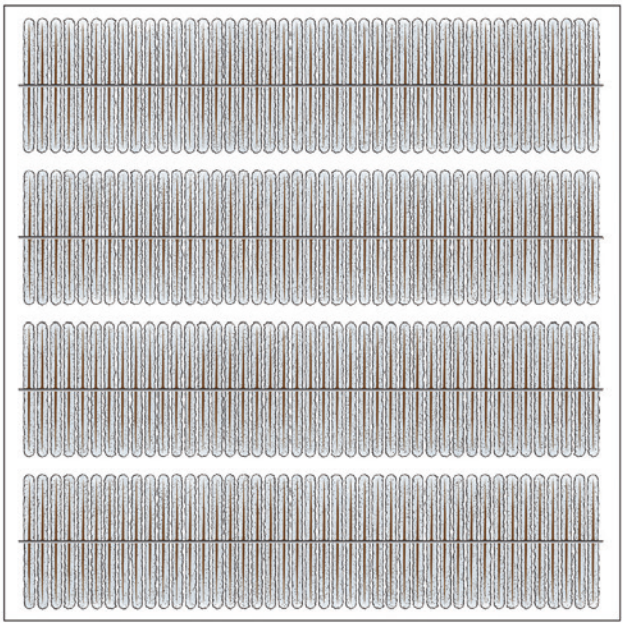
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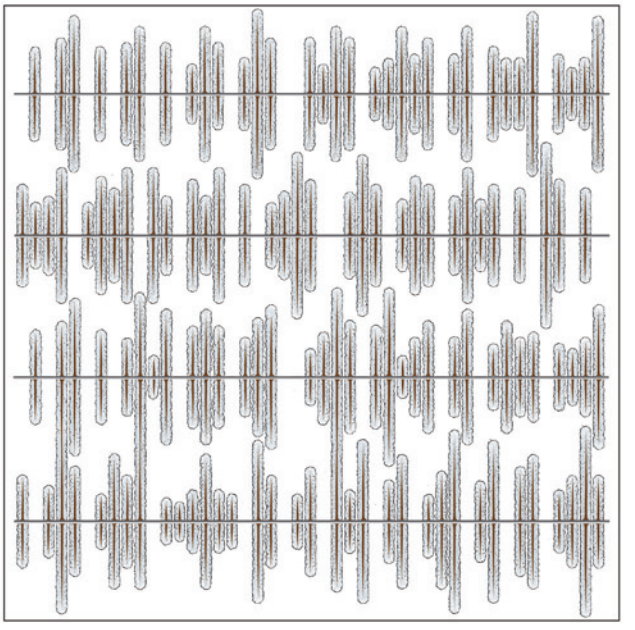
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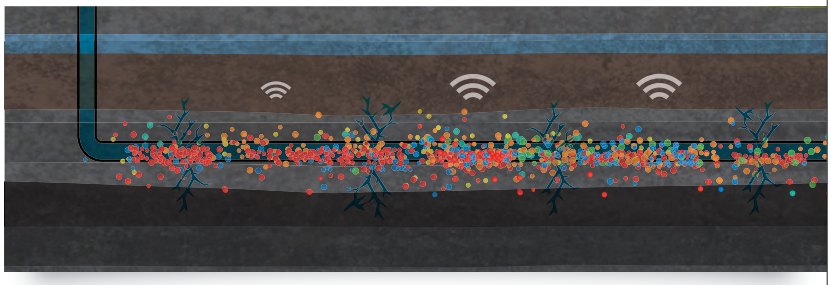
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DATA IS THE NEW OIL

Falling drilling rig counts, capital spending cuts and layoffs are all signs of a bust in the oil and gas sector after the collapse in the price of oil to half what it was a year ago.

What's unique about this bust is that it was in large part caused by the ramp-up of production due to technological advances in horizontal drilling and multistage fracturing that created the shale gas and tight oil revolution. The industry has become the victim of its own success.

The flood of new oil—and consequent stagnant prices—has pushed the shale sector back on its heels. With OPEC seemingly determined to maintain high output levels to drown out higher-cost shale oil (and other relatively high-cost crude, like the oilsands), it may appear the immediate future for the sector is bleak.

But there is a silver lining to this bust, in the form of the merging of big data analytics and the Internet of Things with the fracking technology that drove the shale gale, with the potential to dramatically cut costs and bring about a second production revolution.

The growth in North American production over the past decade has been truly remarkable—U.S. shale oil was responsible for three quarters of new world supply since 2008, and revenues soared from virtually nothing to $70 billion annually, even after the bust. U.S. production grew 1.2 million bbls/d in 2014, the largest single-year increase in a century. As Mark Mills, senior fellow at the Manhattan Institute, a free market think tank, notes, if the U.S. shale industry alone were a country, it would be the world's fifth-largest producer.

But that's only the beginning, according to Mills. In a paper published in May, *Shale 2.0: Technology and the Coming Big Data Revolution in America's Shale Oil Fields*, he suggests that continued technological progress, "particularly in big data analytics, has the U.S. shale industry poised for another, longer boom, a 'Shale 2.0.'"

Remarkably, he posits that Shale 2.0 "promises to ultimately yield break-even costs of $5–$20 per barrel—in the same range as Saudi Arabia's vaunted low-cost fields."

This is possible, he says, because the industry is beginning to embrace big data analytics. Where high prices obscure inefficiency, a bust forces companies to innovate to survive—and they are starting to innovate with big data.

With a proliferation of ever-better sensors, connectivity and cloud-based supercomputing, Shale 2.0 has become possible. Data generated can reach one megabyte per foot drilled, Mills notes, and total quantity of data per well can vary from one to 15 terabytes. Added to downhole data collection is the knowledge gained by above-ground data on all activities associated with drilling and fracking, altogether leading to hundreds of billions of dollars invested in data-generating hardware, infrastructure and equipment in recent years.

More efficient fracking will be one of the main beneficiaries. Of the two or three dozen frac stages typically completed in a horizontal well, only 25–33 per cent, on average, are truly productive.

"Bringing analytics to bear on the complexities of shale geology, geophysics, stimulation and operations to optimize the production process would potentially double the number of effective stages—thereby doubling output per well and cutting the cost of oil in half," says Mills.

Many producers and service companies are already pointing to cost reductions of 30–50 per cent per barrel produced brought about by the use of analytic tools, a trend set to continue as prices remain low.

While not all observers will agree with Mills that "shale's position as an enduring and soon-to-be $100 billion/year U.S. industry is secure," there is little doubt that as the big data revolution hits the oilpatch, big things are possible.

It is a fascinating trend that *New Technology Magazine* will continue to follow closely, with our longstanding focus on oilpatch software and information technology, and our new concentration on the Internet of Things and how it will drive innovation in the oil and gas industry in the years ahead.

Maurice Smith

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GST Registration Number 8265 26554RT.

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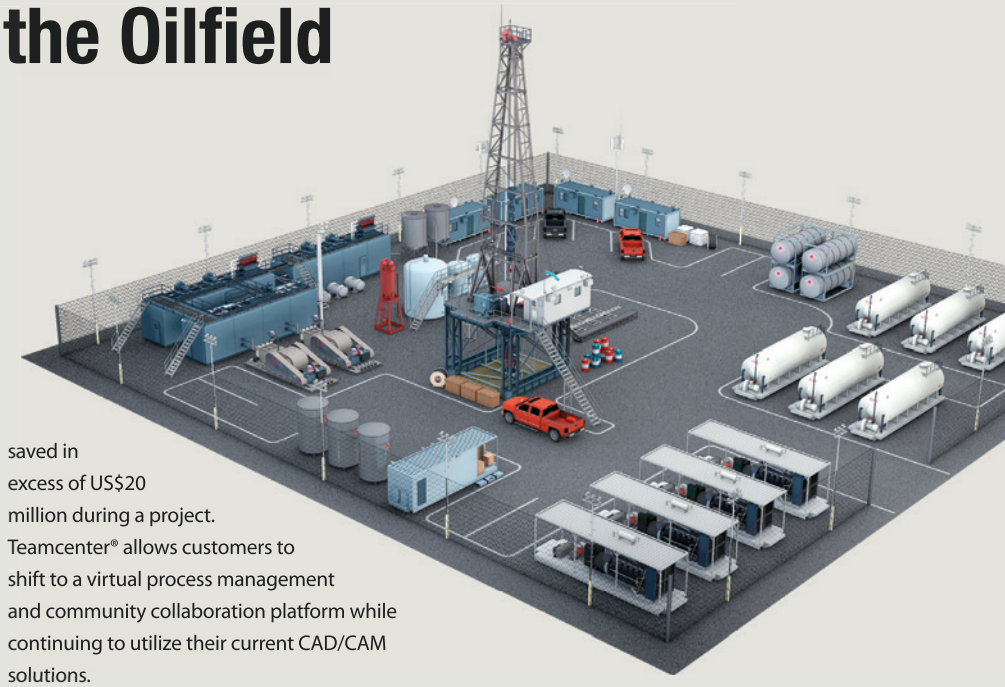
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New Technology Magazine is owned by JuneWarren-Nickle's Energy Group, a subsidiary of Glacier Media Inc., and is published 10 times per year. Printed in Canada by PrintWest. ISSN 1480-2147.

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Boosting Innovation and Productivity in the Oilfield



Those who argue that western Canada's oil and gas industry can't compete with the rest of the world haven't travelled to Germany lately, where engineering and industrial giants like Siemens have helped that country's high-wage economy compete with the world by being more productive.

And now the company, already a big player in Canada's manufacturing, health care, energy and infrastructure sectors, is confident it can help oilsands, conventional and unconventional oil and gas producers, the midstream sector and others in the Canadian energy industry compete head-on with the rest of the world.

"Productivity improvement is the key," says Michael Gardiner, Director of Industry Strategy, Siemens Digital Factory, located in Newmarket, Ontario. "Germany is a high-wage economy, but they invest heavily in technology, engineering and education that makes their manufacturing industry globally competitive. We view the oilsands and other areas of the oil and gas industry as a sector where technologies like ours can help boost productivity and foster increased innovation."

With the evolution of the oil and gas industry at the point where it is looking to advanced manufacturing technologies and automation, Siemens sees it as a logical area for its technologies to be adopted.

"In a SAGD facility, major equipment needs to be designed, commissioned and maintained for optimal performance. We help maximize the efficiency of that process on an integrated platform," he says.

That platform is its Teamcenter® software, lauded by many as the gold standard of product life cycle management (PLM) systems.

PLM is the business function that allows all participants, from project management to engineering to suppliers, to be on the same page during the execution of processes, enabling improved collaboration and higher quality deliverables.

Using PLM platforms makes engineering teams more productive, with fewer hours needed to achieve collective design goals. Changes are also much more manageable across the supply chain. In one case, a company involved in the petroleum exploration, production and processing industries estimated that improving data sharing between saved in excess of US$20 million during a project. Teamcenter® allows customers to shift to a virtual process management and community collaboration platform while continuing to utilize their current CAD/CAM solutions.

"There have been massive improvements in productivity in the manufacturing sector [as a result of the implementation of the technology]," says Gardiner. "For instance, it used to take five years from design to manufacturing of a new automobile, and now it takes 12–18 months."

"It's a virtual platform that allows you to manage engineering data and documentation in a collaborative platform," says Gardiner. "When you have multiple technical partners, our software helps them better optimize the overall system together."

Teamcenter® enables Siemens users to collaborate, sharing files, data and models, and posting them to a common, secure location. It enables users to view engineering data in a lightweight, CAD-neutral format.

Siemens, which has offices in Calgary, Edmonton and Fort McMurray (it has 39 offices in Canada, where it employs 4,500 people), has already had its Teamcenter® technology adopted extensively in the oilfield equipment design and engineering area, where it has helped compress the time needed to design and build new equipment.

Gardiner says its adoption in the exploration and production sector of the industry is in its infancy, however. He believes the efficiencies that can be realized in the sector with the Siemens life cycle technology approach have the potential to be transformative.

In the MRO (maintenance, repair and operations) sector of the oilsands, for instance, which sees operators and contractors collaborate on a yearly or ongoing basis to repair and upgrade equipment, a life cycle approach to design could lead to significant cost savings in the overall system.

"Our technology helps engineers design systems that can be maintained more efficiently," he says. If the technology is used to simulate downstream maintenance operations during early detail design, future debottlenecking and plant turnarounds would be much faster and more effective.

As an example, he said Teamcenter® technology has been used in the shipbuilding sector. By designing for the life cycle of ships, future upgrades and modernization efforts become much easier and less intrusive, reducing the total ownership cost significantly.

"We have a compelling value statement for western Canadian oil and gas producers because we can greatly increase their productivity," he says.

Siemens is also developing cyber physical systems with other technology partners, which, through the use of emerging sensor technology, sophisticated software, advanced automation/robotics and the cloud, help set the stage for more intelligent and dynamic industrial processes.

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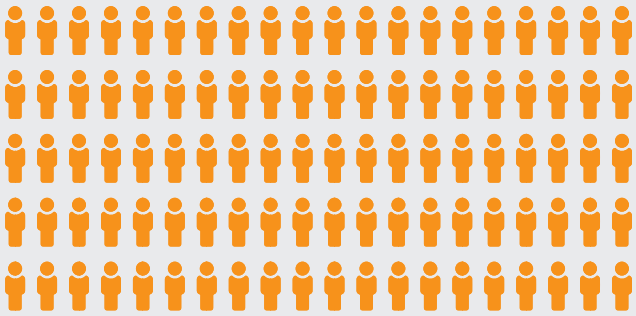
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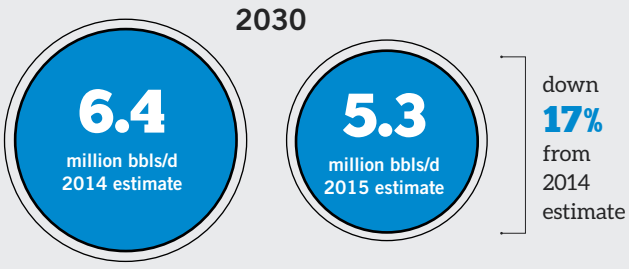
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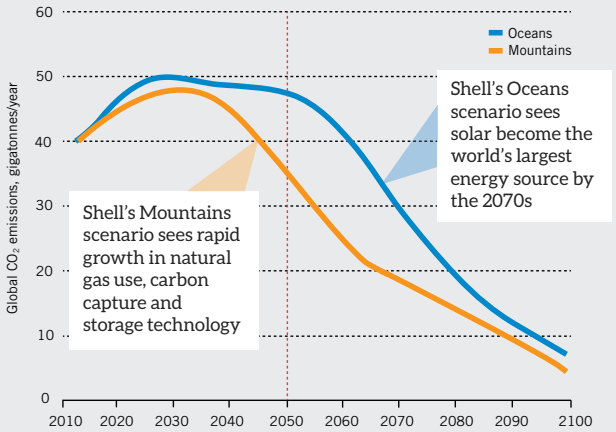
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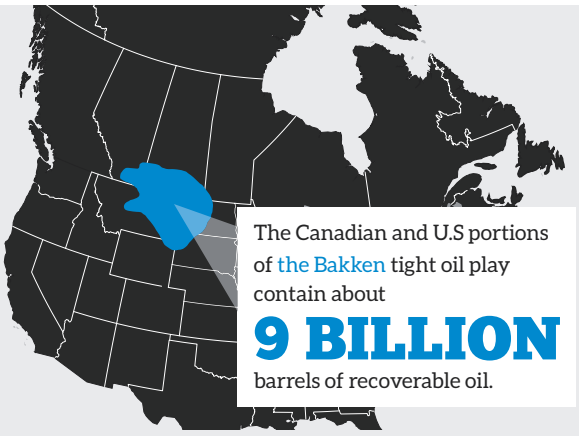
A group of 100 leading North American scientists called for a moratorium on future oilsands development, saying continued growth is not consistent with current climate change targets and is incompatible with limiting climate warming. In a consensus statement, the climate scientists, economists, geophysicists and biologists said expansion of the oilsands and similar unconventional oil sources is completely at odds with efforts to avoid potentially dangerous climate change impacts.



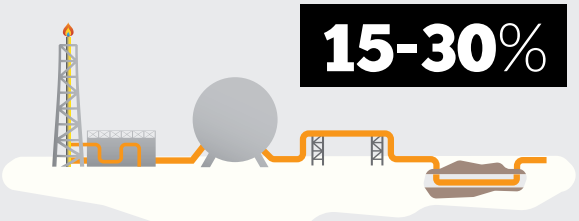
The Canadian Association of Petroleum Producers reported crude output will rise to 5.3 million bbls/d by 2030, down 17 per cent from its 2014 estimate of 6.4 million bbls/d. Oilsands production is anticipated to reach four million bbls/d by 2030, almost double 2014 output. Lower oil prices will force producers to find ways to reduce costs through technology and labour productivity, it said.



Leaders of the world's major industrial democracies resolved to decarbonize their economies by 2100, raising the chances of a UN climate deal this year. "We commit to doing our part to achieve a low-carbon global economy in the long term, including developing and deploying innovative technologies striving for a transformation of the energy sectors by 2050," stated the Group of Seven after a summit in Germany.



The Canadian and U.S. portions of the Bakken tight oil play contain about nine billion barrels of recoverable oil, and fine-tuning producing technology and understanding the rock are key to maximizing output, Steve Sonnenberg, Colorado School of Mines professor in petroleum geology, told the Williston Basin Petroleum Conference. "Technology plays a tremendous role, but geology also plays a hugely significant role in many of the things making this one of the best plays in North America."



The tight oil boom is here to stay despite low oil prices as technological breakthroughs allow further reductions in costs, Ryan Lance, chair and chief executive officer of ConocoPhillips Resources, told a seminar organized by OPEC. "Innovations have already led to a U.S. energy renaissance. Tight oil reservoirs can remain viable today; break-even costs are already down by 15–30 per cent," he said, predicting break-even costs for tight oil would likely go down another 15–20 per cent by 2020.

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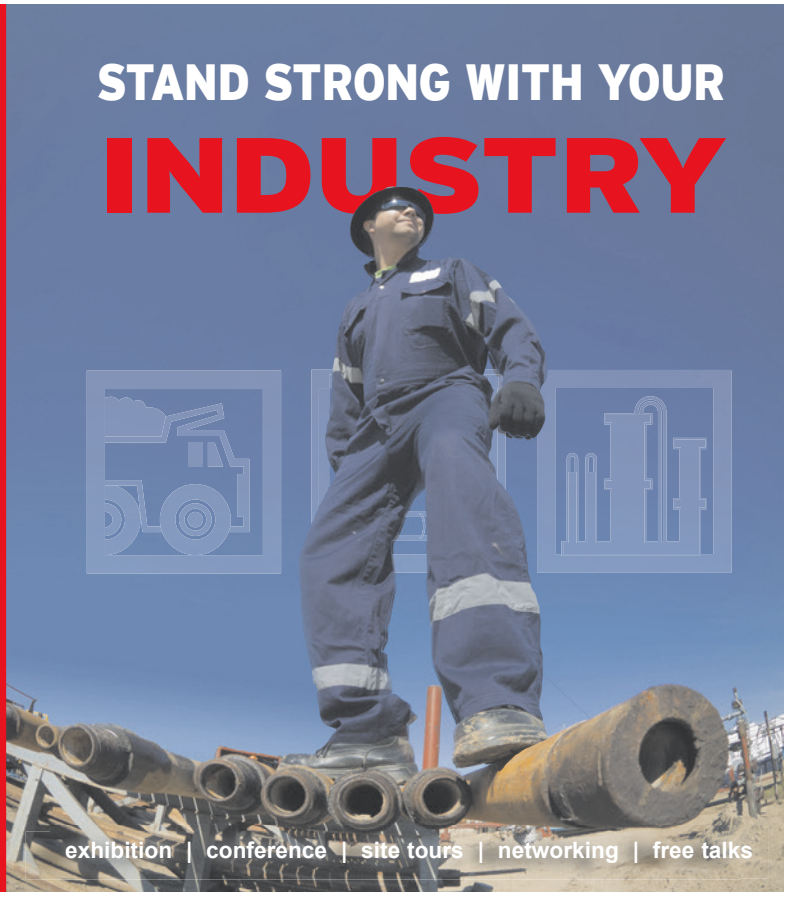
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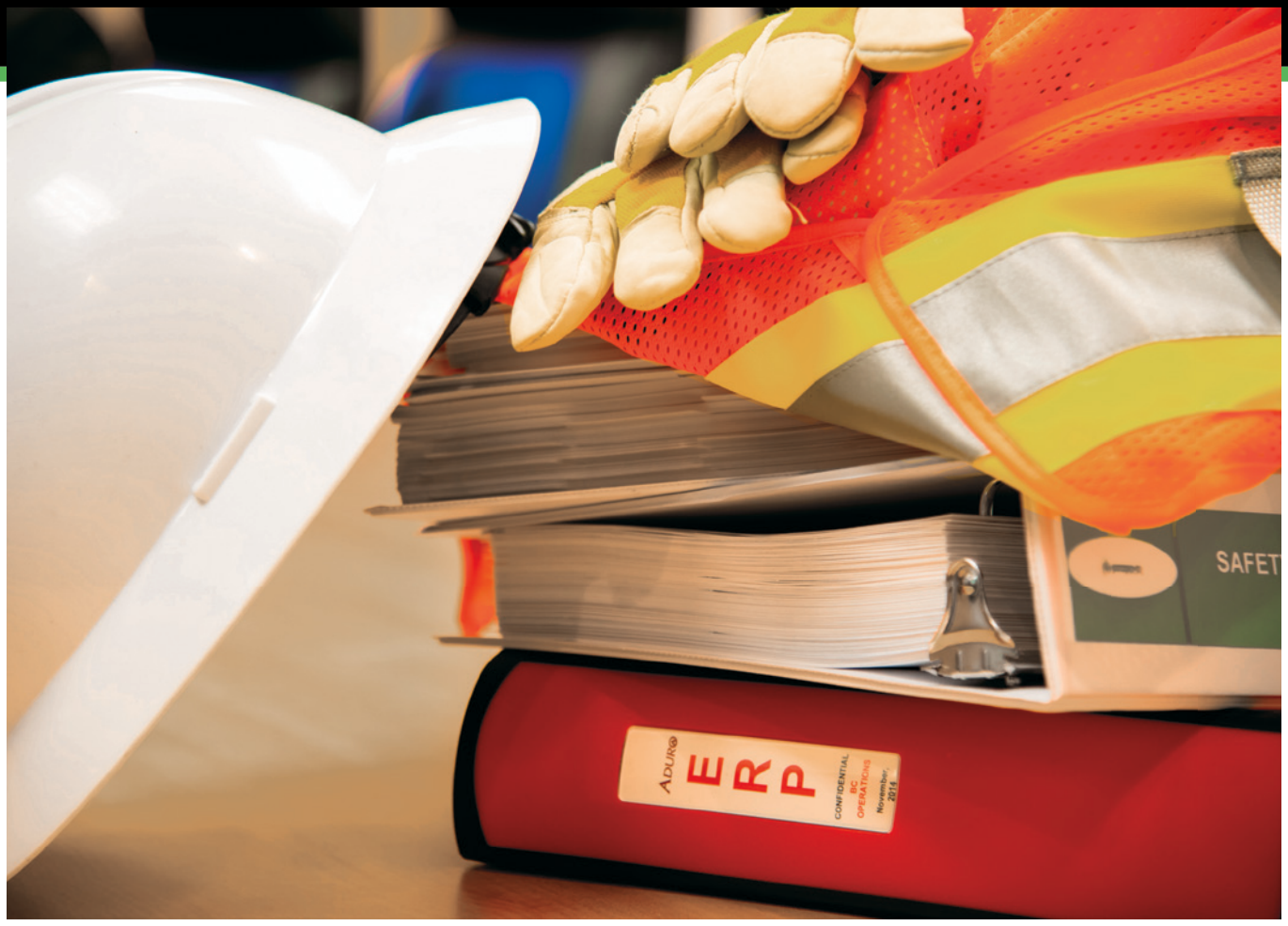


PHOTO: BLACK GOLD EMERGENCY PLANNERS

COMMUNICATIONS

EMERGENCY PLANNING ON THE GO

Software keeps workers in the crisis response loop

For oil and gas producers, the stakes can be high when a field emergency occurs. As a result, most oil industry safety managers don't have to be convinced of the adage that "those who fail to plan, plan to fail."

Because it concerns public safety, emergency planning is a critical area for producers and an ever-more nervous public. As a result, provincial regulators charged with oversight of the industry and ensuring the public's safety are taking no chances.

In Alberta and B.C., regulators have made emergency response planning compulsory. Companies with oil and gas operations in either province must file emergency response plans (ERPs) with their respective agency, either the Oil & Gas Commission in B.C. or the Alberta Energy Regulator (AER).

The AER has mandated ERPs for more than 10 years, but the companies governed by AER Directive 71, which regulates ERPs, go well beyond oil and gas producers, and now include pipeline carriers, midstream companies and operators of oil and gas storage sites, among others.

Although well defined, ERPs are not one-size-fits-all creations. An ERP can be facility-specific; it might, for example, cover a single critical sour gas well or facility. Alternatively, it could be a corporate plan that covers an entire company. Under Directive 71, some companies must file both kinds of ERPs to comply with the rules.

What must be filed depends on the company and its facilities, according to AER spokesperson Bob Curran. For example, a company operating several critical sour gas facilities in the province would file one ERP for each one, as well as a corporate ERP.

Calgary-based Black Gold Emergency Planners meets the demand for ERPs and alleviates the tedium >

^ BEYOND THE BINDER
Today's emergency response plans are moving online with smartphone and tablet connectivity, relegating paper-based plans to history.



MOBILE RESPONSE
As today's employees become increasingly attached to mobile devices like smartphones and tablets, firms like Black Gold Emergency Planners are responding with response planning tools suited to those devices.

associated with traditional paper-based binders. At Black Gold, there's a sense that any oil and gas company that still relies only on paper ERPs is stuck in the 20th century.

"Traditional emergency response planning systems use antiquated methodology," says Jason Swan, Black Gold's vice-president of operations, referring to the old school, paper-based ERPs that often languished in dust-covered binders where they were rarely noticed, much less consulted.

When emergencies occur, especially field emergencies, a company's staff may be far removed from their offices. Many are as likely to be in the field, or in transit between field and office, as anywhere else. Thus, the ERPs that sit in binders on shelves might be of little help in a real emergency. That's where Black Gold comes in.

The company has developed an application for mobile devices that allows company employees to access their company's ERP on any smartphone, tablet or laptop that might be used in the field. In fact, the entire ERP is stored on the device, making it fully accessible.

In many respects, the evolution represented by this change is a concession to human habits that have evolved over time, Swan points out. "[People] are more attached to their smartphones or iPads these days [and] more likely to have those devices in their pockets."

Simply put, Black Gold has tied today's electronic ERP to the devices that company executives and staff are most likely to be carrying at any given time, eliminating the need for traditional binders, wall-sized maps and charts.

Black Gold's system also depends on another key link: a dashboard consisting of an electronic clearing house of sorts, where incoming data about an emergency or incident is marshalled and posted for others in the company to access using mobile devices.

For example, a field operator in northern Alberta might report a sour well blowout using his smartphone. With the Black Gold system, the information goes directly to the dashboard, while a specified list of company executives is alerted through a text message sent to their mobile devices.

As for the link between the user's mobile device and the dashboard, Swan calls it a two-way street. "Anything being done at the dashboard level gets transferred to the smartphone, and anything done on the phone gets transferred to the dashboard," he says.

"[Users] dial into the dashboard, make an entry that there's an emergency, and the end-users get notified via the mobile application," he says, noting the system can also work using Wi-Fi.

In this way, employees can report data that others in the company, including decision makers, can access. The mobile application can provide alerts to be sent to regulators, emergency responders, police and others.

In addition, the dashboard doubles as a mapping device that plots the client company's wells and facilities on a map, highlighting those affected by the emergency. For some companies, this function could be useful in determining whether a blowout affects one of the company's wells or a competitor's well.

Swan acknowledges that the way people sometimes use mobile devices can limit their effectiveness. For example, turning off smartphones renders them useless. Similarly, in areas where cellular tower coverage is limited or non-existent, a smartphone might be of little value.

But regardless of the limitations, incorporating mobile technology in conjunction with traditional emergency response methods has proven to improve emergency preparedness, helping to save lives, property and the environment, the company says.

One company currently using Black Gold's mobile app for ERPs is Painted Pony Petroleum. According to Phil Goldsney, the company's health and safety manager, the application has simplified life for Painted Pony executives, who may be scattered across the country at any given moment.

"They're primarily whom we rolled out the app for, [and] they've got emergency response plan information in their hands 24-7," he says. "We used to print them a large binder that would sit in their office. Maybe they would take it to the cottage, but you can't expect them to lug those around.

"Now, [our executives] have got internal and external contacts, along with information on our pipelines and facilities as well," he says. "[The mobile app] has really enhanced communication among our management group."

So far, neither Painted Pony's executives nor staff has tested Black Gold's system in an actual emergency, although training is scheduled. "We haven't had a full-blown incident where we've needed everyone's involvement, but we'll be getting the full dashboard training," Goldsney says.

James Mahony

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PHOTOS: BLACK GOLD EMERGENCY PLANNERS; CREATIVEMARKET.COM/TOMODACHI



PHOTO: MUDDY BOOTS

DIGITIZATION

THE DRIVE FOR THE PAPERLESS TRUCK

Electronic run sheet promises greater efficiency for field operators

Many predicted the switch to computers would mean a paperless office. That has yet to happen, but many field operators in the oilpatch would settle for a paperless truck. Most operators on their daily field runs still record their activities on paper, then they type some of those records into a computer once they get back to the office.

But some are tapping their data into iPads that automatically upload it to the network. The company providing the web-based service is Calgary-based Muddy Boots. The president and co-founder is Bruce Holman, who played a key role in another venture last decade that successfully converted a paper-based process to an online service now used across the oilpatch. Holman was the technical lead for JIBLink, the online service for joint interest billing, from its inception in 2000 until 2009.

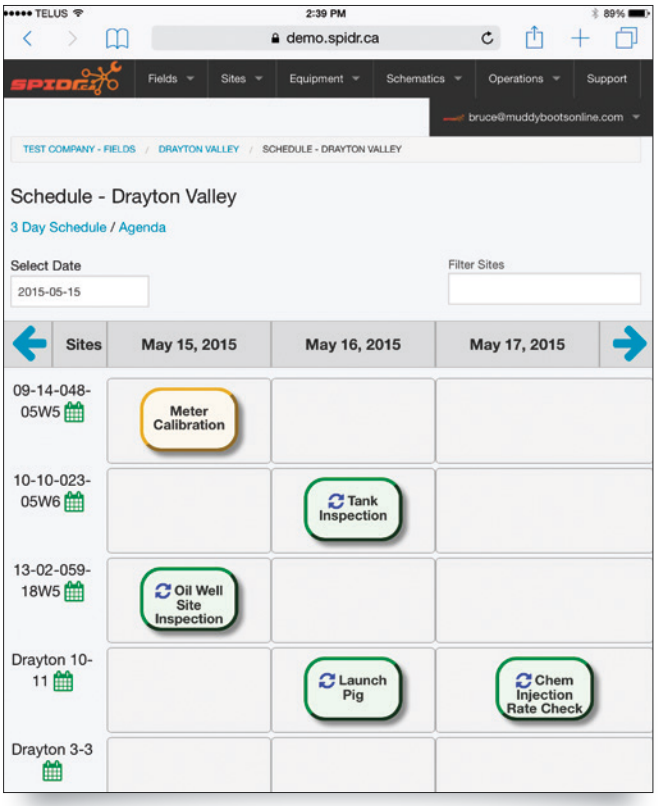
While JIBLink made life easier for production accountants at head office, Muddy Boots focuses on operators working in the field—hence the name.

The company's first project, online measurement schematics, was featured in the 2013 edition of *New Technology Magazine*'s *Canadian Oilpatch Technology Guidebook*. Measurement schematics are diagrams that show the layout of facilities, tracing the flow of production as it moves between the wellhead and the sales pipeline. Components include pipelines, valves, meters, separators, flare points, dehydrators, compressors, etc.

The company's online schematics are easy to update and easy to find in one central location. This enables an oil and gas producer to see at a glance what equipment it has and where that equipment is. Such information is increasingly required by regulators. >

^ OUTSTANDING IN THE FIELD

Muddy Boots' focus on operators working in the field is so ingrained that the company requires every employee, including those writing software code, to spend time with field operators on their daily runs—even if that leads to mud on their boots.



> TABLET ORGANIZER
Muddy Boots' recently launched Schedule product can both book recurring activity and deal with unscheduled events. Though it's web-based, its input functions also work without Internet access.

While Muddy Boots was jogging along when oil was $100/bbl, it's been sprinting since prices collapsed.

UPTICK DURING DOWNTURN

"We have never been busier. We're landing probably one large customer a month since January," Holman said in mid-May. "I'd say our revenues have pretty much doubled in the first few months [of 2015].... We just hired two new people, [bringing the total staff to six]. We've doubled our office space just as of May 12."

Holman believes the increased demand for Muddy Boots' services reflects the industry's heightened focus on cost-cutting since oil prices plunged late last year. With oil hovering around $60/bbl rather than $100, a savings of a few dollars per barrel now represents a bigger percentage of the producer's cash flow.

Muddy Boots recently launched two related products for field operators. One, dubbed Operate, is an electronic run sheet, an online input form that can run on a tablet or smartphone. It replaces the paper forms or logbooks on which operators record data during their daily field runs. The other new product, called Schedule, is for booking recurring activities—anything from a monthly tank inspection to a weekly line pigging (running an inspection tool through a pipeline).

Muddy Boots' application is entirely web-based, so users don't need to install anything on their devices or go through their IT departments. All they need is an ordinary web browser, which is pre-installed on every tablet and smartphone.

But although the application is web-based, the input functions also work without Internet access—a huge advantage for oil and gas operations in remote areas with no cellular coverage.

"When they load up that run sheet when they're within network range, that run sheet will continue to function even while they're out of network range," says Holman. "So they can refresh the screen. They can save the data readings as they go on. So we cache all that locally on the device, regardless of what type of mobile device it is. And as soon as the operator gets back into range, all that [newly entered data] gets pushed back up to the servers."

Muddy Boots' online software, called SPIDR, puts together a run sheet based on the operator's planned activities for the day. For example, if a pipeline pig is scheduled to be launched, that electronic form will show up at the proper location so the operator can record the running of that pig.

But the software can also deal with unscheduled events. Maybe a hydrate plug had to be removed from a line. Or maybe a chemical injection pump was down.

"From that run sheet—even though it's not a pre-planned activity—within two taps they can get to these other forms," says Holman. The operator can quickly record that, say, an injection pump was restarted and is now back to its correct flow rate. "So one tap, two taps. Put in a bit of information. Done. It's not like they have to go fill out another form, or go into another system. It's all right there. They can do it in their truck in a heartbeat and they move on."

And because data entered on the mobile device is automatically uploaded to the network, operators will no longer have to sit in front of a PC at the end of the day, typing in figures they've already recorded on paper.

"They're going to save probably a good hour and a half a day of guys sitting [at] the computer entering numbers...and that's just one guy," says Ken Breland, an assistant foreman in Canadian Natural Resources' Valleyview area in northwestern Alberta. Eight Canadian Natural staff in that area, including Breland, started using the new system late last year.

"Now you can be more hands on and be in touch with your wells versus sitting [at] a computer punching in numbers," says Breland, who believes the new system also increases accountability. The information is now all in one place with the operator's name on it.

And while saving time is a big gain, the online system also has other advantages over paper, says Vince Sterr, an independent consultant who worked with Centrica Canada, the Canadian subsidiary of British power and gas utility Centrica, to convert one district in the company's Edson operations in northwestern Alberta. Until then, operators making their daily runs recorded information in logbooks.

"They were probably the only person that ever saw it, and it probably never got looked at again or analyzed," says Sterr. Now other operations personnel can call up a web page with that information and try to understand where there are opportunities to improve.

"What we're using it for at Centrica is to turn that type of data into actionable things we can do reports on, and find out: What's our worst compressor? What's our worst well? What kind of pumps are we fixing over and over again? What kinds of things can we take progressive action on so that we don't do redundant things that eat time and eat our lunch? That's what we're using it for."

IMAGE: MUDDY BOOTS

For example, Centrica plans to target areas with hydrates occurrences. Natural gas hydrates, which can form in pipelines and compressors at reduced temperatures and high pressures, clog pipelines and curtail production.

"So every time we have a hydrate—be it in a compressor or a pipeline—the guys capture what things they did to resolve it, and how long it was down and all those sorts of things," Sterr recalls. "So we're going to start looking at what conditions we would change in the field to [prevent hydrates]."

SIMPLICITY, SIMPLICITY, SIMPLICITY

But for any of these things to happen, operators in the field have to record the data, and that will only happen if the data capture tool doesn't reduce efficiency. In other words, if the activity an operator is doing in the field takes five minutes, the data capture process better not take 10 minutes, or it just won't happen.

Sterr recalls a data capture initiative at another company that "fell on its face" for that reason. "They had all this information they wanted from the field operators," he says, but in many circumstances, it would take twice as long to record an activity as it would to actually do it—even if the operator "was really knowledgeable and competent.... That kind of stuff doesn't fly in the field."

"Part of the reason these guys [at Muddy Boots] have been successful—and what I love about it because it's so much easier to sell to the people in the field—is it doesn't take five minutes to capture a five-minute activity," Sterr says. "Even that hydrate thing: [you've] got to click three buttons and you type in a start pressure and an end pressure and you're done with it.... It doesn't eat away at your efficiency by having people spending hours on all these complicated entry tools."

That didn't happen by accident.

When Holman and Glenn Kelley co-founded Muddy Boots, they spent most of their time talking to people in the field, not head office. Every employee, including those writing software code, must spend time with the operators on their daily field runs.

"The company name reminds us every day that the operator is our customer," Holman says. "Sometimes people in IT forget that IT is a service industry. That is a very important cornerstone of this company. And that's why we're named how we're named."

But does every lowly programmer really need to spend time in the field? Holman's answer is an unequivocal yes.

On many software projects, a systems analyst talks to the customer, then the systems analyst tells the programmers what to do. But the problem with having layers of designers and analysts is things can get lost in translation, Holman says. "If you have [software] developers worth their salt, they're creative. They know what's possible way better than a systems analyst who is not right at ground zero of the code level."

When Muddy Boots programmers return to their computers, he adds, "They're going, 'You know what, I was out there with Rob the other day and we saw this one little thing going on. So I'm going to put two extra lines of code here so they never have to worry about that.' That's gold. That's proper IT service."

Another cornerstone of Holman's philosophy is "simplicity, simplicity, simplicity. It's easy to build a complex program. It's hard to build a simple program that does a lot," he says. "The target for us is simplicity. If any tool is simple enough, it will be used."

Pat Roche

COMMUNICATIONS

INTELLIGENT CONNECTIVITY

Digital transformation increasingly essential in low-price environment

The current low oil and gas price environment presents industry with a unique opportunity to combine recent drilling and completions advances with Internet-supported technologies to "deliver new levels of business and operational efficiency," according to a study released in April by Cisco Systems, a manufacturer of networking equipment.

"By becoming 'digital technology companies,' oil and gas firms can, for example, further improve rig uptime and oil recovery rates, reduce spillage, boost employee productivity and shrink costs," the study says.

The Cisco Consulting Services' study used interviews with experts at KBR, IDC Energy Insights and Oxford Economics, as well as economic modelling of the costs and benefits of applying Internet-enabled technology and a survey of 50 senior executives, directors, consultants and analysts across 14 countries. Unsurprisingly, after several months of low oil prices, "86 per cent of survey respondents named 'energy price volatility' as the most worrying external market force." Almost as many—78 per cent—saw it as the top inhibitor of growth for their firms.

Citing a range of authorities, however, the study, *A New Reality for Oil & Gas: Complex Market Dynamics Create Urgent Need for Digital Transformation*, argues that relying solely on traditional cost-cutting measures used in past downturns could prove disastrous for companies that are not prepared to change their current operating models. On the other hand, it says, forward-looking producers see today's turbulent market landscape as an opportunity to gain competitive advantage by harnessing new technologies.

According to Gartner Inc., an IT research and consulting company, "The current low-price scenario is unlike prior ones because digital technologies are enabling optimization of business performance, which is increasing the ability of firms to compete at lower price levels. In this downturn, the ability of an upstream company to continue making strategic investments that improve its ability to compete may be an essential survival skill."

The Internet of Things (IoT), the intelligent connectivity of physical >

devices, is driving massive gains in efficiency, business growth and quality of life, Rik Irons-Mclean, Cisco's oil & gas and energy architecture lead, IoE Vertical Solutions Group, told a Calgary audience at a presentation hosted by Cisco in April. Digital technologies continue to see rapid adoption, he noted. In 2011, there were an estimated 12.5 billion smart objects, which had grown globally to more than 25 billion by the start of this year.

The IoT can fully optimize its potential through becoming what Cisco calls the Internet of Everything (IoE), which goes beyond machines, sensors and other devices communicating with each other to encompass people, data and process as well as things, Irons-Mclean says. Besides connecting people in "more relevant, valuable ways," this entails leveraging data into more useful information for decision making and, via process, "delivering the right information to the right person, or machine, at the right time."

When asked, "In which area does your company need to improve most to make effective use of connected technologies?" 48 per cent of the Cisco survey respondents identified data as the area of the IoE they needed to improve most. Twenty-eight per cent said process, 17 per cent said people, and seven per cent said things.

DATA INTEGRATION CHALLENGE

"We have data, but it is poorly integrated and poorly analyzed. This makes it difficult for managers to wade through and find the information they really need," according to a Canadian respondent to the survey.

Such challenges align with a 2013 study from Accenture, a management consulting company, that identified data integration as the biggest challenge for oil and gas companies from the standpoint of both data quality and the ability to analyze data efficiently.

Problems of this sort could soon be rapidly on the wane, however. IDC forecasts that, "with a business case built on predictive analytics and optimization in drilling, production and asset integrity, 50 per cent of oil and gas companies will have advanced analytics capabilities in place by 2016."

As a result, IDC says, producers will have better information about top shale opportunities, which in turn could boost asset value by as much as 30 per cent. Data analytics for faster, better decision making, followed by improved operational efficiency and increased productivity, were the main drivers for industry to invest in connected technologies, according to the Cisco survey.

A Gartner study released in December 2014 points to several ways in which analytics are already being used to improve subsurface operations and processes. First, digital completion technologies are boosting ultimate recovery rates for unconventional reservoirs from around five per cent to as much as 12–16 per cent. Second, advanced sensor technologies are generating high-resolution reservoir data, resulting in more accurate modelling and simulation and better decisions. Third, "Expanded integration of real-time data from field sensors (old and new) with the reservoir model is enabling more robust 4-D modelling and, in turn, more dynamic reservoir management."

Making effective use of the potential amounts that can be generated is no small challenge, however. Data must be integrated from multiple sources and its collection automated, and the data must be analyzed efficiently if it is not to be wasted.

But moving all this data around is no small matter, either. An offshore oil platform can generate from one to two terabytes of data per day. Much of it is time-sensitive, dealing with platform production and drilling safety matters. Using a common communications satellite link with typical data transmission speeds of less than two megabytes (MB) per second, it could take a week or more to move one day's worth of data to a central repository.

THE BANDWIDTH CHALLENGE

Meeting the bandwidth challenge of this and similar remote location scenarios can involve edge computing, or "the fog." Often enabled by cloud computing, companies can cut bandwidth requirements by as much as 97 per cent by shifting computing, including data mining, analytics and other software-supported work, to a field location at the "edge" of their network. "Because of low bandwidth connectivity, customers want to pitch some decision making to the edge of their network," says Cisco's Irons-Mclean.

Gartner and others are telling producers to shift away from the traditional silo-based approach and integrate their operational technologies (OT) with their IT. "Driving down costs, especially in Canada's oilsands industry, where there are some of the highest costs in the world, is essential. Convergence of OT and IT is part of the solution," says Brad Bechtold, senior director, oil and gas transformation at Cisco.

He compares the high-cost proprietary technologies designed for specific problems, which OT has relied on, with IT used on the corporate side of a business, which has achieved low costs through economies of scale, partly because of shared infrastructure. "New trends like the Internet of Everything, M2M [machine-to-machine communication] and sensor technologies will dramatically change how we manage digital oilfields of the future in Canada," he says.

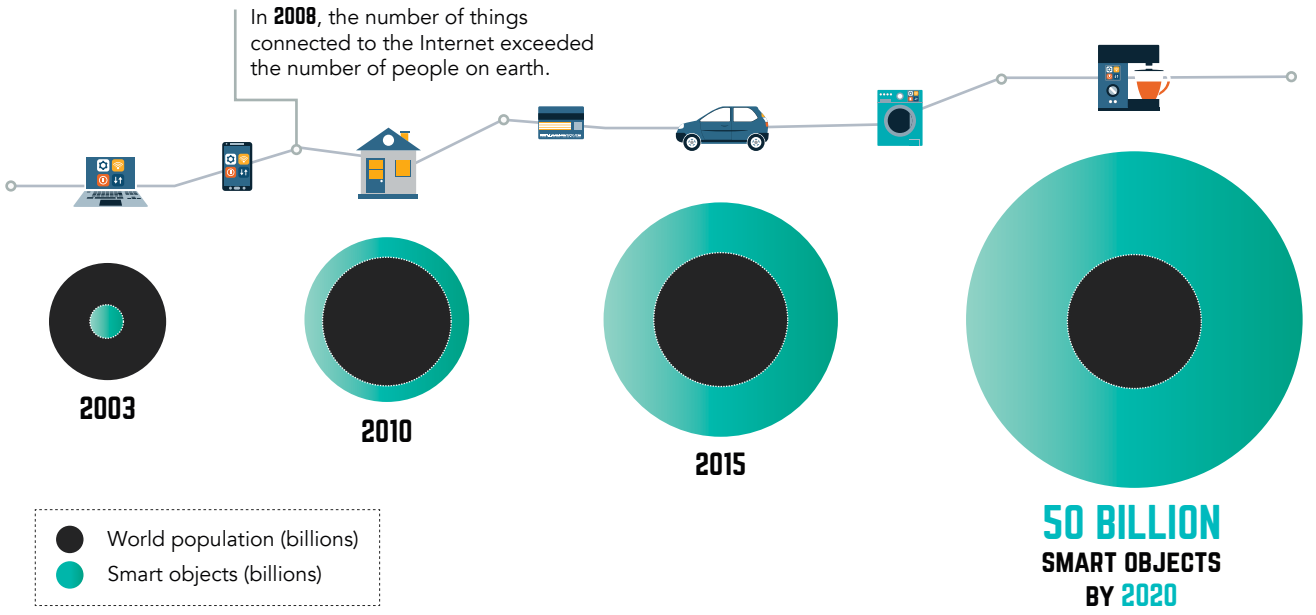
He points to a study on oilfield sensor uptake that forecasts annual growth of over 60 per cent. "The top growth areas will be onshore brownfields and pipelines. These technologies are predominantly [Internet protocol]–based and will require infrastructure



< NEW LEVEL OF AUTOMATION
Rockwell Automation's Armor GuardLogix programmable automation controller, made by the company's Allen-Bradley brand, is the company's first on-machine controller.

PHOTO: CISCO

INTELLIGENT CONNECTIVITY OF PHYSICAL DEVICES



SOURCE: CISCO

not currently mainstream in Canadian oilfields," Bechtold says.

He adds, "In order for this transformation to become a reality, OT will need to embrace horizontal architectures and IT will need to get in the field to a much greater degree."

A device called Remote Operations, which Cisco introduced two or three years ago, uses an open-architecture interface to take a group of proprietary controls for drilling rig operations—sensors, drawworks, top drives, pumps etc.—and connects them in real time to a remote operations centre in, for example, downtown Calgary. Without the Remote Operations box, there would have to be multiple data feeds, with enormous bandwidth requirements, to accommodate each of the proprietary control systems, Bechtold says.

The device includes voice, video and data and makes it possible for experts at the remote operations centre to receive and respond to information in real time. The Remote Operations box has enabled some offshore drilling operations to reduce on-site staff by 20 per cent. "It's just starting to be used onshore," Bechtold says.

SMART SENSORS

The convergence of IT and OT can help with timely maintenance and reduce the chance of equipment failure. As sensors grow smaller in size, the opportunities for their deployment will only increase.

Sensors are also getting smarter. "We now have access to data at the machine and equipment level. Sensors now have the computing power to assess data from a piece of equipment or a process. This could involve calculating the [percentage] of gas X or Y, so now you have the information to adjust the control," says Luis Gamboa, oil and gas market development lead at Rockwell Automation.

Sensors are becoming highly specialized and on-board computing power on a sensor that is two or three inches long is becoming more common. Gamboa expects much more computing happening at the surface and downhole in the foreseeable future. On-machine sensors provide data which, in turn, modify the actions of a Rockwell control. "The key is much more data," he says.

Sensors, controllers and computers in a local area network (LAN) at a remote location can communicate. "The computers can act as LAN data aggregators. This puts info onto the Internet in an aggregated way, so you can access the information you want more easily as a portion of the data has been interpreted. What's aggregated in the field can then be taken to the cloud. More data can be taken from the controller to the Internet as there is more data at the controllers now," Gamboa says.

A new programmable automation controller from Rockwell reflects two of today's emerging IT/OT trends. It has plenty of memory—four megabytes of application code storage space—and is the company's first on-machine controller.

CONNECTIVITY DRIVES PRODUCTIVITY
The adoption rate of digital infrastructure has occurred at a rate five times faster than that of electricity and telephony, according to Cisco.

The upstream sector of the industry has seen a lot more automation in the last three years, says Brian Malkinson, director, global solution architect at Schneider Electric. Omnicomm, a software-based data acquisition engine, is part of the company's supervisory control and data acquisition suite and symptomatic of the push to efficiently manage data from the field. "It connects simultaneously on a hard-wire or wireless basis. It has the ability for simultaneous connections to tens of thousands of devices on a high-speed data acquisition basis," Malkinson says.

With its ability to handle large amounts of data from many devices, Omnicomm enables field automation. It can also be used for better leak detection on pipelines. Significantly, at a time when data is said to be key, Schneider continues to sharpen its focus on this area, Malkinson says, noting it recently acquired a data asset management company for data mining.

■ *Godfrey Budd*

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THE CYB TI



Advanced software, hardware shield critical infrastructure from cyberattack

By Gordon Cope

BERSECURITY HREAT

In 2014, North Korea denounced Sony Entertainment for making a film, *The Interview*, that criticized its leader, Kim Jong-un, in a satirical manner. The denunciation escalated when a group calling itself the Guardians of Peace released a torrent of emails hacked from Sony accounts. They finally threatened terrorist attacks upon theatres, causing the cancellation of its theatrical release.

Every year, thousands of cyberattacks are perpetrated on companies and government agencies. In 2014, over 3,000 corporations in the U.S. alone experienced cyberattacks, including Home Depot and JPMorgan Chase, causing billions of dollars in damage. Many corporations now routinely report cyberattacks as a fact of life; GE, Berkshire Hathaway and ExxonMobil all include cybersecurity as a risk factor in their annual financial filings. "It can happen to any of us," says Kay Ellen Consolver, a former senior executive at ExxonMobil.

Now, a far more serious threat is emerging. "A decade ago, hackers were small scale, lone actors who were interested in highly-visible disruptions," says Robert McComber, the cybersecurity manager for Schneider Electric, a major supplier of operating systems for utilities and pipelines. "Now, they're much more organized, and are capable and effective."

And they're not content with simply infecting corporate networks. Increasingly, they are focusing on infrastructure operated by Industrial Control Systems (ICSs). In 2014, the U.S. Department of Homeland Security's Industrial Control Systems Computer Emergency Response Team responded to 256 specific cyber incidents related to critical infrastructure. Fifty-nine per cent, or 151 of these incidents, took place in the energy sector.

Exactly who is responsible is difficult to ascertain. "There are many reasons for the increase in attacks," says Nate Kube, chief technology officer and founder of Wurldtech, a subsidiary of GE that supplies industrial cybersecurity solutions to manufacturers, service providers and operators of critical infrastructure (including five of the top six oil and gas supermajors).

"There is a military motivation, in that many of the attacks are designed to gather information about the stability of critical infrastructure. There are ideological motivations; if someone is against a company's negative environmental practices, they don't have to try and block those activities in person, they can be aggressive remotely."

But the implications are perfectly clear. "Computer-based attacks are one of the fastest growing threats to American businesses and infrastructure," said Kyle Isakower, vice-president of the American Petroleum Institute (API).

The nature of the threat is both widespread and potentially dangerous. For the last several decades, ICSs have been used to help generate and distribute power at electrical utilities, or control the movement of oil and gas in pipelines. ICSs, which are also often referred to as operational technology (OT), operate separately from corporate IT systems and traditionally have not been connected to the Internet. They were generally safe within the corporate perimeter, which made them difficult to reach.

Ten years ago, however, corporations began switching ICSs to supervisory control and data acquisition (SCADA), which increased operational efficiency by allowing staff to remotely control utility infrastructure but also began to expose once-internal systems to outside penetration. "Pipelines now have isolated monitoring stations that are unmanned but always connected," says McComber. "There is a lot more potential for someone to go in and have the time and opportunity to engineer an attack."

"OT systems were built to last a long time, but were never designed with cybersecurity in mind," says Kube. "Now that they are exposed to the Internet, they are vulnerable because they are hard to update and hard to patch."

HARDENING NEW SYSTEMS

Much is being done to address the threat. In 2006, Wurldtech started supplying industrial cybersecurity solutions to manufacturers, service providers and operators of critical infrastructure, including oil and gas companies. "We went to several supermajors and tested their networked control and automation systems in order to uncover the potential risks to attacks," says Kube. "We devised a certification program called the Achilles Certification that could be used by sourcing organizations within oil companies to ensure the systems >



6 EASY STEPS TO BETTER CYBERSECURITY

Facilities that employ Industrial Control Systems, such as refineries, petrochemical plants and pipelines, can increase their cybersecurity with a number of inexpensive steps.

1. Change passwords frequently.
2. Do not use the same password for different applications.
3. Make passwords more complex.
4. Change default passwords for hardware and vendor systems.
5. Separate critical operation controls from non-critical functions.
6. Employ dual factor authentication systems, where every log-on requires a subsequent password generated by a third-party authenticator.

they are procuring meet a baseline level of cybersecurity, validated independently by Wurldtech."

In addition, the supermajors took a lead role in codifying supplier security best practices in a workgroup called WIB, a program that required suppliers to increase security hardening and supply security services such as patches and updated risk assessments. "In December 2014, their work was ratified in the ISO/IEC security standard 62443-2-4; security requirements for industrial automation and control systems service providers," says Kube. "As such, nine of the top 10 automation vendors are Wurldtech customers as they are stepping up to be a key part of that secure supply chain."

While the latest generation of ICSs are more robust and resistant to cyberattack, thousands of older systems are still operating. "New systems are more secure, but legacy systems still present a problem," says Kube. "That's why we devised security serviceable products such as the Industrial Next Gen Firewall (NGFW)."

The NGFW is a hardware device loaded with cybersecurity software. It sits at the perimeter of a control system and/or in front of a critical asset (such as a vibration monitor, distributed control system controller or safety programmable logic controller) to identify attacks and mitigate risks. It protects industrial and SCADA networks with OT-specific security and threat intelligence, simplifies centralized management and offers a full security view of the industrial network.

In addition to new hardware and software applications, the oil and gas sector is taking steps to coordinate industry responses. In mid-2014, with the help of the API, the sector launched the Oil and Natural Gas Information Sharing and Analysis Center to protect critical energy information from cyberattacks. Based in Washington, D.C., the volunteer-led organization will facilitate the exchange of information, evaluate risks and provide up-to-date security guidance to oil companies. So far, several dozen upstream, midstream and downstream companies have signed on.

Like many other sectors, the Internet of Things (IoT) is coming to the oil and gas industry. Devices such as monitors and gauges can not only gather and transmit data via the Internet, they can also control valves and processes with special software applications.

One of the newest aspects of the IoT is wearable technology, computer-assisted devices that can be worn as clothing or accessories. They can take a number of forms, from smartwatches that strap around the wrist to ultra-chic eye frames that conform to the face (known as Heads Up Displays, or HUDs).

Several companies are working on devices for the oil and gas sector:

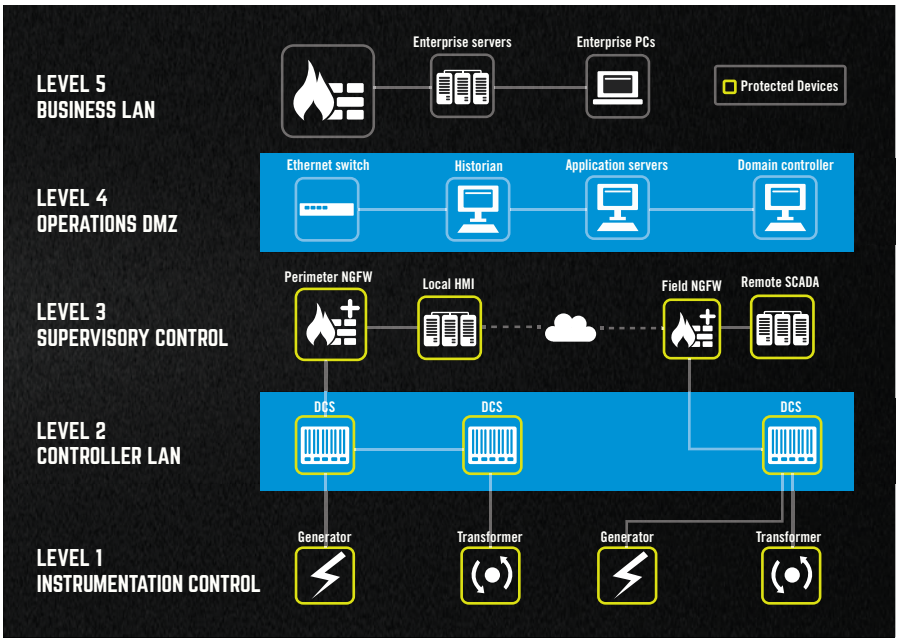
- **Motion Metrics**, based in Montreal, has devised a smartwatch designed for field work. The device features 2G/3G/4G, Wi-Fi and Bluetooth connectivity, has a built-in GPS, pedometer, compass, gyroscope and accelerometer to determine user location and velocity. A QWERTY keyboard and voice input allows communication and queries; all information is displayed on a 2.4-inch colour touchscreen.
- **Vuzix**, based in New York State, has created M100 Smart Glasses. The device has wireless Bluetooth 4.0 connectivity. Pre-installed apps allow the user to record and playback still pictures and video, track timed events and much more. An integrated head-tracking and GPS system can define location and the direction and angle of the user's current view.
- **Daqri**, a start-up based in Los Angeles, is working on a computer-equipped hard hat. The Daqri Smart Helmet resembles a bike helmet with a plastic protective eye screen. The screen acts as a display on which the user can superimpose instructions, diagrams, workflows and procedures. It can be equipped with safety sensors to monitor immediate surroundings and is designed to be sufficiently robust to thrive in field environments.

But will the new devices compromise cyber security? "HUDs and hand-held devices are becoming increasingly common, but I do not foresee a direct, real-time exposure to a threat," says McComber. "Their value to a company is through allowing an expert to show a field tech how to walk through a maintenance process, or to record and review repairs in order to see how it was done, and if it could be done more efficiently. There is low value to someone hacking into these kinds of functions."

The real problem for wearable technology, however, is passcode exposure. "You can potentially capture passwords that allow you access to the corporate network, where the really valuable information is stored," says McComber.

In the future, participants expect the size of the cyber security market to grow rapidly. "According to ARC [Advisory Group], the spend in 2014 for solutions for OT security was US$2.2 billion," says Kube. "Half of that was spent on security services, such as assessments. An assessment involves looking at people, process and technology. Are the people well trained, does the operational process require frequent password changes, and is the technology vulnerable?"

The other half was for firewall products, such as the NGFW. "In all, the spend is growing with a CAGR [compound annual growth



< NETWORK SECURITY
Wurldtech has developed an advanced network security solution, the Achilles Industrial Next Gen Firewall, that monitors and blocks malicious activity and attacks and ensures highly available industrial operations for maximum uptime and secure productivity.

rate] of 12.8 per cent, and we expect that rate of growth to increase significantly," says Kube. "According to the Ponemon Institute, 67 per cent of critical process companies have suffered an attack in the last year, and 78 per cent of their senior security officials polled believe they will likely be attacked within the next 24 months."

In addition to installing new hardware and security applications, McComber stresses that the oil and gas sector needs to look at the larger picture. "First, we need more education and training to learn the skills and basic concepts in order to identify the risks," he notes. "Secondly, we need to leverage the tools in place; we can do event analysis in order to identify anomalous activity, but few do it. Third, we need to contribute to the broader community by sharing experiences and data."

Clearly, the Internet-led revolution currently underway in the oil and gas sector promises tremendous benefits to operations, but it also requires significant precautions. "Great legwork has been done, and now it's time to implement," says Kube. "The supply chain, GE, Siemens and others are doing their part; now operators need to see how they can leverage that work and take action. They can do gap analysis and implement remediation, developing security strategies for people, process and technology. The value that the Industrial Internet brings is not possible if cybersecurity is not addressed." ■

This article is part of a four-part series with sponsorship from GE exploring the Internet of Things and its impact on the oil and gas industry. While GE professionals were interviewed for this story, the company had no involvement in its creation or production.



a Mighty APPROACH

COALITIONS, ALLIANCES AND SERVICE COMPANIES EXPLORE FRAC MONITORING SOLUTIONS

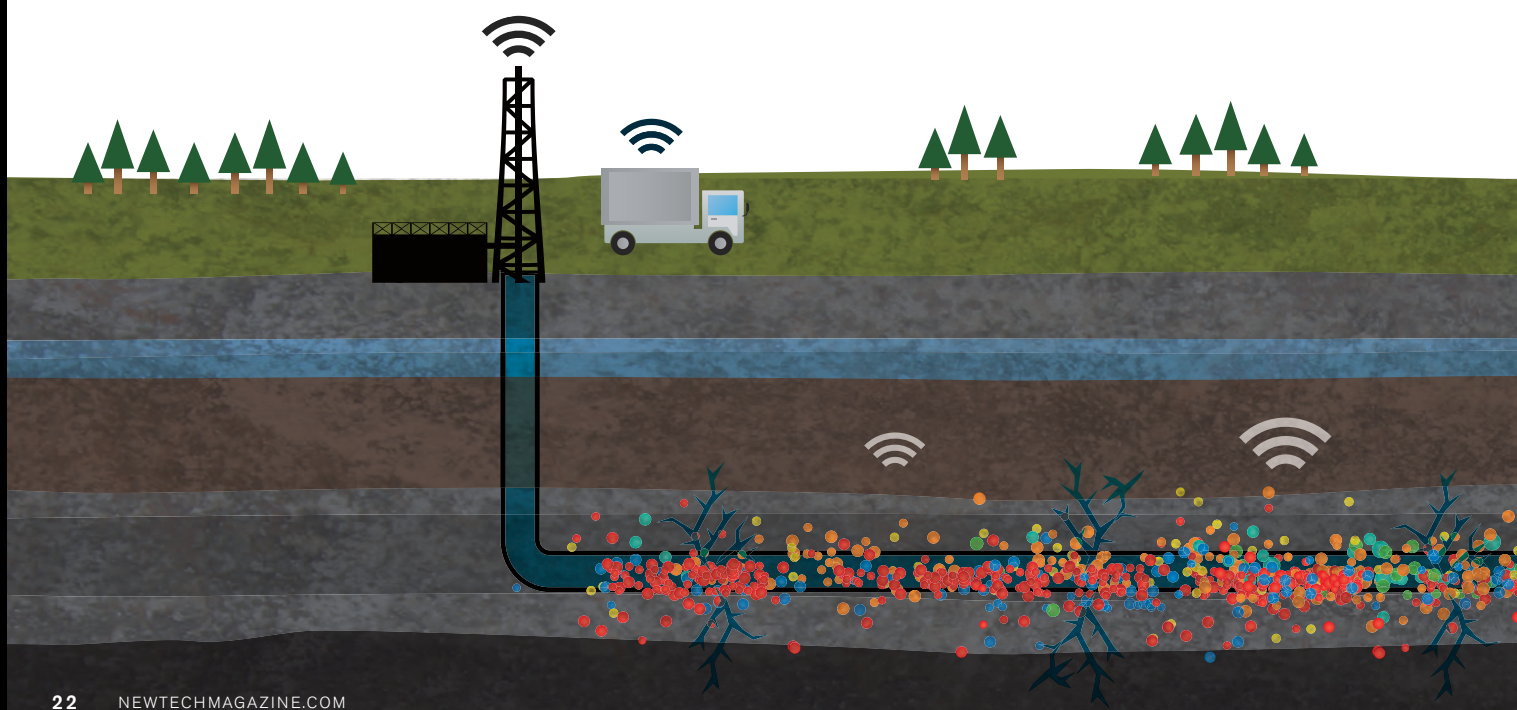
BY CARTER HAYDU

Developing and implementing fracture monitoring technologies and fighting comic-book crime have at least one thing in common: sometimes Justice League–type alliances are a better way to attain common goals than simply going it alone.

For its part, the Microseismic Industry Consortium, a partnership between the Universities of Alberta and Calgary, is dedicated to advancing knowledge in the practical application of microseismic methods for monitoring hydraulic fracture operations and related applications, and it is the only such academic group in the world with its own downhole microseismic system.

"The University of Calgary's downhole microseismic system allows us to acquire our own microseismic data," says David Eaton, professor of geophysics and former head of the department of geoscience at the University of Calgary. "That is a unique aspect of the training environment within the Microseismic Industry Consortium that does not exist elsewhere."

According to Eaton, university settings provide an opportunity for sustained, long-term research efforts. By contrast, industry works on a faster cycle that does not necessarily allow the time to address the fundamental science questions that



academia is built to tackle. Therefore, relationships between industry and academia are fairly natural.

"Also, [universities] produce graduates that provide the industry with highly trained individuals who possess specialized knowledge. This close and productive interaction between industry and academia is very helpful in a Canadian context, helping to sustain our unconventional industry at the technological forefront globally."

The Microseismic Industry Consortium is currently sponsored by some 29 companies, including operators, service companies, acquisition companies and software companies, notes Mirko van der Baan, professor of exploration seismology at the University of Alberta.

"In essence, any company that does not try to innovate and keep up with the technology, over time they just get competed out," he says. "All [companies] that have been around for a long time are very effective and efficient in developing new technologies, or they are simply big enough to buy a new company."

BUILDING A TEAM

Tesla Exploration formed an alliance with four other companies in October 2014: Calgary-based Calfrac Energy Services, which performs pressure pumping; Denver-based NanoSeis, which conducts downhole and surface microseismic processing; Calgary-based Reservoir Imaging, which acquires and processes downhole seismic data in complex situations using optimized downhole equipment and processing software; and U.K.-based Silixa.

Tesla is a leader in 2-D, 3-D, 4-D and microseismic acquisition, with experienced crews to handle the thousands of channels required for large jobs.

"Our primary part of the microseismic monitoring business is the surface acquisition, providing seismic equipment that is used for recording the microseismic events," says Rob Kendall, Tesla's vice-president of research and special projects. "Those are typically large arrays with high channel counts, which basically improve signal-to-noise."

He adds that Silixa manufactures interrogator units that use fibre optic cables with laser light pulses actually measuring dynamic strain, which is very similar to how geophones are used.

"Distributed acoustic sensing [DAS] really is an emerging technology and it has many applications, not just in the microseismic part of it. There is also distributed temperature sensing [DTS], and so if you installed these cables into your wellbore, then there are many applications, from flow monitoring to temperature monitoring to seismic monitoring, both passive and active."

When it comes to innovation in the fracture monitoring realm—including laser-based technologies—smaller companies certainly have their place. But it is also a realm where the Superman-sized clout of a major service provider can be a real advantage within the industry.

"There is a healthy mixture of large and small companies involved in this area," Eaton says. "It is an increasingly competitive environment, and so companies are all trying to find their niche by developing specific technologies that allow them to compete in a unique way.

"There is a spectrum of large and small, and they all have their own approach."

SEEKING LASER PRECISION

According to Priyesh Ranjan, senior manager of global business development for Pinnacle, a Halliburton subsidiary, DAS and DTS are part of the suite of technologies his company deploys for near-wellbore monitoring. These technologies are used to monitor fluids as they leave or enter the wellbore.

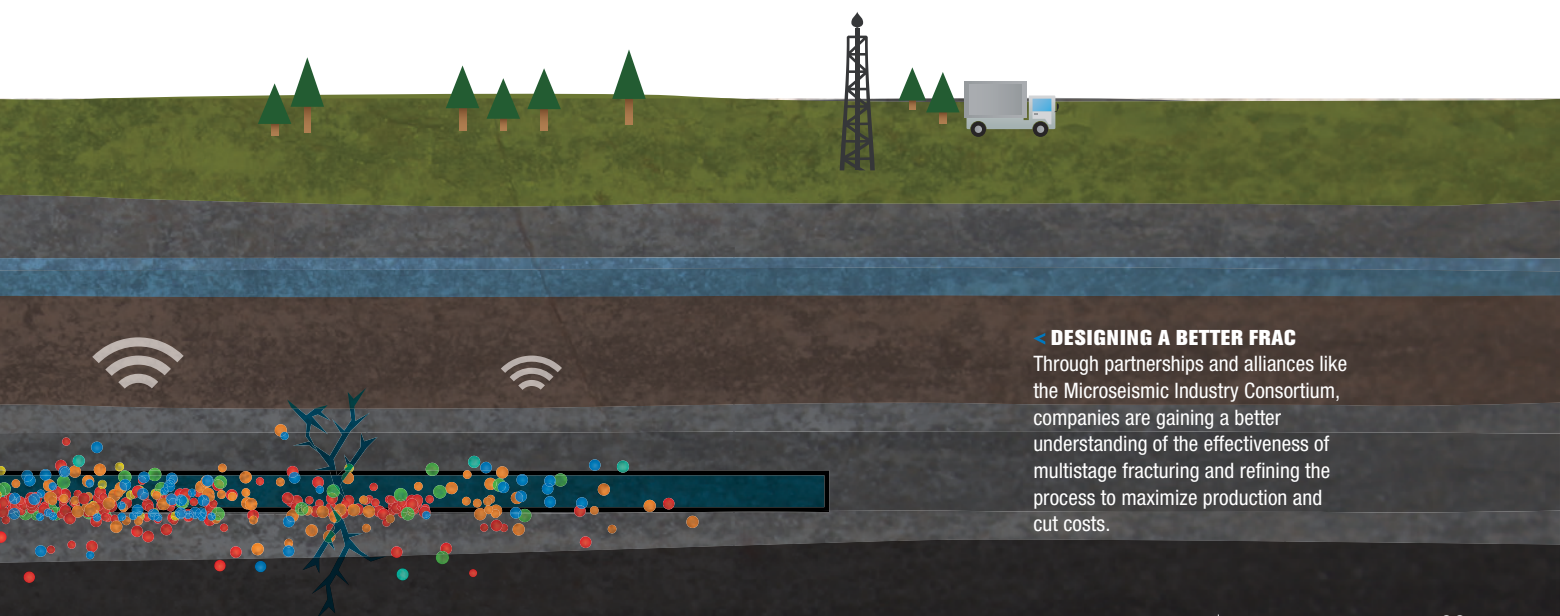
Connected to fibre optic cable at the surface, a DTS interrogator enables measurement of any temperature changes within the wellbore. This allows Pinnacle to monitor fracture initiations, as fractured regions taking in fluid will be cooler than areas that are not, Ranjan says. An additional fibre connected to a DAS surface interrogator acts as thousands of microphones downhole. This enables operators to hear clusters taking fluid.

"For example, during frac operations in plug-and-perf completions, we use DTS and DAS to monitor the distribution of injected fluid across several clusters," he says. "Fibre is also used for evaluating other parameters such as zonal isolation and wellbore integrity.

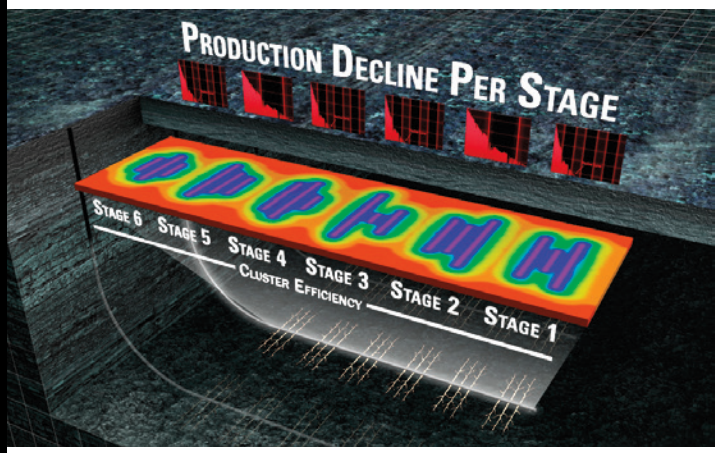
"This wellbore insight heavily dictates how many fracture initiations we have created, as well as the length of the fractures. A similar approach is used in openhole sleeve-packer completions to evaluate [the] number of fracture initiations created. Our end goal is to utilize this information to evaluate the total stimulated reservoir area in a pad from frac operations."

Once fluid leaves the wellbore and enters the reservoir, Ranjan notes, fibre can no longer see the fluid in real time. Pinnacle then switches to far-field monitoring technologies such as microseismic, which detects small noise events when pressurized fluid cracks the rock, as well as microdeformation, which measures the dilation of the frac as it takes in the frac fluid.

"It is a combination of these fibre optic sensors that allows us to figure out where the >



< DESIGNING A BETTER FRAC
Through partnerships and alliances like the Microseismic Industry Consortium, companies are gaining a better understanding of the effectiveness of multistage fracturing and refining the process to maximize production and cut costs.



< INTEGRATED SENSOR DIAGNOSTIC
Pinnacle uses fibre optic analysis for identifying fracture fluid placement by stage. Through integrated sensor diagnostics, the analysis is combined with production decline per stage and is used to calibrate fracture and reservoir models to develop a focused effort on optimizing frac spacing.

fluid is leaving the wellbore, and microseismic or microdeformation sensors for evaluating where the fluid is going into the reservoir. This allows us to characterize fracture geometry and eventually the stimulated reservoir area."

Once a frac is complete, the same fibre that was used for stimulation monitoring can then serve as a production logging sensor. The fibre allows Pinnacle to evaluate which parts of the wellbore are producing and which parts are not, according to Ranjan.

Using this production information and well-interface testing, Pinnacle calibrates fracture and reservoir models. This helps its customers make predictions about future reservoir recovery behaviour in similar geologies.

Says Ranjan, "The calibrated reservoir model allows our operators to run different 'what-if' scenarios with different field development strategies. They are then able to make fiscally material field development decisions around optimum well placement, well spacing, frac spacing and frac design to maximize the recovery from their reservoir."

While fibre optics is currently a near-wellbore monitoring technology, the future will see its implementation in several far-field monitoring applications, Ranjan adds. "We have made several advancements within the fibre optics space that are allowing us to use it for far-field sensing. For example, we are developing solutions to use fibre optics for vertical seismic profiling, as well as several other far-field applications."

Pinnacle has seen an accelerated adoption with its Integrated Sensor Diagnostics (ISD) solution, which uses all the data gathered from its near-wellbore and far-field technologies. The deliverable of the ISD solution is tangible information that facilitates fiscally material decisions such as well placement, well spacing, frac spacing and frac design. These decisions improve reservoir recovery and reduce the recovery costs on a per-barrel basis.

"Additionally, we are getting heavily involved in the re-frac business," Ranjan says. "Operators are utilizing our technologies to evaluate re-frac candidates, as well as evaluate the chemical diversion effectiveness of executed re-fracs by monitoring them before, during and after the re-frac."

He adds: "We, as well as our clients, believe using a diagnostic approach is the only way to evaluate re-fracs in order to reduce uncertainty and increase payback from re-fracs."

INDUCED SEISMICITY DEMANDS ATTENTION

Creating earthquakes is generally seen as bad for business. For oilfield operators, induced seismicity is a hazard to the health and safety of both infrastructure and local populations, potentially influencing public perception of the industry, says van der Baan.

Therefore, using similar microseismic technologies to those used for fracture monitoring, companies are going in before they begin operations to verify the area is not already seismically active, hopefully preventing unintended inducement of seismic events through fracturing or waste-water disposal in the reservoir.

Van der Baan says stricter regulations, such as Alberta's recently implemented Duvernay zone subsurface order, require companies to monitor seismic events and report them if they are above a certain threshold.

"The regulators have declared that hydraulic fracturing has in some cases led to larger felt seismicity, and what that means is that everyone now can openly talk about it, which means the operators [and] regulators as well as the academics can all think about how to best monitor this, as well as look at what might actually be the underlying causes."

According to Kendall, there will be more requirements from governments regarding monitoring for seismicity, especially as companies begin operations near more populated areas. "I think you are definitely going to see more broadband monitoring," he says. "The Alberta government has a network in place, but I think the operators probably through alliances would be the smartest way [to achieve this].

"Let us say you have three operators in a certain area who pool together and deploy a minimum number of broadband seismometers for passive monitoring. Tesla will be involved in that. We don't make the seismometers, but we can do the deployment."

He adds, "This is a prudent thing to do, and the industry is going in the right direction. We pretty much have to live with fracturing, and so monitoring both before, during and after is really prudent."

According to Eaton, innovation is critical for an industry trying to understand induced seismicity. "Vigorous research is underway within academia, industry and government to develop a scientifically sound and complete understanding of how these processes work that will underpin future regulatory development."

Eaton says that universities and industry are "breaking down silos and building bridges" across disciplines; for example, petroleum engineering and reservoir engineering are working closely with geologists in order to help a sector increasingly looking to perform better, safer fracs that increase production and cut costs. ■

> **"OPERATORS ARE UTILIZING OUR TECHNOLOGIES TO EVALUATE RE-FRAC CANDIDATES, AS WELL AS EVALUATE THE CHEMICAL DIVERSION EFFECTIVENESS OF EXECUTED RE-FRACS BY MONITORING THEM BEFORE, DURING AND AFTER THE RE-FRAC."**
>
> ***— Priyesh Ranjan, senior manager of global business development, Pinnacle***

IMAGE: PINNACLE



MANUFACTURING

PLAYING CATCH-UP

3-D printing making inroads into oil and gas sector

Offshore drill rigs can cost in excess of $2 million per day while on site. In order to avoid expensive delays due to equipment stuck in the riser or drill string, operators typically devise a spectrum of contingency plans that often require complex, one-off tools. Unfortunately, the tools themselves can be expensive to design and manufacture using traditional means.

Recently, an operator based in Asia decided to go a slightly different route. It contacted Shepherds 3D Design in Red Deer, Alta., and requested they create a downhole tool that could override a section of latching equipment. Using 3-D software, Shepherds designed and built the tool, but the client then went a step further and had the company contact Javelin Technologies in Ontario in order to make a plastic version on a 3-D printer.

"The plastic version was very valuable for training," says Larry Cyr, owner of Shepherds. "You can't keep a $300,000 tool in the shop just for training purposes—it has to be out in the field earning money. 3-D printer models are relatively cheap and are excellent for training."

The oil and gas sector is finally waking up to the world of additive manufacturing (AM), in which successive layers of material are laid down under computer control to make a 3-D product. Although various forms of AM machines have been around since the 1980s, it wasn't until 2010 that advances in technology and software made the devices economically viable for companies and individuals. Wohlers Associates, a consultancy, reckons that the market for 3-D printers and related services amounted to US$2.2 billion in 2012 and is growing at a rate of almost 30 per cent annually.

Since 1997, Javelin Technologies, headquartered in Oakville, Ont., has been the certified reseller of SolidWorks CAD software and, more recently, Stratasys >

^ ADDITIVE MANUFACTURING Using specialized software and the latest in 3-D printing technology, Javelin can produce true-to-life models, prototypes and parts in a fraction of the time and cost of traditional methods.

PHOTO: JAVELIN TECHNOLOGIES

3-D printers, two of the major companies that dominate the 3-D design and manufacturing sector. Javelin develops new applications for the software and provides training and support. It has six offices in Canada and over 4,000 clients, primarily in education, automobile, aerospace and consumer electronics sectors.

"The value of 3-D design is through cost reductions and time reductions in the development cycle time-to-market," says Dubi Finklshtein, director of advanced manufacturing and 3-D printing at Javelin. "The strength of 3-D printing is in customizing of low-volume items and for making parts that you cannot make using any other manufacturing technology."

For well over a decade, 3-D design software has dominated research and development (R&D) in many different sectors, including architecture, medical supplies, electronics, aerospace and automobiles. Designers can take an idea and do limitless iterations that can refine not only aesthetic appearance but also weight, installation and repair considerations.

The design has its limitations, however. Many stakeholders involved in product development have difficulty looking at a drawing and imagining the object in real life. "No matter how good a picture is, unless you really know what you're looking at, it's difficult to visualize how something will work," says Cyr.

Enter 3-D printers. The devices—which range in price from $1,000 for a hobbyist unit to over $500,000 for a floor model that can print in multi-materials and create objects as large as six cubic feet—are guided by 3-D computer software. The printer lays down plastic in liquid form at 280 degrees Celsius, which then cools down and solidifies at 80 degrees Celsius. The thickness of each layer can vary from 10/1000 inch down to 5/1000 inch. Each pass can take more than a minute to complete, meaning that a large prototype can take well over a day to manufacture.



∧ PRODUCT DEVELOPMENT
One of Javelin's largest oil and gas service customers in western Canada, Packers Plus Energy Services is taking advantage of the industry's slower pace to develop new products and increase efficiency.

During the R&D stage, 3-D design and printing first proved its worth by saving time and money. In conventional R&D, prototypes are made using two main manufacturing processes: computer numerical control (CNC) machining and casting. Designers use 3-D software to create a design, which is then used to guide CNC mills that remove metal.

Prototypes produced in this manner can take several months and cost $250,000. With casting, a foundry creates an object mould from packed sand. They then create a core mould of the volume inside. They place the two together and pour molten metal into the gap. The sand is then broken up, and the metal object is ready. The entire process can take 12–16 weeks, and cost from $5,000 to $30,000.

Both systems have their drawbacks. "In conventional R&D, you sometimes end up with a working prototype that needs alterations," says Cyr. "Reworking costs a lot of money, and it increases your timeline between manufacturing and deployment."

Using a 3-D printer, however, a designer can produce a prototype at a fraction of the time and price of conventional means, allowing clients to see the proposed product and make modifications quickly, inexpensively and efficiently. "With a 3-D printed model, you can give it to a client to hold in their hand—they can see what it will do," says Cyr.

While the oil and gas sector is getting its first taste of 3-D printing, other sectors have moved further down the line. "Four years ago, 3-D printers were used primarily in design and development," says Finklshtein. "Now, about 30 per cent of their use is in manufacturing itself; they are used to create jigs, tools and fixtures." A jig is a customized device that holds a product in a specific orientation so that it can have a hole drilled in it or other component attached. A fixture is a structure that holds tools and implements, allowing a worker to repeat tasks easily, efficiently and accurately.

The next logical manufacturing step is to create parts that can be used directly in a product. As mentioned, current 3-D printing is relatively slow and expensive; the few parts that are being commercially produced are ones that are either difficult to make using any other process or highly customized.

"Over time, the price of 3-D printing will come down and the speed will go up," says Finklshtein. "We may see widespread manufacturing of plastic parts within four to five years. Most companies will have their own printers, and you will see them replace milling machines and injection moulding."

Although plastics are light and durable, there are many applications that require the strength and toughness of metal. The cutting edge of 3-D technology are printers that can print using alloys—the process is called laser sintering. Depending on the material needed, printers can use electron beam melting (for most metal alloys and titanium), selective laser melting (titanium, cobalt chrome, stainless steel and aluminum) and direct metal laser sintering (for almost any metal alloy).

Realistically, however, laser sintering is still several years away from being a practical means to create a usable object directly from 3-D design software. "Metals are expensive and slower," says Finklshtein. "It may be 10 years before we see [commercial] metal parts manufacturing."

In the meantime, companies like Shepherds are relying on Javelin to help promote 3-D design and printing in Canada's oil and gas sector. "I've been using Javelin's software since 2007 and I rate it quite high; I am self-taught, and I found the software to be intuitive and user-friendly," notes Cyr, who recently purchased his own 3-D printer. "They also give excellent support when I have issues."

Cyr has high hopes that the oil and gas sector will embrace 3-D design and printing as they learn its value. "The oilpatch needs to be educated on the benefits."

Gordon Cope

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PHOTO: JAVELIN TECHNOLOGIES

ENHANCED OIL RECOVERY

COMPLETING THE PICTURE

Sequential recompletions offer to restore productivity to horizontal heavy oil wells

As Canadian oil and gas producers hunker down in a bleak operating environment, a Red Deer, Alta.–based consultant is proposing a better "mousetrap" for western Canada's horizontal, cold-flow heavy wells of the kind that dot the landscape around Lloydminster on the Alberta-Saskatchewan border.

Oilfield veteran David Cadrin proposes sequential recompletion as a way to revitalize cold-flow production and improve recovery on tired, but not depleted, heavy oil wells. He says his still-untested technique is a cost-effective alternative to drilling new wells, which producers would readily drill in better days when they were flush with cash.

In the current downturn, cash is harder to come by and drilling a new well is a more costly burden than some companies are willing to bear. In this environment, recompletions are more feasible.

Historically, vertical, cold-flow heavy oil wells have shown a pattern, according to Cadrin. Usually, roughly five to seven years after being brought on, production comes to an end, leaving 90 per cent of the oil behind. In response, industry began drilling more horizontal heavy oil wells, expecting that increased exposure to the reservoir would mean greater recovery per well.

"We drill 1,000–1,500 metres horizontally through the [producing] zone and should be expecting several times more oil than we'd get from a vertical well, but one of two things happen," Cadrin says. "Either the [slotted liner] plugs off, or the formation collapses around it to the point that it stops flow into the slots."

In either case, the result is a plugged-off well. The upshot is that horizontal wells may not be all they are cracked up to be, at least in terms of recovery. Despite the benefit some producers see on the productivity front, Cadrin estimates the wells recover on average only about 10 per cent of the oil in place.

"In fact, [with horizontals,] we're only recovering what we'd get from a vertical well," he says. The result is that today's producers often look to secondary recovery methods, like polymer floods, to boost recovery when horizontal wells start to peter out.

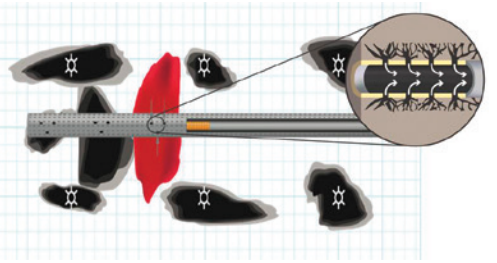


IMAGE: D. CADRIN ENTERPRISES

< WELL REVIVAL
An infill horizontal well between depleted vertical wells. The red area depicts the current producing recompletion reaching reserves left between depleted vertical wells. The two black areas to the left of the red area on the horizontal well depict depleted areas from previous recompletions.

Cadrin says heavy oil wells producing from unconsolidated sandstones can be problematic since common assumptions about producing reservoirs often break down in practice. For example, the assumption that pressure is continuous across a producing reservoir is widespread.

"But that's not case," he says. "There is often a discontinuity in pressure [in the reservoir]. It's something we've all been aware of, but we've missed its significance."

Elaborating, he notes what happens when an unconsolidated sandstone reservoir is produced. Over time, thanks to the outflow of oil, the produced area in the well's immediate vicinity becomes pressure-depleted.

Indeed, the bottomhole pressure there is most often one per cent or less of the original reservoir pressure. Years of monitoring shut-in, depleted heavy oil wells have shown no buildup of bottomhole pressure, he says. "Yet we'll drill an infill well just outside the immediate area and hit virgin reservoir pressure."

Cadrin says geomechanics theory predicts the formation of a dome of compressed reservoir material some distance from the well as fluids and sand are produced. That material prevents flow from the surrounding reservoir from reaching the depleted region around the well.

Whether or not the phenomenon is an exception to commonly held assumptions about continuous pressure across the reservoir, it appears that unconsolidated sands might merit different treatment than other formations, at least in the heavy oil context.

Cadrin estimates that sequentially recompleting a horizontal well from toe to heel can improve recovery more than 30 per cent in a 1,500-metre horizontal wellbore. At the same time, the well can often be recompleted more than once and still remain profitable, he says.

When it comes to production rate, recovery, sand production profile and producing life, he says each recompletion is expected to be similar to a single vertical well.

He estimates the cost of an initial, sequential recompletion of a horizontal well at roughly $400,000 or about 65 per cent of the cost of drilling and completing a new vertical well (about $600,000). If a new horizontal well is the other option, it would cost substantially more.

In terms of payout, a recompletion looks relatively attractive based on Cadrin's model and estimates. Under that model, the recompletion will often pay for itself, although at current oil prices, it could take twice as long but still pay out in less than a year.

He says the cost of the first recompletion, at $400,000, is notably higher than the cost of later recompletions, which would run far less, at about $70,000 each, by Cadrin's estimate.

When it comes to testing Cadrin's sequential recompletion method on cold-flow horizontals, industry might have cold feet, so to speak, since no company has yet stepped up to the plate.

Nonetheless, Cadrin says industry colleagues have told him there's no reason in theory his technique should not work. But, as is often the case with new methods, they typically add that they would rather wait for someone else to road-test sequential recompletions.

James Mahony

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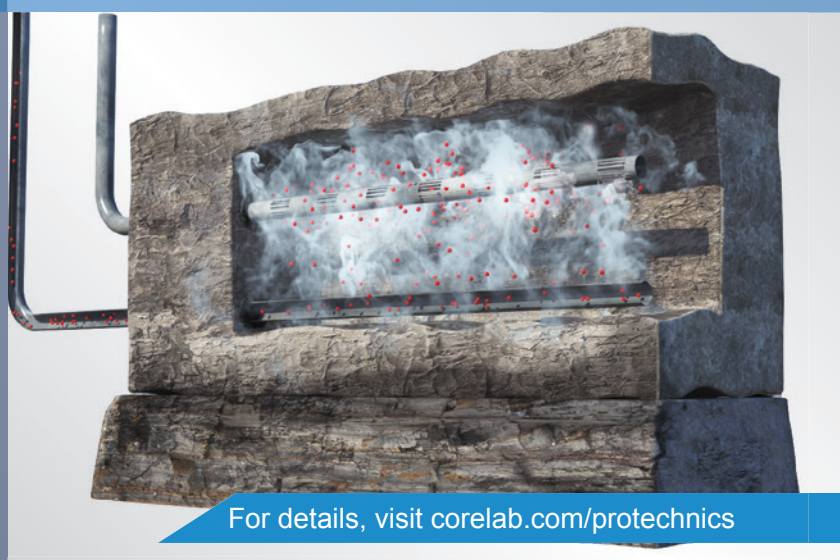
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