A Supplement to

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HART'S E&P

SMARTER WELLS, GREATER REWARDS

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Smarter Wells, Greater Rewards

As smart as the oil industry has been, what with progressively sharper seismic acquisition and interpretation methods, high-tech offshore drilling and production, knowledge sharing and multi-disciplinary collaboration that now spans the globe, it is about to get smarter.

Make way for smart drill pipe, smart wells and smart wellheads.

Imagine a time when an oil or gas well can produce and monitor itself, analyze its downhole conditions and regulate itself in real time, in response to whatever is occurring—without human intervention. That day is coming.

Service companies are adding new tools and enhancements to their existing products to advance this concept. The pressure of well economics is as important as any downhole pressure. Both affect decision-making and affect how a company chooses to maximize the value of its resources.

At the moment, most of the research is dedicated to smart completion and production, but R&D is also moving in the direction of intelligent drilling as well. To date, the industry has made about 100 so-called intelligent completions. These involve permanent downhole tools that gather and transmit data, and downhole flow control tools that adjust the production as needed, especially from multiple zones in one wellbore, or from multiple laterals.

Producing more than one pay zone in a single wellbore is not new, but being able to treat each zone at different times, and in a way unique to its characteristics or needs, is the new goal. That's smart. Some of the new tools allow the operator to isolate and separate different sands, such that each pay zone can be treated separately, leading to enhanced management of the reservoir

The biggest challenge ahead will be making sure that remote equipment such as satellites used for monitoring well progress, and the downhole sensors that relay data to them, are durable and that their performance is repeatable and reliable.

The goal is to achieve greater production efficiency without making the downhole environment so complex as to invite unreliable results or outright equipment failure. Industry is making this dream a reality.

Intelligent completions also can involve tubing-retrievable tools for remotely controlled valves—valves that go beyond just open and shut and midway, but rather, may have numerous positions, easily adjusted. To operate valves remotely reduces people intervention, and reduces costs and risks to people and equipment, particularly in hazardous arenas offshore or in remote locations.

High-cost wells, especially offshore or in harsh environments, will benefit the most from intelligent completions via downhole tools

In the future, the industry will be able to combine subsurface gauges and distributed fiber-optic sensors and actuators downhole. Instead of just opening and closing, valves will have several other incremental positions for optimum flow all along that continuum.

Intelligent human input will no doubt always be needed, but industry research is working toward minimizing that cost at the same time that production is maximized.

—*Leslie Haines, Editor,* Oil and Gas Investor

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THE INTELLIGENCE GAME

Intelligent wells aren't routine yet, but industry acceptance is growing at a rapid pace.

ARTICLE BY RHONDA DUEY

So often the oil industry comes up with a great new idea—often with a great name to match—and then spends the next decade lamenting the fact that nobody is actually interested in using (i.e. paying for) the technology.

Until recently this was the case with intelligent completions. Folks spent hours in technical sessions debating the actual definition of an intelligent completion, service companies spent hours behind closed doors trying to determine their own trademarked version of the common concept, and magazine editors had a field day describing the potential contributions of this amazing technology to an aging industry.

But the few companies to actually stick one of these things in the ground often found that system reliability hadn't yet caught up with the hype.

A funny thing has happened with intelligent completions in just the last couple of years, however. Suddenly these systems are being installed, if not routinely, at least with a degree of regularity that suggests industry uptake is definitely on the rise. Why? Improved reliability is a major factor. There's also been a concerted effort on the part of the service companies to offer a full range of systems rather than assuming every completion needs every bell and whistle available. And increasingly the industry is beginning to understand that the benefits of intelligent completions extend beyond workover savings and may ultimately be one of its best tools for field optimization.

Intelligent offerings

While discussion of the true definition of "intelligent completion" seems to keep pundits occupied for days on end, the generic definition is actually quite simple—most agree an intelligent completion is a system involving one or both of the following: the ability to control downhole devices such as valves from the surface and the ability to acquire well performance data such as temperature and pressure at surface.

Some systems are much fancier than others and include the ability to reinject gas downhole into a different formation, for instance. But a simple hydraulic on/off valve that can be controlled from the surface counts, in many definitions, as an intelligent completion.

Downhole monitoring equipment is really nothing new. So for most, the "intelligence" comes when the information coming up from downhole can be acted upon without hauling in a workover rig.

"When people first started talking about intelligent wells, it was very much focused on the surface-controlled flow controls as the thing that was a big advance," says Graham Makin, marketing director, intelligent completions, Weatherford Completion Systems. "But nine times out of 10, to make proper use of those controls you need permanent monitoring anyway. So the two kind of go hand in hand."

What's interesting about the current crop of intelligent systems is they're both less ambitious and more ambitious than most people might have anticipated five years ago. Many companies have found they can readily adapt existing technology to come up with a system that can be surface-controlled. Osca, for instance, uses straight hydraulics to control sleeves downhole.

"With an interventionless system, there's no mechanism to unlock the valves," says David Walker, product line manager, completions tools. "It's proven technology in sealing and sleeve actuation. We took our existing technology and actuated the hydraulics. We didn't come out with something new. It's like a one-off downhole sleeve."

Weatherford also has focused its control efforts on hydraulics, and through its purchase of CiDRA, it is focusing its sensing efforts on fiber optics. "In an electronic system, there's a lot of really critical components run in the well itself," Makin says. "An optical system is very simple. The components run in the well are electronically passive, and all of the clever, complex stuff happens at the surface."

This is of key importance because of the life expectancy of these systems. While much of the important data acquired in a field are acquired within the first few years, there's also a critical period 10 or 15 years later where the final efforts toward field-life extension also require good data. "We're aiming to produce a good-quality datastream for the field life, not just at the start," Makin says.

Other companies, though, are having success with more complex systems, but reliability concerns are making the going rather slow. Baker Oil Tools has been working on its intelligent completions initiative since 1995.

"We asked a lot of operators what they would want in the perfect intelligent well system," says Kevin Jones, senior manager, intelligent well systems development group. "We got a lot of our specs from that and have

developed this very complex but very functional system that gave them the bells and whistles they asked for at the time. We're now seeing that get into the marketplace and are getting a lot of credibility with it. But it's taken a long time."

The credibility factor will only take off as the systems begin to prove themselves in the field, and some won't be called upon to do much for several years. But the industry is beginning to compile a scorecard of intelligent completion success that's spurring greater acceptance of the technology. And some of the systems that are getting the most attention are the most complex.

At WellDynamics, a joint venture of Shell and Halliburton, the product offering ranges from simply hydraulic systems to the top-end system, known as Surface Controlled Reservoir Analysis & Management System (Scrams). Mike Fleming, WellDynamics chief executive officer, says the industry is rapidly overcoming reliability problems that may have plagued earlier systems.

"I think there has been a misunderstanding in the past that putting electronics down the hole and increasing the sophistication leads to reliability problems," he says. "Quite often the contrary is actually the case because electronics provide the opportunity to design redundancy into the system architecture, giving operators the ability to switch control paths to steer around problems. There's a belief amongst some operators that the so-called high-end systems are the most reliable and the least likely to give problems over the life of the field. Complexity doesn't necessarily relate to reliability exposure."

Case studies

In fact, some of the field tests are offering some rather astonishing results. Shashidhar Rajagopalan, WellDynamics strategic marketing manager, tells of customers who want a guaranteed 10-year life before deciding to install an intelligent system, but others have been willing to take the plunge without the proof.

"One of the Norwegian operators went with a high-end system and spent quite a lot of money for it," he says. "They made a return on their investment in 18 days. If the decision criteria is based on a guaranteed 10-year life, they've inappropriately postponed a decision that could have satisfied return on investment. If you can create significant incremental value in 18 days that you would not otherwise have created and the system fails on the 19th day, you've still made a sound investment decision."

Other service companies also have had marked success with their systems. Schlumberger, for instance, completed a horizontal section in Indiana as an intelligent completion and demonstrated the well at the recent Offshore Technology Conference in Houston. The horizontal section is segmented into three sections isolated with packers. Each segment is controlled with monitoring, pressure gauges and a distributed temperature measurement.

"This well is a cross between a showcase and a system that enables us to demonstrate the value that operators get from being able to control this type of reservoir," says Jeremy Walker, Schlumberger marketing manager, testing and completions. "As such, we've been using the control valves that are in those three sections fairly extensively. It's all part of this issue of building the industry's confidence."

Shell has about 20 intelligent wells worldwide and is actively working to increase that number. One of its showcase pieces is a well in the Brent Field in the North Sea. The well produces oil but also has a perforated gas zone uphole that's opened for a short period every year to meet a gas contract.

Baker has its own success stories. A well drilled in Indonesia saw total daily output increase 25% once a dual-zone intelligent well system was installed, and the well's lower zone, which previously produced only water, is now producing 1,104 barrels of oil per day.

Smart fields

As the range of services grows and success stories mount, the industry is beginning to recognize the full gamut of what intelligent completions can offer. Whereas once the technology might have been viewed as a tool to minimize or avoid costly interventions, it's now being realized that the constant flow of information from these wells gives insight into what's happening at a reservoir level and can even be helpful while a field is still under development. This is helping to speed industry acceptance of the technology.

Smart Remote Monitoring

Although remotely monitoring data from producing gas wells is not new, picking up the data at an Internet site via the web is new, and this is being used increasingly by E&P companies.

Stewardship of a gas well's production and performance has moved beyond the mechanical to the digital. Those in the know predict that in the next three or four years, all mechanical meters and paper charts will be replaced by this technology.

For example, zed.i solutions inc., a Calgary-based company, has developed an advanced remote monitoring system that allows gas producers to replace their mechanical charts at the wellhead with a wireless, digital flow computer—beyond the traditional meter. With the trademarked system, called Smart-Alek, an operator can monitor in real time, and with greater accuracy, a well or pipeline's flow, temperature and pressure and thus, react swiftly to optimize field production. It combines sensors, dual processors and a rechargeable power supply.

"The device allows you and all your partners in a well to get information in a secure, password-protected manner," says Fred Wenzel, president. "This gives them the information they want, when they want it, without having to go to the location." —*Leslie Haines*

At Shell, intelligent well technology is important enough that the company has established an implementation group, which travels the globe encouraging Shell's business units to consider using the technology. "People need to be satisfied with the reliability," says Carlos Glandt, Shell smart wells global implementation manager. "But there is also an issue of value. If the value is clearly identified up-front, then we can talk about the risk.

"Early in this process this was only driven by well engineers and completion engineers who were excited about the technology but unsure about the risk. When you bring the subsurface community to the table, you bring the value, and by bringing the value you can understand the risk in a better context."

Part of the risk reduction is realized through cycle-time reduction, says Arun Sharma, WellDynamics director, reservoir solutions. "In the past there was a large lead time between collecting data and being able to make a decision and act upon it," he says. "The loop between monitoring, decision-making and actually changing something downhole was weeks if not months. With a smart well in the ground, that cycle time can be reduced to a day, giving you the flexibility to experiment with numerous scenarios until production is optimized.

"Smart wells are essentially options that are creating the flexibility to respond to uncertainty faced by reservoir assets as new information about the reservoir arrives. We are beginning to quantify this value for our customers, and it is significant."

Charlie Cosad, marketing manager, Schlumberger Reservoir Monitoring and Control, says that once installed, the "loop" consists of several steps. "First is 'monitoring,' which we define as simply plotting data against depth or location and events taking place in the well or field, with threshold or event-based actions," Cosad says. Next is "surveillance," where data is validated and integrated with limited other data and simple models, driving actions.

Monitoring and surveillance can be an almost completely automated processes, and some pundits predict that eventually a truly "smart" well will be making many of its own diagnostic and optimization decisions as well. For now some of the hurdles include capturing this massive amount of data in such a way that useful decisions can be made.

"From there comes diagnosis, where more complex models are introduced and slow loop action and optimization are initiated," Cosad says. "Production data is different than the episodic world of well construction. The meaning of 'real time' in the production phase is not defined. There are large volumes of data being generated onsite and multiple trends and events to consider, many of which require off-site data integration and analysis. In progressing this, the industry needs to be rigorous in weighing value against the costs of such things as bandwidth and necessary information technology infrastructure."

Adds Jones, "There are some operators saying, 'That will never happen in my well. I don't want a machine shutting off my well.' That's probably going to be the biggest leap of faith—the operators turning over the production of a reservoir to a computer." ■

Coming to a well near you: Smart Pipe

Is there anything so basic, brawny and tangible in the oil and gas business as plain old drill pipe? Indeed, oil patch veterans often refer to it, and to drilling rigs, as "dumb iron." But that image is about to change as drill pipe becomes brainy, too. Companies are now pursuing the application of 21st century digital technologies to oil country tubulars in addition to seismic exploration, completion techniques and reservoir monitoring.

After all, how can a company make an intelligent completion if it hasn't first drilled an intelligent well? Houston-based Grant Prideco, a manufacturer of drill pipe and premium connections, is close to making this a reality. It has teamed with Provo, Utah-based Novatek to create what Grant Prideco now calls IntelliPipe, which is trademarked. This new product is to be unveiled this fall following testing at the Gas Technology Institute's research facility in Catoosa, Oklahoma, with initial commercial applications scheduled for 2003.

IntelliPipe is a telemetry transmission drill pipe that enables large amounts of downhole data—from the bottom of the hole and other intervals along the drill string—to be sent to the surface—and back—in real time and at very high speeds. The protected electrical cable along the pipe can transmit as much as 1 million bits per second, or more than 100,000 time faster than conventional industry tools. Operators can more closely monitor hydrocarbons in the reservoir. It also means they can drill more safely because they will be able to monitor the well more accurately, spotting potential gas kicks earlier, for example.

"We look at IntelliPipe as enabling technology for the Downhole Internet," says Michael J. Jellison, vice president of product management for Grant Prideco's drilling products and services division. "IntelliPipe transforms the drill pipe from being just a tool used to make hole, into being a value-added information tool. This is real enabling technology, a bridge that will allow other downhole technologies to be more fully utilized.

"In the past operators could only get information from the bottom of the hole, and at low speeds, so they were essentially 'flying blind' along the rest of the hole. IntelliPipe is designed so the signal travels the length of the well without losing signal strength or data accuracy." In a patented process, the signal can "jump" through the pipe connections as well, and without significant degradation, which has been one of the industry's biggest challenges as it tried to develop this type of system.

A second feature is that data can be sent in the other direction, back down the hole, while drilling. Jellison explains: "For example, you could 'tell' the downhole tools to turn on or off, or activate a valve, or send a specific measurement to the surface from one tool if there is more than one tool down there." *—Leslie Haines*

GRANTPRIDECO

There has been much written and discussed about intelligent well technology (IWT) or "smart wells." Most of the discussion has centered on completion technology. Thus the definition of a smart well has hinged on the use of permanent downhole gauges that monitor and collect wellbore and/or reservoir data, or downhole fluid control devices with on/off position control.

Others define an intelligent installation as one that monitors wellbore and/or reservoir characteristics in real time; adjusts flow from multiple zones or laterals based on monitoring; and utilizes downhole flow control devices for flow control. No matter what the definition, there have been only slightly more than 100 intelligent completions to date.

Grant Prideco believes intelligent completions start with intelligent drilling. To that end, it has developed IntelliPipe™, a telemetry transmission drill pipe that allows large amounts of downhole data to be transmitted in real time from any point along the drill string—traditionally the bottomhole assembly (BHA)—to the surface at high speeds regardless of the drilling activities under way. IntelliPipe is virtually transparent to standard rig operations and there are no special handling or make-up procedures.

System development

As far back as 1939, technology had been proposed to link serial drill string components to provide a network for the transmission of power from the surface downhole—and data from downhole to the surface drilling platform. The stumbling block in most instances was bridging the drill pipe connection, or "tool joint." The core technology behind the IntelliPipe system is a passive communications link that connects discrete components together.

Development of the IntelliPipe system was initiated by Novatek Engineering, Provo, Utah, and was partially funded by a grant from the Department of Energy/National Energy Technology Laboratories (NETL). The DOE identified IntelliPipe as a key strategic technology and one of the agency's highest priority projects. Grant Prideco began working with Novatek on the IntelliPipe system in early 2000, and a new joint venture was formed called IntelliServ™ to market the IntelliPipe system.

Grant Prideco tested IntelliPipe™ at the Gas Technology Institute's Catoosa, Okla., testing facility.

The initial IntelliPipe design uses Grant Prideco's 5-7/8" eXtreme Reach™ drill pipe and eXtreme Torque™ (XT) connection. Grant Prideco has tested IntelliPipe at the Gas Technology Institute's Catoosa, Okla., testing facility. Day-to-day well testing is also performed at Novatek's facilities in Provo with initial commercial applications expected in early 2003.

Seamless data transmission

Data retrieved by the IntelliPipe system can be logging data extracted from the LWD (gamma ray, resistivity, etc.), drilling data extracted from the MWD (azimuth, inclination, vibration, etc.) and any other form of data extracted from any type of sensor along the drill string, such as pressure while drilling (PWD) tools which extract pressure data.

Traditionally, drillers collect this data from the sensors in the BHA (LWD, MWD and PWD) and use pressure pulsations in the mud column to transmit the data to the surface in real time while the tool records the data to its hard drive downhole.

This method of transmission is called mud pulse telemetry. Conventional mud pulse, MWD technology allows about 10 bits per second (bps) of data to be transmitted. In comparison, a normal dial-up connection transmits 56.6 kilobits per second (kbps). Even newer attempts at resistivity logging with electromagnetic telemetry only allow 100 bits per second.

Consequently, the resolution of the data at the surface is so poor that the driller often cannot make crucial decisions real-time and is forced to trip the drill string to retrieve the MWD, LWD or other tool, and download the hard drive data stored on the tool for higher resolution.

The IntelliPipe system transmits data with speeds on the order of 1,000,000 bits per second, or more than 100,000 times the current industry standard.

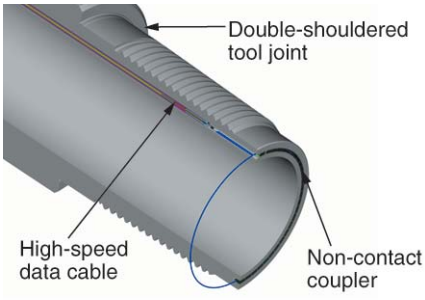
Drilling efficiencies

IntelliPipe will allow drillers to send high resolution, collected data to the surface so it can be reviewed in real time and decisions can be made without tripping the drill string, promoting faster drilling, maximizing on-bottom time and minimizing nonproductive time. As a result, overall well costs can be reduced.

Drilling enhancements include improved bit life and reduced trips to replace worn bits; optimized casing point selection; enhanced well control; elimination of sidewall coring and wireline log runs; reduced or eliminated survey time to retrieve MWD and LWD data; and increased availability of underbalanced drilling (UBD). Drillers can routinely monitor borehole stability using downhole pressure and tension measurements in conjunction with surface indicator weight.

Combined with the petrophysical data, the borehole stability data help to identify, prevent and cure fractures and permeable sands that are responsible for poor borehole stability.

Multiple measurements—after drilling passes over the exposed-hole section—over



time, tell a petrophysical story about what is happening to the formation environment and borehole stability and is referred to as time-lapse logging. With real-time logging information, drilling costs can be reduced, and well control and early kick detection is enhanced.

Production, future efficiencies

For field productivity, IntelliPipe will help improve reservoir recovery because it allows the driller to identify the best-permeability zones for geosteering, isolate potential zones of loss and gains, and identify the propagation of natural fractures and drilling-induced fractures—in other words, position the wellbore in the sweet spot of the reservoir.

Additionally, IntelliPipe will allow for increased use of UBD to improve well productivity by reducing formation damage from drilling fluids. When combined with advanced MWD/LWD that permits detection of formation data ahead of the bit, IntelliPipe will allow operators to alter the drilling fluid properties prior to drilling into target formations and optimize well placement, accelerate the reserve prove-up process and enhance identification of secondary pay zones.

Most importantly, IntelliPipe provides a high speed bi-directional communications link from the bit to the surface (which has never been done commercially), opening up new technologies that can be developed and brought to the market such as the ability to gather seismic data at the bit.

Previously this technology had not been pursued because the industry perceived that a large amount of seismic data could not be transmitted to the surface.

Design elements

Unlike other systems, which require expensive composite coiled tubing for drilling applications, IntelliPipe transmits data using Grant Prideco proprietary drill pipe connected with a high-speed data cable and proprietary coupling built into the pipe. The cable is positioned such that it is protected within the pipe and tool joint, but does not interfere with mudflow or the deployment of tools through the center of the assembly.

Based on engineering analysis and discussions with users, the preferred OD drill pipe for deepwater, ultradeep, high pressure/high temperature (HP/HT) and any application that needs more hydraulic horsepower is 5-⅞". Grant Prideco not only manufactured the first string but nearly all subsequent strings of 5-⅞" eXtreme Reach™ (XR) drill pipe.

The IntelliPipe design incorporates a circumferential non-contact coupler (a milli-hop coupler) embedded in Grant Prideco's eXtreme™ Torque (XT) connection. As the pin screws into the box, the two couplers come together and permit the transmission of data. Through the use of a proprietary coupling design and other materials, electronic degradation of the signal between the connected pipes is minimized.

As the signal travels through the drill string, it must be amplified. To amplify the signal, proprietary amplification subs are used. These subs correct and amplify the signal so that the signal can be transmitted passively (without amplification) through the drill pipe to the next amplification sub and on up to the next, all the way to the surface at intervals of around 1,000 feet.

Each amplification sub can be equipped with sensors to extract drilling data such as pressure, temperature, vibration, torque, tension, etc. Thus, data can be collected at multiple points along the length of the drill string (for example, annulus pressure data near the last casing shoe).

Having amplification subs along the drill string capable of gathering data, as well as a communications link along the entire string, basically creates a downhole network or ethernet. The transmission line includes telemetry drill pipe, drill collars, heavyweight drill pipe, jars, stabilizers and other specialty tools.

Conclusion

IntelliPipe provides robust and reliable operation, and its rugged configuration resists damage. The system changes drill pipe from a drilling tool to an information tool, making IntelliPipe truly enabling technology.

The system offers data transmission rates that are large orders of magnitude beyond the transmission rates for current mud pulse and electromagnetic telemetry. Two-way or bi-directional communication is now a reality. Commands from the surface or between downhole devices can be sent, received and acted upon.

Ultimately, a downhole drilling network is established, improving drilling and production efficiency and providing even greater applications in the future.

Grant Prideco, which aims to provide tomorrow's technology today, offers IntelliPipe as one example.

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WellDynamics

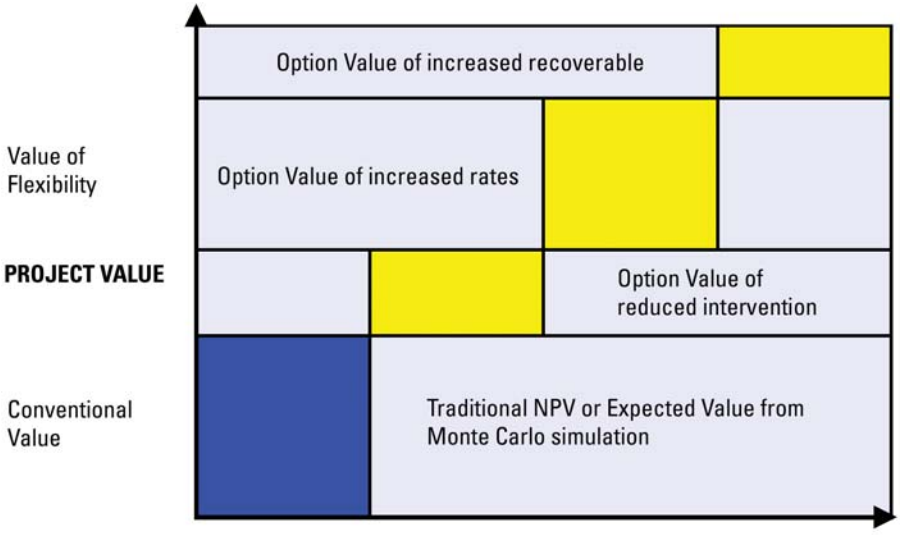
WellDynamics is a joint venture between Halliburton and Shell that combines SmartWell® (PES/Halliburton) and iWell™ (Shell) technologies to create the market leader in SmartWell® intelligent completions.

The company's origins can be traced back to Petroleum Engineering Services Ltd. (PES), an Aberdeen, Scotland-based company founded in 1985. By 1995 PES launched a joint industry project to develop a revolutionary new completion technology known as SCRAMS™ (Surface Controlled Reservoir Analysis and Management System).

To facilitate the worldwide roll-out of SCRAMS™, PES formed a SmartWell® strategic alliance with Halliburton Energy Services (HES) in September 1996. This Alliance was further strengthened when Halliburton acquired 26% of PES in May 1997. In February 2000 Halliburton completed the acquisition of the remaining PES shares, and PES became a wholly owned HES subsidiary. Shell on its part had been conducting research and development in the area of smart or intelligent well technology for many years, using the collective term iWell™. In April 2000 Halliburton and Shell announced their intention to combine their SmartWell® and iWell™ capabilities to create a new venture to be called WellDynamics.

WellDynamics is headquartered in Aberdeen, where the company has office and equipment assembly facilities. Most of the company's research and engineering is carried out in Houston, where it also has extensive assembly and test facilities. The company has a third major facility—a manufacturing plant—at Livingston near Edinburgh, Scotland. In addition WellDynamics has its own offices in Norway, Italy, Dubai and Malaysia, and is also represented by Halliburton throughout the world.

WellDynamics has the largest installed base of SmartWell® systems in the world. This installed base is significantly larger than any one competitor in the market.



The potential value of management flexibility under reservoir uncertainty.

Transforming reservoirs

The company's vision is to transform reservoirs. This means

- Delivering a step change in economic performance;
- Enabling an operator to respond to reservoir changes;
- Enabling continuous reservoir optimization;
- Providing monitoring of reservoir rock and fluid movements;
- Providing data of a quality which transforms field development planning; and
- Providing the data infrastructure to support this.

As the intelligent well leader, WellDynamics is developing this market with the following beliefs and insights:

- Support the market in identifying, creating and realizing the value of SmartWell® applications.
- Desired reservoir functionality has to be clearly linked to the type of SmartWell® configuration proposed.
- SmartWell® technology provides operators reservoir management options, giving them the flexibility to respond to future reservoir production uncertainties.
- All SmartWell® technology must be screened to deliver the "right level of smartness for the right asset at the right time with the right level of risk." This characterizes the options created.
- Not all wells will require intelligent completions, and looking to smartness as a means to reduce the number of wells in a field should be an imperative.
- SmartWell® technology can increase project capex and as such, value to risked capex trade-offs need to be clear.
- Data alone without the ability to convert it to knowledge and action will not lead to a timely response to reservoir uncertainty, effectively diminishing the value of the field. SmartWell® technologies form a system that provides both monitoring, decision-making and control; they are not just a completion product.
- Ultimately SmartWell® technology and smart fields need to favorably affect an operator's income, cash flow, proven reserves and portfolio risk.

Technology innovation

WellDynamics is an intelligent well specialist focused and committed to setting the pace in this emerging market through an aggressive research and development program.

WellDynamics is aggressively using its application design and installation experience to focus, fund and realize a set of unique capabilities. These are discussed below:

Full range of product offerings. Developing markets require a full range of product offerings to build completion configurations that meet a large variety of well architecture and reservoir functionality needs. The following systems are in the portfolio: SCRAMS™, digital hydraulics, direct hydraulics, permanent downhole gauges, completion accessories, surface control systems and PC interface.

Design for reliability engineering and assurance. WellDynamics is an IS09001 certified company with mature processes in place to guide, monitor and optimize system delivery and performance. WellDynamics also has a dedicated reliability assurance department that manages reliability procedures and processes. The company maintains a field performance database of each SmartWell® installation to capture learning to: calibrate design predictions, optimize the design and production process, and capture the diverse well environments where SmartWell® technology has been deployed

Reservoir screening and evaluation services. WellDynamics has developed an asset screening methodology that is aimed at identifying opportunities with added value; in each case the level of detail is flexible and can be tuned to suit customer needs: high-level screening and quick asset reviews, detailed asset screening, and advanced SmartWell® field development optimization.

Reservoirs are generally more complex than initially defined by available data at the start of an asset life cycle. SmartWell® technology can help improve an operator's ability to respond to new reservoir information and realize the value of active reservoir management. To fully understand this potential and quantify the value, WellDynamics has developed methods and software to model and design the most appropriate well architecture and quantify its reservoir value through the use of real options. These tools allow operators to quantify the potential value of flexibility under uncertainty along with traditionally quantified value using decision criteria like net present value (NPV). These additional value components have been shown to be significant.

WellDynamics retains experienced in-house resources and the necessary (Software) tools to complete these screening studies. WellDynamics also has the ability to leverage Halliburton's Asset Performance Consulting and Well Construction groups, Kellogg Brown & Root and Granherne's FEED design expertise, as well as other strategic relationships. These relationships are based on the belief that the asset's value is maximized at the conceptual study and FEED phases in an assets life cycle and this is where screening for SmartWell® application should take place.

Project and communication/control integration engineering services. Based on experience to-date, integration and interface complexities are often underestimated and are a significant barrier to achieving deployment excellence, especially in subsea projects. This is due to the paradigm that SmartWell® technologies involve onlycompletions equipment rather that an integrated system tied to a variety of asset management components from well-site to asset team offices. WellDynamics has a core team that specializes in control system and communication support.

Reservoir monitoring and optimization services. WellDynamics is in the business of transforming reservoirs by providing SmartWell® technology, both hardware and knowledge. The challenge for customers is not only to economically justify SmartWell® hardware, but to also demonstrate the ongoing value of the SmartWell® technology to their asset. Data management, work processes, and engineering tools are prerequisites for realizing SmartWell® technology value through improved asset management. Flow estimation and flow-allocation are part of the foundation of asset management. A significant benefit of intelligent well technology is realized when real-time downhole production information can be actively and frequently used to optimize production and manage reservoirs.

WellDynamics is addressing this challenge by developing, integrating and implementing a suite of products (both proprietary and third party), which provide production data management, flow estimation and flow allocation (FE&A) capabilities. WellDynamics has focused on providing SmartWell® data management tools and asset management tools in a web-enabled environment.

Creating value

WellDynamics has extensive experience in developing unique solutions like:

- Co-mingling, monitoring and controlling production from separate reservoirs to realize the value of production acceleration,
- Optimizing artificial lift efficiency,
- Controlling production from, or injection into, zones with varying permeability,
- Varying flow from various zones to shut off or choke back on water or gas after breakthrough,
- Actively controlling water and gas coning, to reduce OPEX,
- Reducing capex and accessing additional reserves with innovative Smart Field Development Programs, and
- Reducing OPEX through intervention cost savings.

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WellDynamics

Zed.i solutions inc. is the world's most advanced designer, manufacturer and developer of well testing and gas well monitoring solutions.

In Japanese, "zed.i" means "the final frontier, the unique and even absolute." zed.i strives to generate a positive impact on earnings of its customers—natural gas producers—and does this through the application of its unique well-test and well-monitoring solutions, as well as through the integration and streamlining of enterprise knowledge.

During the past 15 years, zed.i has earned a reputation for creating robust, accurate and reliable downhole tools that deliver value through a better understanding of reservoir dynamics. Customers' adoption of the award-winning and patented technologies has played a key role in leveraging zed.i's business beyond well testing to invent a new paradigm for gas well monitoring. The common shares of zed.i solutions are listed on the Toronto Stock Exchange and trade as ZED.

Smart-Alek™

Time Of Alarm	Sensor	Recorded Reading	Alarm Type
2001/08/01 10:07:29	Differental Pressure	0 in H2O	ALARM_LOW
2001/08/01 10:07:29	Orifice Gas Flow	0 MCF/Day	ALARM_LOW

The Smart-Alek™ system has the ability to increase earnings in three key ways:

- Increased revenues. An alarm call-out feature significantly reduces well down time from the industry average of 18 days.
- Increased productivity. By using the powerful production reporting and trending applications, engineers can optimize production of individual wells and maximize throughput of gas gathering systems by monitoring interdependencies.
- Reduced operating costs. By increasing the number of well sites with intelligent remote monitoring, field operators can eliminate status monitoring and data administration activities and focus on adding more value.

zed.i solutions has five locations in North America. The head office is in Calgary. The company was founded in 1987 in Edmonton, Alberta, which remains the location for research, development and manufacturing.

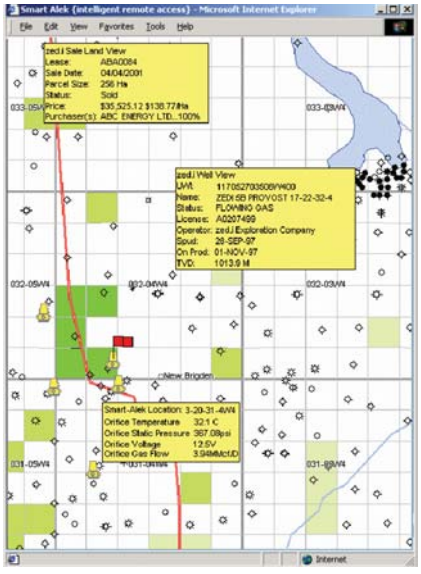
Programming the Smart-Alek unit to collect and send gas flow data over wireless communication networks.

The main office for zed.i's U.S. operations is in Houston, with full service and support facilities.

FINE™ System

Since the company's inception in 1987, zed.i has earned a reputation for excellence in field intelligence in the development, manufacturing and distribution of well-test field instruments such as the Shut-In Tool, Electronic Memory Recorder and Surface Data System. The development and release of Smart-Alek™, a gas well monitoring solution, now provides opportunities to earn revenues across the value chain as defined by the FINE™ system.

The premise of zed.i's business model is based on the concept of an end-to-end system, and it has trademarked the acronym FINE to help describe the three main aspects of the business model: field intelligence (FI), network (N) and end-user (E). Field intelligence data is collected from sensors and then analyzed and interpreted in an intelligent form. The communications network is where data is processed, encrypted and transmitted from a remote location to the corporate office. In an end-user interface, customers



The map interface allows users to access various layers of proprietary public and real-time information.

can seamlessly access and utilize production data and other proprietary data and applications. Through FINE zed.i can provide one-stop shopping for customers seeking an end-to-end solution to push data to the desktops and beyond.

Integrated information, instantly

zed.i solutions launched the commercial version of Smart-Alek in October 2001, the world's first wireless digital flow monitor approved for hazardous environments. Smart-Alek helps natural gas producers increase business productivity, optimize well and field production, and significantly reduce down time. Value is delivered through an end-to-end system that displays real-time production data in a meaningful context that helps decision-makers maximize earnings. zed.i's customers purchase the Smart-Alek solution primarily to replace existing mechanical flow meters and paper charts.

The value of Smart-Alek extends beyond the instrument, as it is part of a complete end-to-end intelligent remote monitoring system. This system includes network infrastructure, communication standards, database integration, and geographic-based software applications that create a seamless business environment designed to improve the productivity of natural gas operators.

Using the Smart-Alek system, it is possible to deliver applications and reports on pressure, flow and temperature to anyone with an organization with access to the Internet. The total solution enables large-scale monitoring of even the most remote assets for maximum revenue at minimal cost. Using its own IP address and communications via cellular or satellite, the Smart-Alek represents the most comprehensive, accessible system for intelligent remote monitoring available.

The local display on the Smart-Alek unit allows operators to view gas flow parameters in real time.

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