To the last drop

How wireless communication supports the lifetime extension of oil and gas production

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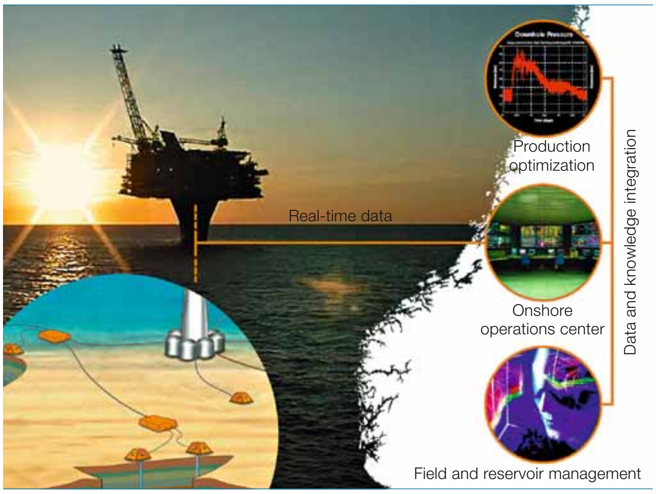
Cost efficient exploitation of primary energy is one of the major challenges of today's society. This is especially vital when oil and gas fields reach the limits of their reservoirs and start to "dry out". Oil and gas production companies then try to use the installed equipment as long as possible in order to avoid costly new installations. Every improvement in operational efficiency directly pays off in such a situation.

Many of the oil and gas installations in the North Sea were built in the 1970s, and are now entering the tail production phase. Few new large greenfield projects are currently planned in the Norwegian and British sector, hence the industry's focus is shifting to brownfield projects. As a consequence of this shift critical issues have to be addressed:

- In the tail phase of production efficient operation is vital to prolong the life of the fields.
- The aging equipment requires more maintenance.
- Condition-based maintenance aimed at the reduction of operational cost is crucial.

1 Major elements of a production site in the North Sea



Integrated operations

To get a grip on this huge task of managing thousands of devices, systems and installations, an extensive use of online data for both increased production and efficient operation and maintenance is the way forward. Within the upstream oil and gas industry, many initiatives along these lines have been started, known as Integrated Operations, e-Field, Field of the Future, Smart Fields etc. The potential for Integrated Operations on the Norwegian continental shelf was estimated at 250 billion NOK in 2006 in a report issued by the oil industries association in Norway [1].

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ABB is an active player, collaborating with oil companies, other vendors, and academia to realize the Integrated Operations concept Factbox.

The challenge of data acquisition

Upstream oil and gas production plants consist basically of a production plant taking hydrocarbons from a reservoir in the ground to an export line with processed oil and gas. In the North Sea, the production plant is normally located offshore. It resides on a steel jacket, concrete structure or a floating unit depending on the sea depth and technology available at the time of construction. The latest developments also include sub sea processing facilities. 1

In order to be able to use a reliable and secure bandwidth to collect the required data in this challenging environment, oil companies have invested in a fiber-optic network in the North Sea. Further enabling technologies to support extensive data transfer are under development: fiber optic networks in the wells, wireless communication around the platforms (support vessels etc) and throughout the plant, at the top side facility or between platforms.

Traditionally installation of sensors for online data collection requires wires. For new installations, wireless sensors can save on cabling costs. When it comes to retrofitting wiring, this is even more costly and often impossible on a large scale as it requires installation personnel on site. Furthermore, limited bed and transport capacity on the oil rig is often a restraining factor. In order to wire the sensors, it may also be necessary to set up scaffolding, remove insulation and traverse bulkheads and explosion and fire-protected compartments, further adding to costs.

Factbox Collaborating for success

ABB is delivering products within condition monitoring, performance monitoring and production optimization to many different upstream installations.
ABB was selected as the industrial research and development partner by StatoilHydro within the area of operations and maintenance, heading a consortium known as TAIL Integrated Operations including AkerKværner, SKF and IBM [2].
Another major R&D program is a wireless vibration sensor development supported by BP and StatoilHydro. ABB is heading the consortium which also includes SINTEF and SKF.
The two above projects are supported by the Norwegian Research council under the Petromaks program.

Wireless sensor networks

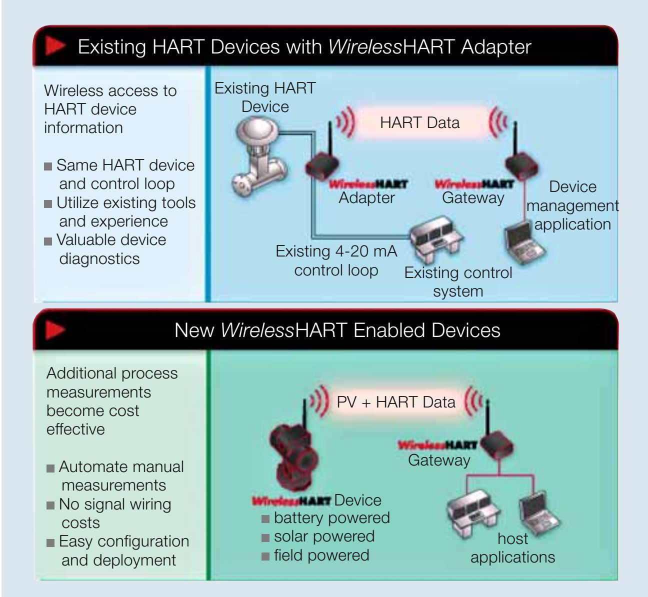
In mature offshore fields, the use a low-cost wireless sensor network (WSN) presents a major advantage when it comes to feeding measurement and communication equipment data to central units. The WSN can be retrofitted on offshore platforms that have hundreds of pumps, fans, and other motor driven devices requiring permanent maintenance.

The technical challenges of a WSN in this environment are significant, however. The WSN's principal requirements include:

- Reliability of the communication in harsh environments
- Predictable latency, ie, the delay and determinism of the communication
- Low power consumption of the sensor node and communication
- Security, which ranges from message confidentiality (end-to-end encryption), message integrity checking, authentication and secure procedures for network access
- Coexistence with other equipment and competing wireless systems

For condition monitoring applications, which typically have a lower update rate, the latency is less important

2 The use of WirelessHART in existing and new applications



whereas reliability, security and power consumption remain vital.

Power consumption has a dramatic impact on the life time of the sensors (if battery operated) or on the feasibility of a self-powered solution (eg, harvesting energy from heat or vibration sources in the surrounding environment). To reduce energy consumption, the node needs to be dormant as much as possible and, when active, send as few bits as possible [3].

In addition to coping with the extensive steel structures on a platform, the WSN also has to co-exist with other typical offshore systems that potentially disrupt the safe exchange of data. Among those are large power generators, UHF/VHF radios, radars, safety and automation systems, and more increasingly also WLAN[1)].

Spectral analysis on such offshore locations, however, do not indicate any significant background noise in the 2.4 GHz frequency band – the band that is targeted by many of the existing and upcoming solutions for WSN. On the other hand, future deployments of WLAN (IEEE 802.11) and WiMax (IEEE 802.16) systems may change this picture [6]. For future WSN solutions it is mandatory to be able to co-exist with WLAN, the most wide spread technology in this industry.

In search for WSN standards

One of the most significant concerns within the automation industry in general has been the lack of suitable standards to fulfill all of the demands mentioned above. This picture is gradually changing with the release of the WirelessHART™ Standard [4] in September 2007. ABB has played an active role in the definition of the WirelessHART specification[2)].

Another emerging standard that looks promising for industrial applications is ISA100 – Wireless Systems for Industrial Automation [5]. ISA100 has a much larger scope than WirelessHART and aims to address a whole family of standards:

- Process automation (ISA100.11a)
- Factory automation (discrete focus)
- Transmission and distribution (long distance focus)
- RFID (industrial tagging focus)

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Since WirelessHART already provides a good solution for process automation applications, there is an ongoing discussion about how WirelessHART could be best integrated with ISA100.11a so that co-existence and interoperability is ensured.

The advantages of *Wireless*HART

The development of *Wireless*HART was based on the same principles that governed the development of wired HART: The communication and application levels are both part of the solution and the protocol itself is kept as simple as possible.

This similarity of the standard permits an improved use of existing instrumentation in off-shore installations. In fact, many off-shore installations are already equipped with HART instruments. These cannot, however, be used to their full extent due to the fact that legacy DCS systems are blocking the HART signals and hindering any HART communication between device and operator station.

A simple *Wireless*HART adapter at the existing instrument can provide the missing additional functionality and boost the performance of the entire control system. Condition monitoring, urgently needed in tail operation is then possible via the wireless channel. 2

*Wireless*HART is based on the 802.15.4 standard which provides the lower layer levels of the communication stack. The IEEE standard focuses on low-cost, low-speed ubiquitous communication between devices with little to no underlying infrastructure. Using 802.15.4 as basis ensures a reliable radio technology and numerous suppliers of technology.

The 802.15.4 radio is specified to provide a minimum of 10-meter communications range and a transfer rate of 250 kbps. With more sensitive radios and power amplifiers, however, WirelessHART should be capable of reaching distances up to 200 meters (line-of-sight).

Wired HART already has an installed base of over 24 million devices as of 2007. To make best use of the tools and software already available it makes sense to build on that installed base.

*Wireless*HART was developed to support the following applications:

- Field device troubleshooting
- Device status and diagnostic monitoring
- Critical data monitoring with more strict performance requirements

Footnote

1) WLAN: Wireless Local Area Network

2) See also “Wirelss – the future for instrumentation,” *ABB Review* 4/2007,16–17.

- Supervisory process control
- Calibration
- Commissioning

Meshed network concept
Utmost reliability of the *Wireless*HART network is achieved through means of a meshed network where all nodes are able to route messages from a neighboring device, efficiently providing an additional data path.

The ability to avoid disturbances when these occur by shifting from one frequency to another is also adding to the overall reliability of the network. The frequency hopping is realized through a TDMA (time division multiple access) scheme, which makes sure that nodes are communicating on different frequencies at different points in time.

The system provides alternative communication paths so that communication can continue when the original path is blocked by a physical obstruction or by interference. As every device should aim to have at least two routes to the receiver, one of these can instantaneously come into use when the original one is blocked.

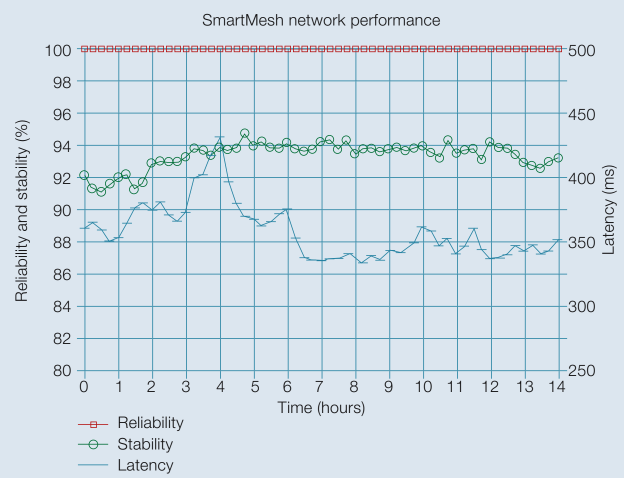
Low power consumption
TDMA guarantees a reserved time slot for each link between communicating devices. This ensures low power consumption as the nodes are synchronized and only need to be active during the appropriate time-slots and for re-synchronization.

Security
The 128 bit AES[3] encryption defined in the 802.15.4 standard is widely accepted as state of the art. Although more advanced security solutions (as elliptic curve cryptography) might be required in the future, AES fully satisfies today's requirements bearing in mind that low power is one of the fundamental goals of the communication solution, and complex security solutions add to the power requirements. Distributed keys are used to allow only authorized devices to enter the network; this in itself helps guarantee the authenticity of data.

Coexistence
Because *Wireless*HART uses the media access control protocol defined by the IEEE standard, harmonic coexistence with other networks using the same IEEE standard (eg, ZigBee) is ensured. Tests with sensor network protocols similar to *Wireless*HART show that the communication works very well also in a heavily-loaded WLAN environment [6].

3 shows the behavior of such a network during testing, reliability being almost 100 percent all the time.

3 Result of a test measurement of a *Wireless*HART system



WSN for efficient production
WSN is a significant prerequisite for the achievement of cost-effective on-line condition monitoring. The market response with industrial standards and products being launched from a large range of suppliers underlines the growing need for this communication platform. Major oil companies are planning to run pilots with the new *Wireless*HART technology in 2008.

A WSN enabled on-line condition monitoring system contributes to safe and reliable operations by providing early warnings of potentially hazardous situations while also increasing understanding of long term equipment performance and wear. Cost savings result through the reduction or elimination of down time of critical equipment, introducing more effective maintenance concepts and predictable and clear maintenance work processes.

WSN is another example for an enabling technology boosting the business performance of an entire industry that needs to use their assets "to the last drop."

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[4] HART Communication Foundation, http://www.hartcomm.org (January 2008).
[5] ISA-100, http://www.isa.org
[6] **Doyle, P., Vatland, S., Petersen, S., Aasland, C. S., Andersen, T. M., Sjong, D.** Requirements, Drivers and Analysis of Wireless Sensor Network Solutions for the Oil & Gas Industry. Proceedings of ETFA 2007.

Footnote
3) AES: Advanced Encryption Standard