In today’s down market, oil and gas producers are emphasizing hyper-efficient production techniques and full automation for their fields. Layoffs and retirement are shrinking the workforce as decades of knowledge and specialized skills leave the industry, while the demands of the oilfield remain the same. The message to operations teams is clear: reduce costs and maximize the return on every investment.

When producers consider the essential components they need for drilling, completing and automating wells, communications technology is often an afterthought.

This story is quite common within the industry: drilling crew arrives at the pad site to prepare for drilling. After drilling, the fracking crew moves in to stimulate the shale formation underground. Another crew follows, completing the wells and leaving a Christmas tree of valves, spools, pressure gauges and chokes on each. By the time wells are in production, the company has missed important cost-saving opportunities to monitor a multitude of aspects that greatly affect rates of decline and, ultimately, the bottom line.

At today’s well pad, sensors and meters can collect vast amounts of data that companies are using to make more targeted decisions about production. These data yield actionable intelligence about operations on the pad, leading to predictive maintenance, longer life cycles for equipment and higher production rates. Better asset integrity in the field helps to keep wells online and pressures and flows more consistent. However, the network required to transport all of this telemetry data from the well pad back to the field office is often failing due to out-of-date technology, or even worse, is absent altogether.

Companies still relying on field personnel to manually inspect each well without the aid of remote monitoring and diagnostic tools risk falling behind in an increasingly competitive marketplace, as producers struggle to prioritize maintenance tasks and minimize non-productive time in the field. As McKinsey & Company states, “Improving production efficiency by ten percentage points can yield up to $220 million to $260 million bottom-line impact on a single [existing oilfield] asset. For declining assets, automation could extend field life in an economically viable way. The potential could be even more significant for greenfield assets, where required instrumentation can be included from the start as part of the design.” Well pad automation does not reach its full potential until companies have real-time, remote visibility into all processes in the field.
Imagine that a private wireless network is already in place before the drilling rig arrives. What if the well pad is connected to the field office before the first drop of liquid flows from the ground? Here's how the story of an onshore well pad might play out differently.

**Real-time data from the beginning**

A construction crew arrives to prepare the pad site for drilling and installs a broadband wireless mesh router on a pole, powered by solar and battery pack. The broadband mesh router immediately searches and forms wireless mesh links to other nearby pads, and the site goes online with full connectivity to the field office and beyond.

Next, the drilling rig and field technicians arrive onsite to begin drilling. Their mobile office trailers are equipped with mesh routers, which automatically connect to the existing mesh router on the pole. From the moment drilling begins, crews can take advantage of private, secure mobile broadband communications to the corporate network and the Internet. Computerized drilling rigs can transmit real-time data such as Revolutions Per Minute (RPM), circulation solids, down-hole pressures captured through Measurement While Drilling (MWD), and remotely steerable down-hole tools. Cameras transmit real-time video feeds, but only when conditions change, enhancing worker safety and enabling time-saving process improvements. Engineers at headquarters or in the field office now have remote visibility to wells as they are being drilled.

When drilling is complete, the crew packs up the rig and moves on to the next site, where another broadband mesh router has just been installed. The newly drilled wells at the previous pad are capped and moved to inventory status as the decision to produce now depends on commodity prices. When the company decides to produce, instrumentation for monitoring pressure, temperature and flow is installed. The wireless network transports data that is aggregated from pressure and temperature sensors, as well as operational logs, to the field office or operations center for analysis. Field technicians are able to view Human-Machine Interface (HMI) screens and check in with the office, seamlessly and securely, from their handhelds, laptops and even from their vehicles. A private broadband wireless network greatly reduces and in many cases eliminates the ongoing per diem expense of satellite (VSAT) communications. The company builds the network as they build out their field, leveraging their communications investment at each phase in the life cycle of the asset.

Next, a flow computer is installed and wireless communications equipment goes into the control cabinet along with analog and digital inputs and outputs (I/O). The radio onsite transports real-time data over wireless mesh links back to the field office or operations center, where SCADA systems and analytics software help operators adjust production in real time. Flow and pressure can be remotely monitored to help determine when artificial lift is needed. With secure broadband communications in the field, engineers can continually harvest valuable flow data and potentially avoid spending resources on under-producing wells. Recently, producers have been reducing costs by closely monitoring chemical injection for each well, thereby minimizing the waste of one of the most expensive elements of production. As Forbes magazine states: “Another major challenge is that the current (chemical injection) process is very manual; requiring gaugers to visit each well site to check chemical stock levels, adjust injection rates, supply
the chemical, and check current production rates. Inventory control is very important because the chemicals start to lose their effectiveness once they have passed their defined shelf life, generally measured in a few months. Determining the correct dosing rates is also very critical. Under-dosing causes damage to the drilling infrastructure (corrosion), safety issues (hydrogen sulfide), and product quality (emulsifiers). Over-dosing increases cost, creates environmental issues (unneeded chemicals being introduced to the environment), and can potentially damage equipment. By monitoring the chemical injection process and continually transmitting the data to the field office, companies can shave costs. Better monitoring leads to more granular samples, higher production rates and allows producers maximize profitability, even in these lean times.

Along with chemical injection, other processes like custody transfer have traditionally been tracked manually via paper tickets. Tickets get lost, and volumes get misreported, which results in significant discrepancies and lost revenue. When oil was trading at $100 per barrel, there was much less focus on volume lost in custody transfer. These days, every drop counts. The custody transfer process can now be entirely automated, and real time data can be sent to the field office as well as the midstream partner receiving the product. Product received can be reconciled immediately and, most importantly, accurately. Using automated custody transfer applications, as well as digital meters and flow computers that communicate over a modern wireless network, producers can now be sure that they are paid for the exact volume transferred to the midstream partner.

Another benefit of modern network connectivity at the well pad is asset tracking. Lease operators are increasingly concerned that company-owned equipment gets moved between well pads and across the field, without being tracked. This leads to lost items and, unfortunately, theft in many cases. Asset tracking refers to the ability to remotely locate equipment that moves around the field like power generators, tools, trailers and other expensive equipment. Tags placed on each asset can send location coordinates to the field office or control center via Real Time Location Services (RTLS) over a field-wide WiFi network.

Video surveillance provides yet another method of securing assets and ensuring compliance with worker safety regulations. Smarter, less expensive, more ruggedized cameras are on the market today, and they need a smarter, economical private network in the field to transmit those critical images back to the operations center. Recently, a producer told an ABB Wireless engineer: “I need you to engineer people off of our well pads.” In other words, they are asking for solutions that enhance safety and reduce workforce cost, which is the mandate of many upstream companies today. With video, full automation, and modern wireless network connectivity, technology vendors have the tools to truly allow producers to engineer people off of the well pad.

More than a device connection

Traditionally, producers thought of field radio systems as just a necessary evil – a way to poll supervisory control and data acquisition (SCADA) devices on the well pad. These devices, such as RTUs and PLCs needed a radio, so the operations team installed whatever radio was on the shelf at the time. The concept of a fully-architected, modern network in the field was understood by only the most progressive companies who had capital reserves to fund extensive pilot projects.
and technology ventures. Today, most producers understand that they need to modernize their communications but have legitimate concerns about the value that various technology offerings on the market provide.

A field administrator may ask: broadband looks great but how does modern wireless technology deliver such high performance, especially in unlicensed radio spectrum?

It starts with radio frequency (RF) spectrum management. Traditionally, wireless networks used for SCADA have been powered by narrowband, point-to-multipoint, serial radio technology operating in the 900 MHz frequency band. This decades-old technology is in such wide use today that RF interference has become a major problem for SCADA managers and field technicians. Oil and gas leases operated by competing companies are often located on adjacent and even overlapping properties. The SCADA networks deployed by these companies commonly use the same 900 MHz radio technologies, and as a result they suffer from excessive interference caused by neighboring systems. Interference causes transmission interruptions and data loss, leading to reductions in asset integrity and productivity. In many cases, the only way to improve connectivity is to increase radio output power, which has an additive effect as companies try to overpower each other’s radio transmissions. Interference prohibits reliable operation of the network and as communications fail, asset information is not updated and productivity suffers. Interference avoidance mechanisms such as Frequency Hopping Spread Spectrum (FHSS) are less adequate when operating in the vicinity of multiple other FHSS systems. So how do companies overcome these challenges?

For the digital oil and gas field, moving to a wireless network that uses all available spectrum, both licensed and unlicensed, coupled with intelligent radio resource management software that both mitigates interference from other sources and minimizes self-interference, makes the most sense. Such a broadband wireless network offers multi-megabit speeds and high reliability, which are essential for real-time production monitoring. Broadband mesh technology avoids the problems faced by radio networks operating solely in the 900 MHz band by operating on a sophisticated listen-before-talk protocol, coupled with sophisticated radio power control algorithms; the routers not only avoid interference from other systems, they cooperate with each other to provide the cleanest RF path for the given environment.

A complete transition away from traditional sub-1 GHz radio systems is not always the best answer, however. These radio technologies can still be used strategically in geographies where upper bands fail to achieve the same distance or obstacle penetration. Sub-1 GHz frequency bands have longer wavelengths and even with low transmit power, signal can travel great distances; however, there is not enough bandwidth to support real-time data, video and Internet access. Companies relying on traditional 900 MHz radio systems to create their core field network infrastructure must consider a more diversified approach in order to provide the bandwidth required by their various business units. The right combination of higher band frequencies in 2.4 and 5 GHz with sub-1 GHz creates a frequency-diverse architecture that can work extremely well in most geographies.
An ideal use of the sub-1 GHz frequency bands is to keep those signals at the geographical edge of the field, or local to the well pad. Device-level communications technologies using wireless radios to aggregate Analog and Digital Input/Output (I/O) are becoming more common. The main advantages of wireless I/O lie in the ease of deployment and lower installation costs. Copper cabling is increasingly expensive and labor-intensive to install and maintain. Theft of cabling is also a concern for many operators. With wireless I/O, many commonly used sensors and measurement devices can be delivered to the pad with factory-installed communications. Companies can build out an automated, connected well pad more quickly and more economically.

**Combining radio technologies to create a more robust field network**

To overcome distance and obstacles in the wireless signal path, combining different radio technologies to build a robust field network is often the best approach. When companies have tower infrastructure located near their field assets, fixed broadband wireless systems, such as point-to-multipoint (PTMP) and microwave point-to-point (PTP), generally provide the highest throughput to the field. However, PTP systems have limited flexibility and are expensive to design and install. When used in conjunction, PTP/PTMP systems and broadband mesh wireless mesh provide very high performance and reliability by maximizing each other’s strengths. PTP systems provide the backbone, and broadband mesh can extend that capacity to the edge with the ability to route around points of failure. Additionally, field personnel can roam throughout the field with mobile mesh routers providing connectivity to their vehicles. The sub-1 GHz bands are still the most economical way to reach remote sites, making the combination of frequencies and radio technologies a necessity in the modern field network. One thing is for sure: one size does not fit all when it comes to communications in the digital oilfield.
One wireless network, multiple applications

Traditionally, SCADA managers have demanded that their data can never exist on a shared network. Each department would procure its own field network solution and take on the fiscal and technical responsibility for maintaining that infrastructure. This method of operating disparate networks within the same company has clear technical and economic inefficiencies.

The notion that each process or application needs its own wireless radio system has gone by the wayside as broadband Ethernet technologies mature and become as economically viable as legacy narrowband systems. A wireless broadband network that provides a scalable and reliable next-generation communications platform can securely support multiple applications on one physical infrastructure. Polling intervals can be driven by application needs, not the limitations of the wireless network. This means that if every department, from the drilling team to operations, adopts a holistic view when considering how to deploy the highest-performing network for the lowest overall cost, the company wins. Particularly when market fluctuations force companies to optimize capital expenditure, a common network infrastructure leveraged by all departments is the most efficient use of available budget.

The obvious question is: how does the company maintain secure separation of data over a common field network infrastructure? The answer lies in the feature set of a standards-based IP architecture. Virtual Local Area Networks (VLANs) and Quality of Service (QoS) settings allow corporate IT and network administrators to enforce strict policies that keep data from various departments completely discrete. Traffic prioritization using QoS enables the network administrator to decide which applications are the most critical when network congestion occurs. IP-based firewalls and Access Control Lists ensure that devices in one department cannot communicate with those in another department. These methods combined represent a robust set of features for controlling and shaping data traffic over a common IP network infrastructure.

A single modern wireless network can simultaneously support a range of oil and gas exploration and production applications such as:

- Real-time video feeds and surveillance – increase situational awareness; enhance security by monitoring wellheads and other key facilities
- Health, Safety and Environmental – improve worker safety via constant contact; enhance facility security with access control
- Drilling rig communications and diagnostics – monitor drill bit depth and tilt, mud weight, temperatures and pressures; remotely run diagnostics and analyze results
- SCADA – production and injection well monitoring, measurement, logging and control; source and disposal water well monitoring; emergency equipment shutdown and recovery
- Asset tracking – track and update the location of assets in the field to maximize production efficiency
- Field workforce connectivity – keep work crews in the field connected with remote access to flow computer screens, instant messaging and email at remote sites even if they lack cell service.
- Voice – use IP phones for mobile worker voice communications even in remote areas with no cellular coverage
Cybersecurity at the network edge

When companies extend broadband connectivity to the oilfield, they can alleviate concerns about security vulnerabilities by deploying technology that can stop attacks at the edge of the network. Cyber attacks can be very costly, and companies are beginning to recognize that security holes in the field leave SCADA and business networks open to exploitation, not just by foreign entities but by insiders as well.

To protect against attacks, modern wireless networks implement a multi-layer, defense-in-depth security architecture using open security standards. Open standard, enterprise security tools and techniques have been honed for years, and are constantly being updated. Security solution vendors, government-funded organizations (agencies such as CNSS, outside bodies such as CERT) and security researchers constitute a large and active security community around the globe. These groups and individuals discover and publish vulnerabilities and ensure that vendors maintain transparency about the security of their products, and correct any weaknesses.

As a result, oil and gas companies can leverage the past and ongoing work of the enterprise and Internet security community. Using a multi-layer, defense-in-depth approach with firewalls onboard every router, broadband wireless networks have met United States Military cyber security standards. Figure 3 below shows how broadband mesh products implement security standards at key layers of the IP network stack.

The fabric connecting the digital oilfield

By utilizing computerized drilling and automation technologies, oil and gas producers gain a clear advantage over the competition because they can make better, more timely decisions. This advantage translates to increased production efficiency and higher profitability. However, without reliable, modern connectivity in the field, companies are forced to maintain an expensive field workforce or else operate in the blind. Instead, if they build out the field networks as they expand operations and commit to a secure, modern wireless communications infrastructure, they will be in position to lead when the market rebounds. The leading oil and gas players are transitioning to a hyper-efficient, digital oilfield, and modern wireless communications can help customers realize the potential of real-time monitoring, safety and control, from lease to production…and beyond.
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