PRODUCERS HAVE A NEW TECHNOLOGY ALLY, OR PERHAPS more accurately a super team of high-tech support that delivers valuable information for better completion designs, well and fracture spacing, and ultimately improved well performance: Pinnacle’s integrated sensor diagnostics (ISD).

“The big thing is really the combination of all these technologies,” says Mike Mayerhofer, director of the Hydraulic Fracturing Center of Excellence at Pinnacle, a service of Halliburton.

“It is about bringing all these different things together with the engineering that gives the additional insight, because when you use technology by itself, you just can’t tell all the different nuances.”

The suite of ISD technologies includes FiberWatch distributed optical sensing, which provides real-time sensing results during fracture treatments, determining cluster efficiency, fluid distribution and completion effectiveness. Pressure gauges use downhole sensors to provide information on fracture treatment pressures, bottomhole glowing pressures during production and cross-well communication.

“When we are fracturing one well and we have a fibre optic cable in another well, we are looking for pressure and distributed acoustic sensing signatures that are coming across that fibre optic cable and that the pressure gauges can see. This could be an indication that the hydraulic fracture is right next to the well,” Mayerhofer says, adding cross-well diagnostics use fibre optics and pressure gauges to see how fractures propagate, in more detail, between wells.
is being pushed to the other well through natural fractures.”

Other ISD tools include FracTrac downhole microseismic monitoring, Pinnacle’s fracture-mapping technology that determines fracture geometry, azimuth and fracture complexity. Surface microseismic imaging compliments downhole microseismic tools by providing fracture geometry information to constrain hydraulic fracture models.

FracHeight micro-deformation monitoring combines downhole tiltmeter sensors with microseismic receivers conveyed on a fibre optic cable, providing fracture deformation insight as a function of depth and very reliable results for determining hydraulic fracture heights. FracNet micro-deformation monitoring is a surface deformation-based technology that delivers clarity on fracture azimuth and orientation, as well as complexity.

“For this ISD approach, the main deployment is going to be a permanent fibre optic installation because we want to monitor both the fracture-injection portion of the treatment, and then we also want to measure the flowback and production with the fibre,” Mayerhofer says, adding that fibre optics is probably the key technology within the suite.

“We are trying to get a more detailed picture with fibre optics than we do with microseismic. We look for distributed temperature sensing (DTS) communication and whether there is a cool-down at a certain location along the fibre optic well, meaning the fracturing fluid actually hits that well. Determining the location and extent of a frac hit is an important diagnostic for determining fracture geometry, complexity and azimuth.

“Sometimes, we see the opposite. We see it heat up, which tells us it might not be directly related to the hydraulic frac, but rather it could be a displacement of reservoir fluid that one that sort of holds it all together because it starts out at the wellbore.”

Simply by reducing cluster spacing, one company estimated a revenue improvement of $2.7 million per well based on the ISD interpretations, Mayerhofer says. “That is a really sizable prize, but the big prize is really the overall development.” In one example, Pinnacle calculated a $72-million revenue gain per section, which entailed drilling three extra wells in an area at about $8 million per well. “So that’s $24 million of extra cost to get a $72-million gain.”

“Long term, the suite of sensors can assist with optimizing assets in the recompletion of wells.”

— Eric Holley, production line manager of unconventional resources, Pinnacle

“Long term, the suite of sensors can assist with optimizing assets in the recompletion of wells,” says Eric Holley, production line manager of unconventional resources at Pinnacle.

“For a lot of these basins under development, the Barnett for instance, since they were completed a decade ago the philosophies have changed in what is the best way to complete the particular geology. Therefore, we are now going back in and investigating...”
Pinnacle’s calibrated fracture and reservoir modelling can determine the ideal lateral spacing for a given field development, maximizing acreage, capital and reserve recovery.

**INTEGRATED SENSOR DIAGNOSTICS**
Pinnacle’s advantage suite of diagnostic technologies allows for real-time monitoring of near-wellbore and far-field stimulation behaviour, which can be directly applied to the optimization of subsequent stage completions.

**REAL-TIME STIMULATION MONITORING**
Gathering near-wellbore fluid distribution results as well as far-field fracture geometry forms the basis for Pinnacle’s integrated sensor diagnostics.

“**If we thought our well spacing was too far apart 10 years ago, then what do we get if we drill a central well? How would that be impacted by existing horizontals? We are employing these technologies to not just look at untouched virgin reservoirs, but also to go back into some of these mature fields to reassess and revitalize some of these assets.**”

So far, Pinnacle has deployed ISD on 20 projects and 73 wells across North America, using at least two or three of the technologies offered. Not all available sensors are necessarily deployed in every situation, Holley notes, but rather, Pinnacle works with companies, sometimes over the course of many meetings, to tailor the right suite for each particular situation.

“We do not simply want to deploy sensors for the sake of deploying sensors. What we want is to actually try and address challenges to come up with solutions. Our goal is to characterize the fracture footprint that will then provide inputs for fracture and reservoir model calibration. The differentiator here is utilizing the [Center of Excellence] to take all of the valuable sensor results and turn those into tangible recommendations for well and field improvement.”

Pinnacle works with a company to lay out a site and its nuances, determining what tools the company has already deployed, then helps the company to choose sensors that will complement what is already in place to help meet their needs.

**THE FUTURE**
According to Holley, distributed acoustic sensing (DAS) is a technology that has matured a lot over the past couple years, and Pinnacle is quantifying its injection profiling with the FiberWatch service.

Currently, Pinnacle is using temperature sensors on fibre optic cables for production outputs. However, because interpretive techniques can be used with legacy fibre optic cables, an operator could add DAS to complement the production results from DTS.

“Multi-phase production analysis with DAS is something we are working towards,” Holley says, adding that ISD is designed to resolve universal problems across most unconventional resource plays. While there have been some difficulties convincing companies to approach diagnostics from a broader perspective through reservoir models, over the past two years, more clients are accepting the approach.

“We have seen quite a lot of people buying in to the process. They have seen a few case studies, or their partners have done it.”

Much of ISD’s future enhancements will entail better hydraulic fracture models that more accurately reflect the conditions depicted, Mayerhofer says. He notes that models have already advanced over the past 20 years, largely thanks to experiments in Colorado, which demonstrated how hydraulic fractures behave and grow.

“They obtained measurements by including both microseismic and tiltmeters, actually drilling through the fracs to physically see where they were and validate the results. This information provided a lot of insight and clarity, which we applied to our frac models by modifying some of the physical settings.”