Crossing the Technology Chasm: Permanent Downhole Monitoring

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Editor's note: This is the third and final installment of a multipart series examining key upstream technology uptake challenges in the oil and gas industry, and the reasons for the lack of accelerated acceptance of viable technologies needed to exploit increasingly challenging drilling and production environments.

Similar to the managed pressure drilling (MPD) article published in the February *JPT* and the seismic while drilling (SWD) article in March, a permanent downhole monitoring (PDM) survey was conducted among SPE readership around the world. In total, about 1,500 SPE members responded to the survey. The majority of the respondents were operators (64%) and technology providers (13%).

Unlike the previous two technologies analyzed, PDM generally has a higher level of acceptance among operators because it has been on the market for a longer time, and because significant reliability and performance improvements have occurred over the past several years. A key question in the survey was: "What are the main value propositions you see for permanent downhole monitoring?" As shown in **Fig. 1,** the most important value propositions were: 1) optimizing production through continuous information, 2) avoiding the necessity to shut in the well to obtain pressure ratings, and 3) emerging distributed temperature capabilities that add further value in understanding and optimizing production. There was general agreement among both operators and technology providers on the importance of these benefits.

The relevance of these value propositions was stated by Shahab Mohaghegh, president of Intelligent Solutions: "The thought of being able to know what is going on in the well and in the reservoir in real time is very exciting. You imagine sitting in your office thousands of miles away from the field and being able to decide what needs to be done and then being able to see the consequences of your decision in near real time."

A similar view was expressed by Garrett Skaggs, monitoring product champion at Schlumberger. "The value of permanent downhole monitoring systems stems from the ability to provide continuous, reliable well and reservoir performance information without the need for intervention," he said. "These measurements enable operators to manage decisions regarding hydrocarbon assets including production optimization, problem identification and diagnosis, updating reservoir models, and field development planning."

The growing importance of fiber optic technology and distributed temperature sensing was also raised by a number of operators. Significant improvements in these systems over the past few years have led to an increased acceptance of this downhole technology. In the view of Glynn McColpin, director of reservoir monitoring at Pinnacle (a Halliburton service): "I think we are actually seeing the next wave with fiber optic sensing. Electronics can only get you to a certain temperature, then you start worrying about longevity and failures. You start looking at the fiber optic solutions coming out—we can go into steam wells up to 350°C with just glass and the glass itself is a sensor."

Reasons for Slow Uptake

The survey also asked the fundamental question: "Why has perma-

About this Series

The petroleum industry has a proud history of developing technology capable of exploiting reserves in increasingly harsh surface and downhole environments. Despite these considerable accomplishments, it has been documented that the speed of technology acceptance is slower in the petroleum sector than in a number of other industries. As exploration continues to focus on even more challenging environments (e.g., high pressures, high temperatures, deep water, and extended reach applications), the need for advanced technology to successfully exploit hydrocarbons will only escalate. *JPT* and Decision Strategies, an oil and gas management consulting firm, have teamed up to examine these key upstream challenges, the potential technology solutions, and the reasons for a relatively low acceptance rate of some new technologies in the industry.

To begin this market analysis, a worldwide survey of SPE members was conducted to identify specific technologies that represent real benefit to end users. The initial survey asked one question: "What do you believe are the most important upstream technologies that will be needed in the coming years?" Respondents supplied more than 1,000 suggestions, with no single technology mentioned with dominant frequency. However, several products and services were identified by both users and service providers as being important technologies for the future. Technologies identified as having significant potential were managed pressure drilling (MPD), seismic while drilling (SWD), and permanent downhole monitoring (PDM).

A second, more detailed survey among SPE members was conducted to identify the value propositions for these technologies, determine why they are not more widely used, and to analyze its potential if these obstacles to technology acceptance are addressed. Results were then shared with representatives of technology providers and users to further explore the issues surrounding the benefits possible with the uptake of this technology. The first installment in this series examined MPD and the second looked at SWD. This third installment summarizes the challenges with PDM technology uptake in the petroleum industry, and the path to a more accelerated acceptance of this technology.

Comments about this series can be sent to jdonnelly@spe.org or sjacobs@decisionstrategies.com.

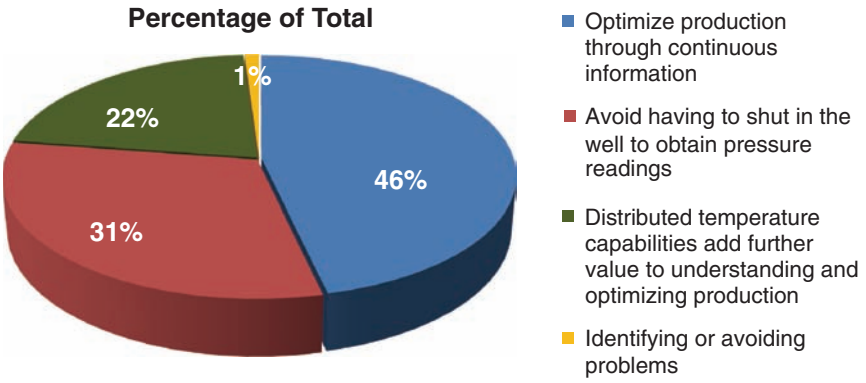

Fig. 1—PDM value propositions.

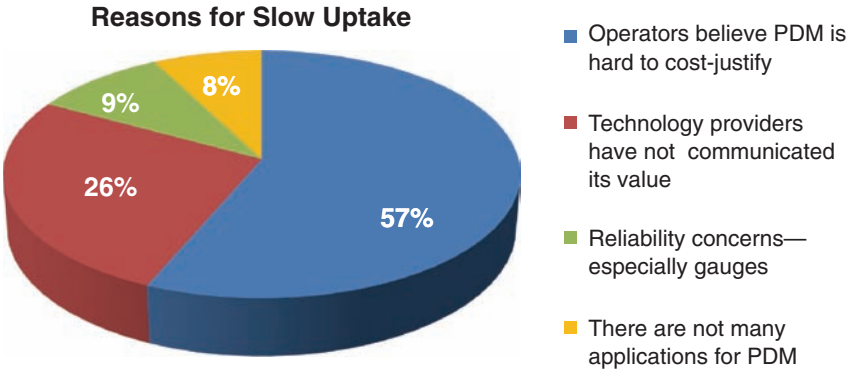

Fig. 2—Why PDM has not been accepted more quickly by operators.

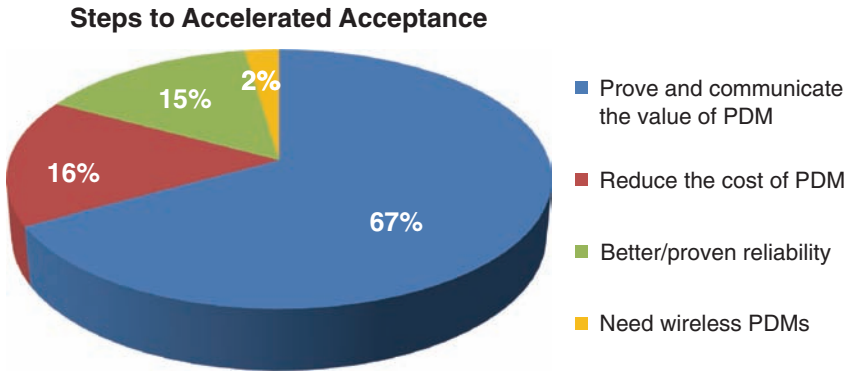

Fig. 3—How to achieve acceptance.

nent downhole monitoring not been accepted more quickly by operators?" As shown in **Fig. 2,** by far the most frequent answer was that operators believe PDM is hard to cost-justify. The following comments from oil company personnel who responded to the survey addressed this issue:

- "Operators do not believe the additional information is worth the money spent."
- "The technology providers have to be able to show that the value exceeds the costs."
- "Service providers have tried to provide very low failure rates, which can only be achieved by high costs."

One technology provider had a different view on the uptake issue. "I would say that it has now been accepted as standard in the industry due to improved system reliability," said Graeme Young, product line director of Intelligent Production Systems at Baker Hughes. "A secondary factor that contributed to the delay (in widespread acceptance) was due to reservoir/production monitoring needs not being adequately addressed at the initial drilling/completion design phases. Now we find that permanent downhole monitoring is standard and easily integrated into the overall completion design."

The second most frequently given reason for slow uptake in the initial phase of PDM acceptance was that technology providers do not adequately communicate the value propositions to the operators. This situation was addressed by the respondents in the next question.

Steps to Accelerated Technology Acceptance

In a follow-up question, survey respondents were asked: "What steps can be taken by operators and technology providers to accelerate the rate of acceptance of permanent downhole monitoring?" As shown in **Fig. 3,** two-thirds of the responses involved better demonstration and communicating the value of this technology. This point was addressed in the following comment from an operator: "It is hard to demonstrate the incremental value of PDM. I personally have operated many wells where PDM was nice to have, there was a

lot of data to review and analyze, but only in a few cases it really influenced a decision. Clear demonstration of value and lack of value is required. Also, we need to be clear on the additional rig time required to install PDM systems in wells. Upfront capital expenditure, depending on the system, can be significant."

While such operator views are no doubt a source of frustration for PDM technology providers who believe they have communicated the value propositions, this is a common response from operators about a new technology, based upon numerous market assessments conducted by Decision Strategies. From a technology provider perspective, it is still a challenge to: 1) persuade potential users to take the time to evaluate a new technology, 2) provide solid data to adequately convince operators of the merits of the technology, and 3) provide a level of early systems reliability that minimizes the pain and anguish that operators endure when they traverse the technology acceptance cycle.

Some survey respondents stated that operators have a responsibility in testing and adopting new technology for increasingly harsh downhole environments. This view was expressed in the following comment: "Operators need to adopt an attitude of continuous learning to complement their attitude of continuous improvement. PDM data is not always straight forward to process into value-added information. It takes dedicated technicians/engineers with a good understanding of the project to be highly devoted to the task and supported by management."

Another reason why PDM has not been accepted more quickly by operators is the cost of the technology. Whether it is "sticker shock" from a commercial evaluation of the technology, or a realization of the hidden costs that must be incurred (evaluation time, personnel training, etc.) cost-justification has been an obstacle. In addition, while considerable improvement in reliability has occurred for PDM systems over the years, there is still a concern among operators. About one out of every 10 respondents in the survey indicated that reliability issues exist, with gauges being the most frequent component mentioned.

Offshore Market Potential

A final question was asked of operators and technology providers: "If these steps are taken, what percentage of all offshore wells will use PDM technology five years from now?" While a wide range of opinions was obtained, the sample average was that approximately two-thirds of all offshore wells will use PDM in five years. (In the previous surveys, SWD is expected to be used in approximately one-third of offshore wells in five years; for MPD, the estimate was 40%.) This optimistic view of future PDM usage was attributed to: 1) PDM technology has been in the marketplace for decades and is therefore better understood by operators, 2) significant improvement has been made in the reliability of gauges and other components of PDM systems, 3) improvements in software for capturing and analyzing the data, and 4) sensors and fiber optics that provide additional measurement capabilities for monitoring downhole conditions have been introduced (e.g., problems with "hydrogen darkening" on fiber optic systems for steam-assisted gravity drainage wells have been solved, which has accelerated the rate of acceptance of this specialized technology).

"PDM is a very important technology for deepwater wet completion satellite wells," said Celso C.M. Branco of Petrobras E&P. "Reliability of the downhole devices is of utmost importance. The association of pressure and downhole flow measurements would enhance the use of this monitoring mainly in heterogeneous reservoirs. Innovative procedures to incorporate this dynamic information in simulation models are always welcome."

Approximately 17% of the respondents stated that they are considering using PDM services in the future. Clearly, the acceptance of PDM technologies is on the increase after many years of slow uptake.

Conclusion

The results of these three technology assessments are similar to a number of other emerging technology analyses conducted by Decision Strategies over the past 25 years. While many factors contribute to the speed of acceptance for emerging technology in the industry, there are typically three that have a dominant influence:

1. **Immediacy and Magnitude of Benefit.** The most important factor in determining the speed of technology acceptance is how much benefit will be obtained, and when the user can expect to receive the benefit. For example, MWD was accepted more quickly than logging while drilling (LWD) because the operator benefited immediately from significantly reduced nondrilling time because long correction runs were avoided, and better drilling of the wellbore was possible. Conversely, LWD suffered a considerably slower uptake because the quality of the initial formation evaluation logs was inferior to those obtained via wireline, and there were issues with reliability and the limited capability to use the information on a real-time basis. This situation reduced the benefit received by operators in the early years.

2. **Early Systems Reliability.** In their haste to introduce new products and services, technology providers sometimes introduce these offerings before they are ready for the market. Additionally, achieving early reliability for a technology that must endure a downhole environment can be extremely challenging. A number of technologies that became mainstream because of their "immediacy and magnitude of benefit" suffered a slow uptake because of less than acceptable reliability. The new product development process is sometimes one of pain and anguish for operators who must endure a lengthy and arduous process to improve and eventually accept these technologies as part of their drilling and production technology arsenals. (As mentioned, technology users also have hidden costs that are sometimes not appreciated by technology providers and this can make the new technology acceptance process even less palatable to operators.)

3. **Comparative Cost.** Technology users often focus upon the comparative costs of a new technology versus the previous generation of products and services. Another frequent inhibiting factor to the speed of technol-

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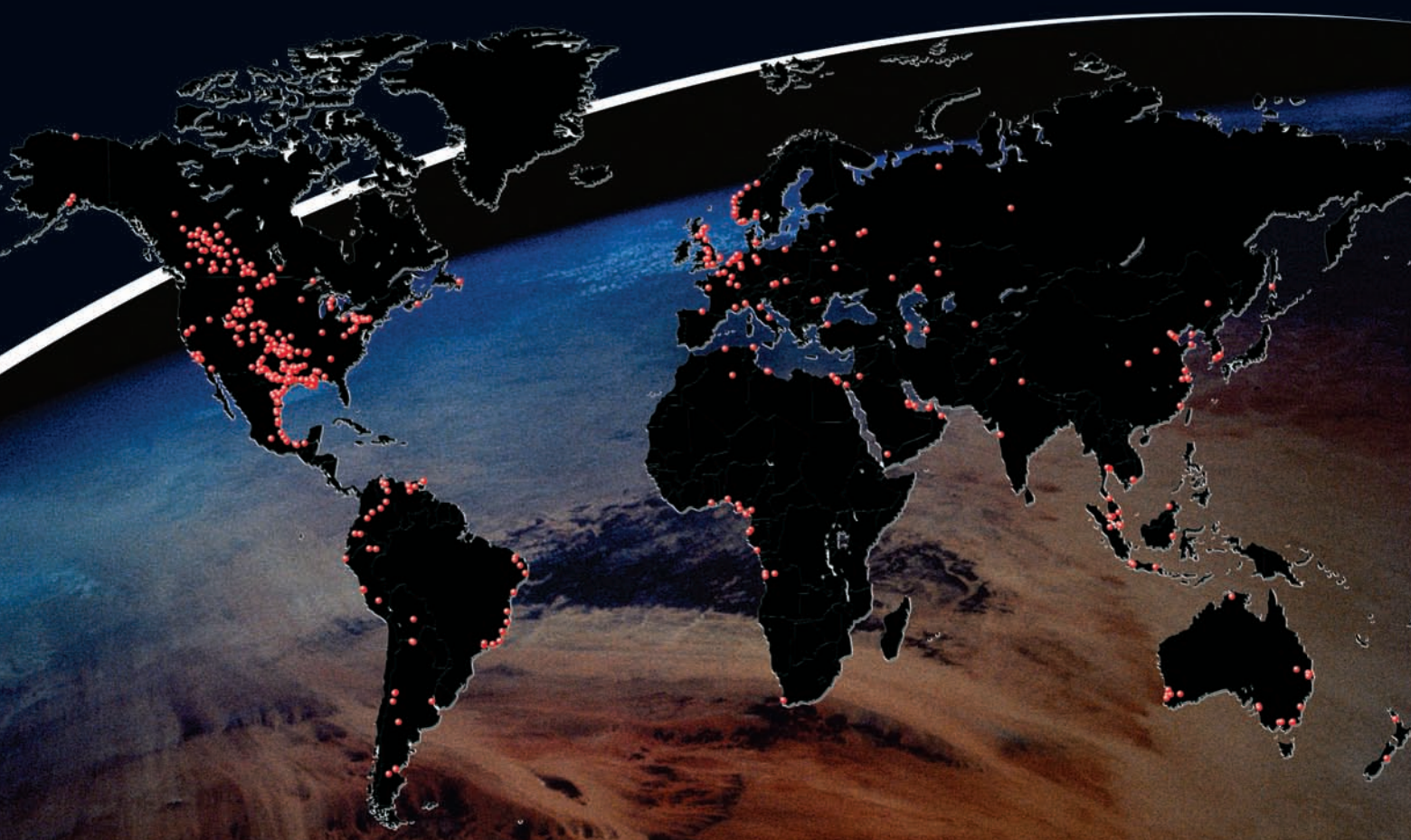

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ogy acceptance is when a product or service is viewed by operators as providing only incrementally more benefit, but at a considerably higher cost. This combination has been the failure mode for many technologies within the industry over the past several decades. This situation can also be compounded by a laborious testing and adoption program on the part of operators that makes it difficult for them to appreciate the value propositions of a new technology.

The interaction and impact of these important factors can be shown in a rough model for determining the speed of technology acceptance. As shown in the "Technology Cube" **(Fig. 4),** it is possible to estimate the outcome for a new technology by plotting where the candidate technology falls on the three influence axes. This exercise provides a reality test on the likelihood that a new product or service is a viable technology and will achieve an accelerated market acceptance.

New technologies having the highest level of benefit to the user with high early systems reliability and at a cost comparable to the current technology typically have a higher acceptance rate. Some technologies that fall at the midpoint of these axes in the Technology Cube should be expected to have a moderate and likely unacceptable speed of technology uptake. Failed technology is the result of products and services having minimal benefit and low reliability at a higher cost. It is not uncommon for operators and technology providers to have different views on the merits of a new technology.

Based upon emerging technology assessments conducted over many years and the three *JPT* surveys, a number of keys exist to accelerated technology acceptance:

• The premiere value proposition in the industry is to provide technology that increases ultimate recoverables or the rate with which they are produced. Any technology delivering this outcome is likely a winner.

• Developing technology that is a solution to a problem can be a way to fast track the speed of technology acceptance. (Sometimes the downside to these technologies is when they represent only a niche market opportunity to the service companies.)

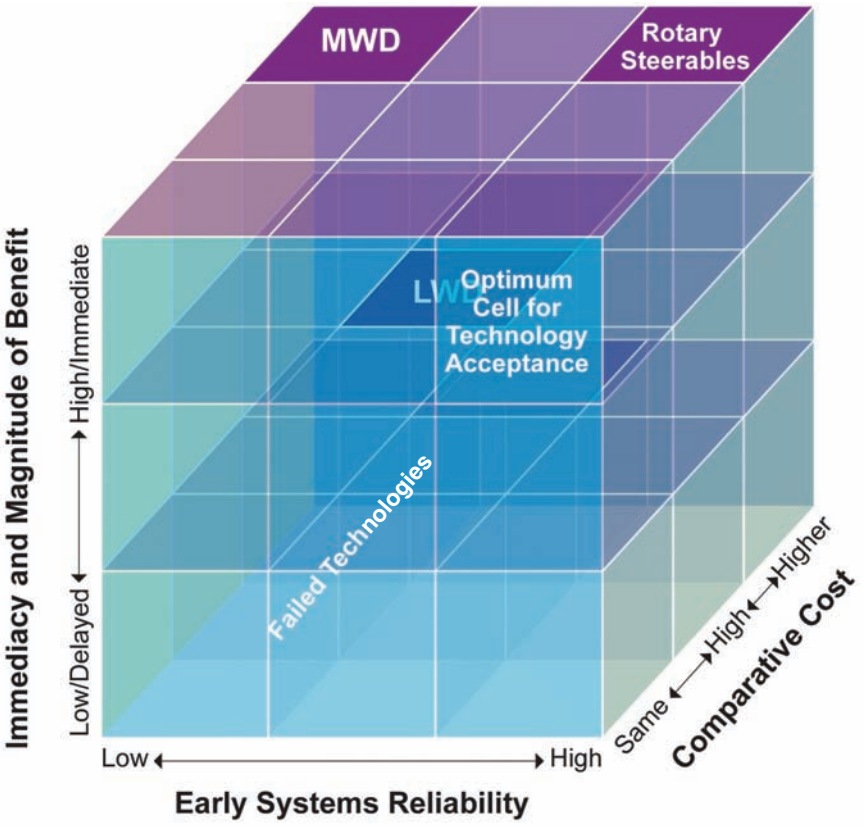

Fig. 4—The Technology Cube.

• Having the discipline to refrain from introducing new technologies that have reliability issues is an important factor in the speed of acceptance for a product or service.

• A quality marketing and sales effort is extremely important. Oil company personnel often state that there are inadequate data and case studies available to properly evaluate the benefits to be received from a new technology. This must be a continuous process of market communication.

• Products and services that enhance the performance of other technologies can enhance the speed with which the emerging technology is accepted.

• Technology providers must listen closely and continuously to technology users to understand their emerging needs. Various feedback mechanisms are available for ensuring that adequate communication exists between technology providers and users.

• Joint technology development efforts between operators and service companies can be a successful way of enhancing and proving the benefits of the technology and accelerating the rate of its acceptance.

• Whether conducted in-house or through a third party, market research can be helpful in identifying technologies for service companies to develop and for accelerating technology acceptance. As with seismic surveys, market research does not always have adequate granularity to "find the prize" but is frequently accomplished in identifying attractive market opportunities.

A new technology development effort is like an airplane racing down the runway. The objective is to gain altitude (market acceptance) before reaching the end of the runway (having to pull the plug on a failed technology). The future challenge to technology developers and users is to work more closely together to ensure that the increasingly complex systems required for extremely harsh environments are both appropriate and efficient in providing hydrocarbons for a world with an increasingly insatiable appetite. **JPT**