Second Layer of Automation

Jonas Berge **explains how implementing a wireless instrument infrastructure allows plants to extend measurement beyond the process and solve a number of business-critical challenges.**

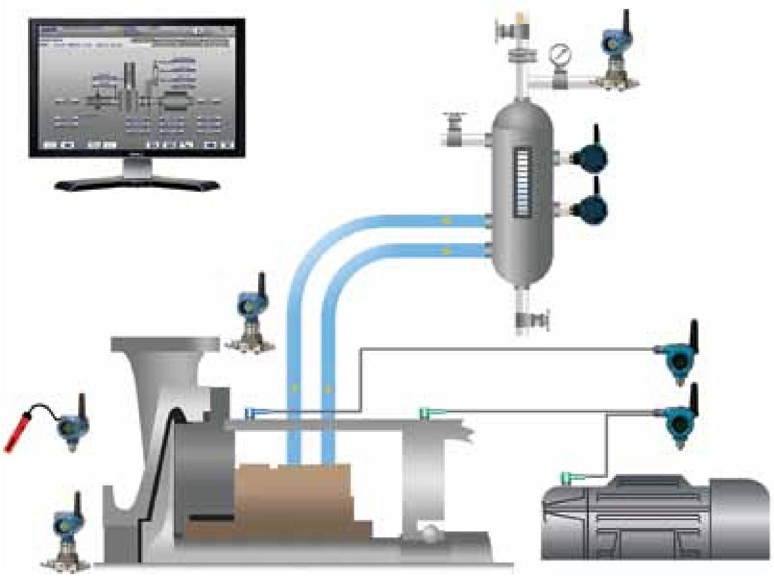
My parents' car had only three sensors providing information for the driver: the fuel gauge, temperature gauge, and oil pressure warning. Periodically they manually checked tyre pressures, the water level, and the other fluids. At the repair shop the mechanic used test equipment for troubleshooting.

Now cars have dozens of sensors onboard and multiple digital communication networks for the drivetrain and brakes, for climate control, and for information. Some of the raw sensor data is aggregated into information for the driver on the dashboard, but most of the data is used by the mechanic in the repair shop who has a different dashboard for servicing the vehicle.

These networked sensors have made modern cars more reliable, more fuel efficient, more environmentally friendly, and safer. Modern plants, which today face many business challenges, should be no different.

Instrumentation to date has delivered better and better process critical measurements. These measurements help to safely control the plant. But plants are also concerned about environmental regulations, the safety of their people, how energy costs are impacting them and how they are going to meet those challenges.

All of those things, the things that are important to run the plant but which are outside of the day-to-day process operations, are referred to as "business critical". These include: site safety, environmental, reliability, and energy.



For this reason, existing plants are now being modernised to help solve business critical problems. These measurements are partly for the operator in the control room driving the plant, but are mainly for those outside the control room. The information provided to the plant's operations and maintenance organisation helps make plants more reliable, more energy efficient, more environmentally friendly, and a safer place to work.

The missing measurements

The operators at the distributed control system (DCS) and safety instrumented system (SIS) consoles in the control room are getting just about all the real-time data they need to do their job – running the plant efficiently and safely.

This data comes from existing wired sensors, part of the "primary layer" of automation used for real-time process critical closed loop control and functional safety, which appeared on the P&ID when the plant was originally built.

However, the other important people in the plant – the maintenance, reliability, energy efficiency, and HS&E disciplines do not sit in the control room, and only get a small portion of the data they need. There is a lot of data they don't receive or have to collect manually, referred to as "missing measurements".

These measurements fit into three major categories: essential asset monitoring for reliability, energy conservation measures for energy efficiency, and HS&E monitoring for environmental and site safety to reduce risk.

Reducing downtime, cutting energy costs, minimising environmental impact, and reducing personnel risk are trends seen across all industries around the world. Getting the data needed to take action in these areas requires adding more automation to the plant.

So why haven't plants been adding more sensors to their control systems? Traditionally, adding a new sensor required cutting and welding the pipe or vessel, which could only be done during a plant shutdown. Moreover, signal and power wires had to be run for the transmitter which required junction boxes and cable trays to be opened, carrying risk of damage to existing cables. As a result, many improvement projects got no approval.

Today, plants have discovered some very innovative application solutions for "pervasive sensing", beyond the P&ID and for personnel beyond the control room (see Table 1).

Without wires

Many sensors are now non-intrusive, like temperature

Essential Asset Monitoring (EAM)	Energy Conservation Measures (ECM)	Health, Safety, and Environmental (HS&E)
• Heat exchangers	• Steam trap failure	• Safety showers and eye wash stations
• Pumps	• Heat exchanger fouling	• Manual and bypass valves
• Blowers	• Steam consumption	• Relief valves
• Air cooled heat exchangers	• Chiller water consumption	• Gauges, sight glasses, variable area flowmeters, and dip sticks
• Compressors	• Compressed air consumption	• Grab sampling
• Cooling towers	• Filter & strainer blocking	• Vibration, temperature, acoustic testers
• Pipes and vessels	• Cooling tower fans	• Instrumentation inspection
• Filters and strainers		• Control valves
		• Passing valves

Table 1: Pervasive sensing takes the measurement possibilities beyond the process.

sensors which clamp on to the outside of the pipe. Wireless pressure sensors can connect at fittings which until now were used for pressure gauges. Position sensors for bypass valves and other hand valves simply bolt on to the outside of the actuator. Acoustic sensors for monitoring for steam trap failure, relief valve release, and passing valves simply strap on to the outside of the pipe.

Vibration sensors can be screwed on to the outside of equipment or even attached by epoxy or magnet. Other types of non-intrusive sensors are also available. Pipefitters no longer need to get involved because no new process penetrations are created in the mechanical installation, saving time and reducing the cost and risk of deployment.

The applications beyond the P&ID are often not as demanding as the control loops and safety functions on the P&ID. Therefore, clamp-on temperature sensors measuring the pipe surface temperature effectively provides the data needed in these applications. Similarly, non-critical pumps and other equipment may not need extensive monitoring systems when a vibration transmitter can provides the needed data. When mechanical pressure gauges are replaced by wireless pressure transmitters, even an entry-level transmitter gives superior benefits over a gauge.

WirelessHART transmitters eliminate the need for running signal wires to each of these additional instruments, saving time and reducing the possibility of damage to the existing installation. They also eliminate the need for an electrician to get involved.

Such transmitters throughout the plant area form a mesh network where every device is capable of serving as a router, thereby also eliminating the need for backbone routers and their associated network and power cabling.

The wireless transmitters also form a web of interconnected devices, a digital architecture for the plant to gather intelligence from the field in order to improve plant performance – an industrial version of the Internet of Things (IoT).

A WirelessHART network only requires a gateway which is easy to deploy at the edge of the plant area. And the WirelessHART networks throughout the plant can be joined using a HART-IP backhaul and together they form a "second layer" of automation covering the plant.

WirelessHART transmitters are powered by long-life batteries, which eliminates the need to run power cables to each transmitter. Again, installation time is saved because electricians are not needed to install the transmitters. The transmitters can be deployed when required with little or no risk, giving the plant the agility to freely add measurements.

The WirelessHART signal is completely digital, communicated as a real number in engineering units. There is no 4-20 mA signal so there is no need to configure a measuring range in the transmitter or control system, and no need to perform a 5-point loop check. Digital transmitters use the sensor with full accuracy across its full sensor limits, which makes these sensors easy to use and less prone to commissioning errors.

Not controls centric

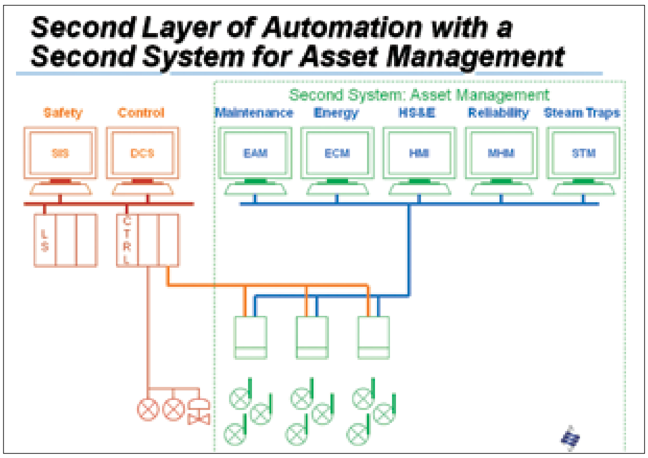
Most of the measurements collected through pervasive sensing relate to maintenance, reliability, energy efficiency, and the HS&E disciplines. This data is useful to the maintenance supervisors, reliability engineers, the HS&E officer, energy manager, and the third-party service company that looks after the steam traps, etc.

These people do not sit in the control room, so it would be inconvenient for everyone if they had to come to the control room and disturb the control system operators to get their data and reports. The control system is also not the ideal display for most of the new information.

Moreover, due to the process critical nature of the control and safety system, system engineers are cautious with changes to the system. There are policies and rigorous management of change procedures to get the control system configured to collect data from a new device and to display a new value. Many times it may be necessary to call the system vendor's service engineer to come to make the addition. Although non-intrusive sensors and WirelessHART transmitters make obtaining measurements very agile, getting them displayed on the control system is less flexible.

So since most of the additional measurements now collected are not related to the process critical side of the plant (control and safety), plants deploy a second separate system for asset management with specialised applications for asset monitoring, energy management, and HS&E that can be accessed in the offices of the people that use this data.

With this, personnel can capture events, see trends, generate



Data from WirelessHART transmitters go to the control system and the asset management system.

reports, and even get the data into Excel spreadsheets. There is no need to go to the control room to get the data or disturb the operators. This makes more effective use of the data which will become a natural part of the decision making process for the various disciplines. Most of this information is not required by operators; therefore most of it does not go to the DCS.

For example, the HS&E officer wants to see information on the activation and health of eye wash stations and safety showers as well as relief valve releases, status of bypass valves and other hand valves, etc.

Maintenance staff need to know if valves are passing, and see the data from the vibration and temperature transmitters they deployed to take the place of handheld testers. Same goes for data from pressure, temperature, level, and flow transmitters that take the place of clipboard rounds. The maintenance personnel need the raw data from multiple sensors aggregated into simple indicators of health and fouling for the process equipment around the plant for the purpose of scheduling daily maintenance and planning the next turnaround.

The energy efficiency officer wants data on energy consumption for each unit to track conservation initiatives. The energy efficiency officer would also want to know if certain process equipment is fouling, as this reduces their energy efficiency.

Using a web server and web browser interfaces, staff could be anywhere in the enterprise and access this information; for example as a shift report. Measurement agility requires freedom to quickly and easily add the reading from a new transmitter on the screen at somebody's desk.

The asset management applications for asset monitoring, energy efficiency, and situational awareness are not process critical and therefore much more flexible and open to changes than the control and safety system. It is much easier for these disciplines to make their own modifications to suit their needs on a separate second system than on the DCS.

Personnel from the many disciplines are able to freely add sensors around the plant, and are able to quickly configure the separate system for the new devices and get the data onto a screen in their office without having to disturb the system engineers to change the DCS configuration.

Getting the information

Standalone HMI software is capable of generating and logging alarms, displaying graphics and summaries arranged as required, trend logging, and reporting. Computation, totalising, and logic aggregate raw data to extract useful and actionable information.

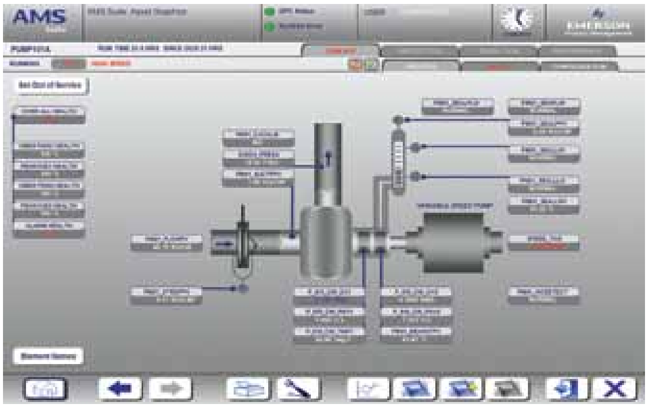
Standalone HMI software in the HS&E office is ideal for displaying plant data to reduce risk and help meet regulatory requirements. For instance it can create an alert when an eye wash station or safety shower is activated indicating somebody is in distress and in need of help, and it can also keep track of when the stations were last tested.

Software also tracks if any relief valve has made a release, and the duration of the release, enabling the amount to be estimated more accurately. Personnel can easily see if any bypass valves or dyke valves are left open, and the position of other hand valves around the plant.

Standalone HMI software in the maintenance office flags if closed valves are passing, and if vibration or temperature of equipment like pumps, fans, agitators, conveyors, and motors etc. is high. Data previously checked from gauges, sight glasses, dip sticks, and variable area flowmeters etc. in clipboard rounds are automatically collected and printed in reports.

Specialised asset monitoring software in the maintenance office displays the health and fouling of heat exchangers, air cooled heat exchangers cooling towers, blowers, and pumps, etc computed using multiparameteric algorithms from the raw data from multiple sensors on each piece of equipment.

When operators call about a problem, maintenance personnel can check the software first, to decide what needs to be done before going to the field. It is a data-driven maintenance paradigm that has to be reflected in work processes.

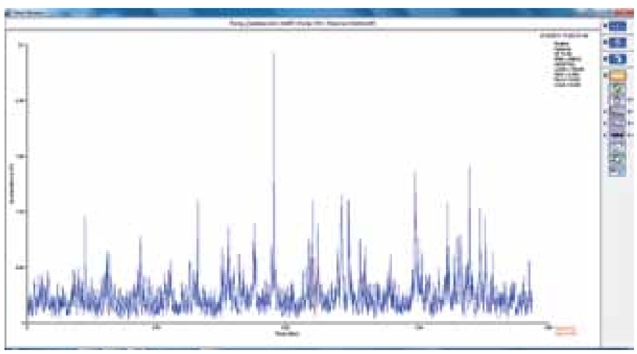


The asset management system monitors process equipment like pumps.

Standard HMI software in the energy office tracks energy conservation initiatives by reporting the consumption of steam, compressed air, and chilled water etc. for each plant unit. The energy efficiency officer uses the same equipment fouling data as the maintenance team to determine if an asset needs cleaning to improve its energy efficiency.

Specialised machinery health monitoring software in the reliability office enables analysis of vibration in motors, pumps, fans, and conveyors, etc around the plant. For example, the simple overall vibration value from a WirelessHART vibration transmitter may be monitored in the DCS to alarm operators to operational problems, while the HART-IP backhaul may be used to transfer the detailed vibration spectrum for analysis in the asset management system application by a reliability engineer. This enables reliability engineers to centrally manage not only critical turbines and compressors from their office, but also smaller essential assets like pumps.

The plant usually outsources the maintenance and replacement of steam traps to a third-party company that has staff on site in a small workshop. Specialised steam trap monitoring software provided on a computer in the steam system workshop enables



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an at-a-glance overview of the health of critical steam traps throughout the plant. The data is integrated using the HART-IP protocol, enabling the technicians to quickly tend to steam traps before equipment is damaged by trapped condensate or energy is wasted due to blowing steam.

Many plants also have a Plant Information Management System (PIMS) often known as a "historian". Many of the missing measurements collected using pervasive sensing will be collected in this plant historian. The historian collects data from the DCS as well as the WirelessHART networks and other sources, enabling the data to be analysed together for new insights.

Algorithms that aggregate raw data into actionable information can be created in the historian for asset monitoring and energy consumption tracking, etc. However, machinery health monitoring and steam trap monitoring is likely to use specialised software.

The historian has tremendous capacity for data collection, long-term data storage and analytics. This is often referred to as Big Data. Using the historian, personnel can find data fast and visualize it to make decisions.

Primary layer of Automation	Second layer of Automation
• On the P&ID	• Beyond the P&ID
• Hardwired or fieldbus	• Wireless sensor network
• Millisecond response time	• Seconds, minutes, hour update period
• Control and safety system	• Asset Management System
• Control room operators	• Beyond the control room
• Rigorous management of change	• Flexible and agile

Table 2: First to second: pervasive sensing takes the measurement possibilities beyond the process.

Simplified modernisation

Many plants are now installing WirelessHART coverage throughout their process unit areas to meet these business critical needs. Plant modernisation is not necessarily about system migration, but more about adding automation where it didn't exist before.

Indeed, it is not necessary to replace the control system to add wireless sensors. Plants deploy wireless sensors and link the new process critical data to their existing control system, while data from most of the new sensors link to a separate asset management system.

Plant modernisation using wireless sensor networks is a new business opportunity for EPC and independent consultants as there are thousands of ageing plants in need of a second layer of automation for other business critical needs, with a second system beyond the control room to assist the plant's run and maintain organization in making these plants more reliable, more energy efficient, more environmentally friendly, and a safer place to work.

When it comes to new plants, these should not be built the old fashioned way where only process critical control and safety is automated, but rather built to support business critical needs from the very beginning, including wireless sensor networks and an asset management system with its specialised applications. This way, the plant is prepared to quickly and easily add more sensors when needed in the future as industry demands inevitably change. **CEA**

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