# Wireless Device Network Planning and Design

*Best practices for including wireless instruments and infrastructure in project designs*

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Any major capital expansion project should at minimum consider the inclusion of a wireless device infrastructure such as WirelessHART for two reasons. The first is the use of wireless instead of wired devices on the current project in all process areas due to factors such as lower installation costs, quicker installation time, faster commissioning, and more efficient change order management. Even when there is a convenient junction box for connecting a wired instrument, WirelessHART devices will still be more efficient in terms of design and implementation.

The second reason is to have an infrastructure in place for the future installation of wireless devices in areas which can't be addressed now due to capital or time constraints. This infrastructure can also be used to install wireless devices in areas which may benefit after new installations, or due to changes in processes or equipment operation.

Once the need for a wireless infrastructure is accepted, the next step is to plan and design such a system.

## Defining the Automation Philosophy

In the early design phase, the project should make sure the automation philosophy includes a statement of requirements with wireless included as an acceptable technology.

Failure to do so will mean that wireless is not recognized as part of the project design philosophy, and will thus be relegated to a secondary or tertiary role, and possibly dropped from the project. This frequently occurs due to misconceptions about the technology, for example when project engineers aren't aware of the ease with which wireless infrastructure can be integrated with any existing DCS or other control system.

The project team can work with a WirelessHART supplier to help appropriately specify technology and solutions. Emerson Process Management has a simple template which can be used as an insert to the project specification. This template includes guidance on how to specify wireless devices and infrastructure for both process and diagnostic applications.

If the project team is unfamiliar with wireless, Emerson and other suppliers offer workshops and other training opportunities to inform project stakeholders as to the latest wireless technologies. This will allow informed decisions to be made early in the project planning process.

It's also helpful to describe categories of applications so the project team can visualize current and future wireless device system deployments. Table 1 lists leading wireless device application categories. One of these categories is illustrated in Figure 1, which shows a wireless guided wave radar device used to measure tank level, with the device mounted in a location where it would be difficult to connect a wired device.

*Figure 1. This wireless guided wave radar device is being used to measure tank level, an application particularly well suited for wireless as connecting a wired device would be difficult due to the hard to access location. (Courtesy of Emerson Process Management)*

**Table 1: Leading Wireless Device Application Categories**

| | |
|---|---|
| Process Monitoring & Control | • Hard to reach locations<br>• Process efficiency calculations<br>• Better insight into process<br>• Ad-hoc measurements<br>• Additional measurements from multivariable devices<br>• Calculated variables in devices |
| Equipment measurement | • Vibration<br>• Corrosion<br>• Oil pressure<br>• Air flow |
| Health and Safety Systems | • Gas Detectors<br>• Analyzers |
| Environmental | • Steam traps (energy usage)<br>• Water / Discharge Treatment<br>• Flow<br>• pH<br>• Stack emissions<br>• Relief valves |

If required, modify the project automation philosophy to define WirelessHART as an acceptable device protocol, and to include the following:

- Integration plan to connect the wireless system to the basic process control system (BPCS).
- Integration plan for data to be routed outside the BPCS, for example to external systems such as data historians or business applications.
- Network architecture and data flow showing connectivity of the WirelessHART infrastructure with the wired BPCS and business systems networks.

Once this initial phase is completed, the next step is design.

## Design Overview

There are three key steps when designing a wireless device network:

1. **Scope** – Determine the method to distribute WirelessHART gateways across the site. This can either be on a geographic and spatial basis, or more commonly driven by the logical arrangement of the plant; i.e. by process area or unit.

2. **Design** – Apply simple design rules to ensure optimum connectivity of field device back to the WirelessHART Gateway.

3. **Fortify** – Identify and correct any potential weaknesses in the network design by using applications which can help in the design process.

## Scope

***Gateways***

Wireless gateways are used to connect wireless devices to the BPCS. Gateways should be logically distributed throughout the process unit like junction boxes. A gateway is usually localized to a process unit or area, and wireless devices are then assigned to the gateway based upon this logical assignment.

***Devices***

A mesh network gets its reliability from multiple communication pathways, so ensuring each device has multiple neighbors within range will result in the most reliable network. To achieve this, it is recommended that a minimum of five wireless devices are within effective range of each gateway. Each wireless device in the network should have a minimum of three other devices with potential communication paths.

## Design

***Device Rules***

The following design rules are conservative and are based on real-world deployments of WirelessHART field networks. These rules of thumb are used to simplify the design process. There are options and techniques for obtaining even farther distances of up to 1km between devices and gateways.

The effective range of a device is the calculated linear distance between WirelessHART field devices in the presence of process infrastructure. Typically, if WirelessHART devices have no obstructions between them, have clear line-of-sight, and are mounted at least 6 feet above the ground—then the effective range with 10 mW/10 dBi of power will be approximately 750 feet.

Below are three basic classifications for calculating effective range in process environments:

- Heavy Obstruction – Range of 100 feet. This is the typical heavy density plant environment.

- Medium Obstruction – Range of 250 feet. This is a process area with less density, with lots of space between equipment and infrastructure.

- Light Obstruction – Range of 500 feet. Typical of tank farms. Despite tanks being large obstructions, there is typically lots of space between, which makes for good RF propagation.

These values are practical guidelines and are subject to change in different types of process environments. Conditions that significantly reduce effective range are:

- Mounting field devices close to the ground, below ground or under water. The RF signal is absorbed and does not propagate.

- Mounting field devices inside or outside a building relative to the main network and gateway. RF signals can be attenuated by the materials of construction.

Small fiberglass instrument and device enclosures are often deployed to house wireless instruments and gateways in very dirty or harsh environments, and show minimal to no impact on propagation of the RF signal. Large metal enclosures or foil lined enclosures will prevent RF signals and are not recommended without additional engineering considerations

***Project Documentation***

Electrical loop drawings are completely eliminated for wireless field devices. Instead, a simple chart or plot plan mark up showing the physical location of each device and gateway is sufficient to describe the field installation.

Standard Instrumentation specification sheets can be supplemented with the following data fields:

- Scan Rates
- Antenna Type
- Power for each device: battery module, battery with energy harvesting or wired power
- Communications protocol; e.g. WirelessHART

Wireless device selection is based on the desired process measurements.

Table 2 shows what types of variables are commonly monitored with wireless devices, and Figure 2 depicts wireless devices being used to monitor equipment variables.

**Table 2: Wireless Devices Monitor Variables & Equipment such as:**

- Spray Water Systems
- Pumps
- Heat Exchangers
- Rotating Machinery
- Air Compressors
- Temperature Profiling/Tank Level
- Boiler and Furnace Temperatures
- Steam Trap
- Storage Tanks and Vessels
- Plugged Filter Detection
- Roller Bearings
- Calcining Units
- Steam Cracker
- Pipeline System
- Boiler and heater gas flow
- Steam Distribution Lines
- NOx and other Emissions
- Fuel Supply Systems
- Gas Storage
- Pressure Relief Valves

*Figure 2. Wireless instruments can be used to monitor variables on equipment such as heat exchangers, pumps and piping systems. (Courtesy of Emerson Process Management)*

Wireless devices are often used in locations that are hard to reach with wired devices and their accompanying wired infrastructure. Wireless devices can be used for all core measurement and diagnostic functions in a process plant, and for some real-time control applications.

Planning tools are available to assist with these design steps, such as Emerson's AMS Wireless SNAP-ON software (Figure 3). This software allows users to upload a plot plan of the plant, and then design the wireless network for the designated area. The software can then check proposed designs against industry best practices.

Once the wireless network is designed, this software can be used as an automated tool for designing and testing network designs. The software can also monitor networks after installation to ensure correct ongoing operation. This monitoring includes troubleshooting tools driven by graphical displays and predictive network diagnostics, and reports of key network operating parameters. Using the software, network performance can be monitored and maintained by balancing wireless network usage and gateway capacity.

Online calculators are available to estimate the life of each device's battery power module (see Reference 1). If the device application is such that an enhancement is required, energy harvesting technologies can be used to provide longer device life.

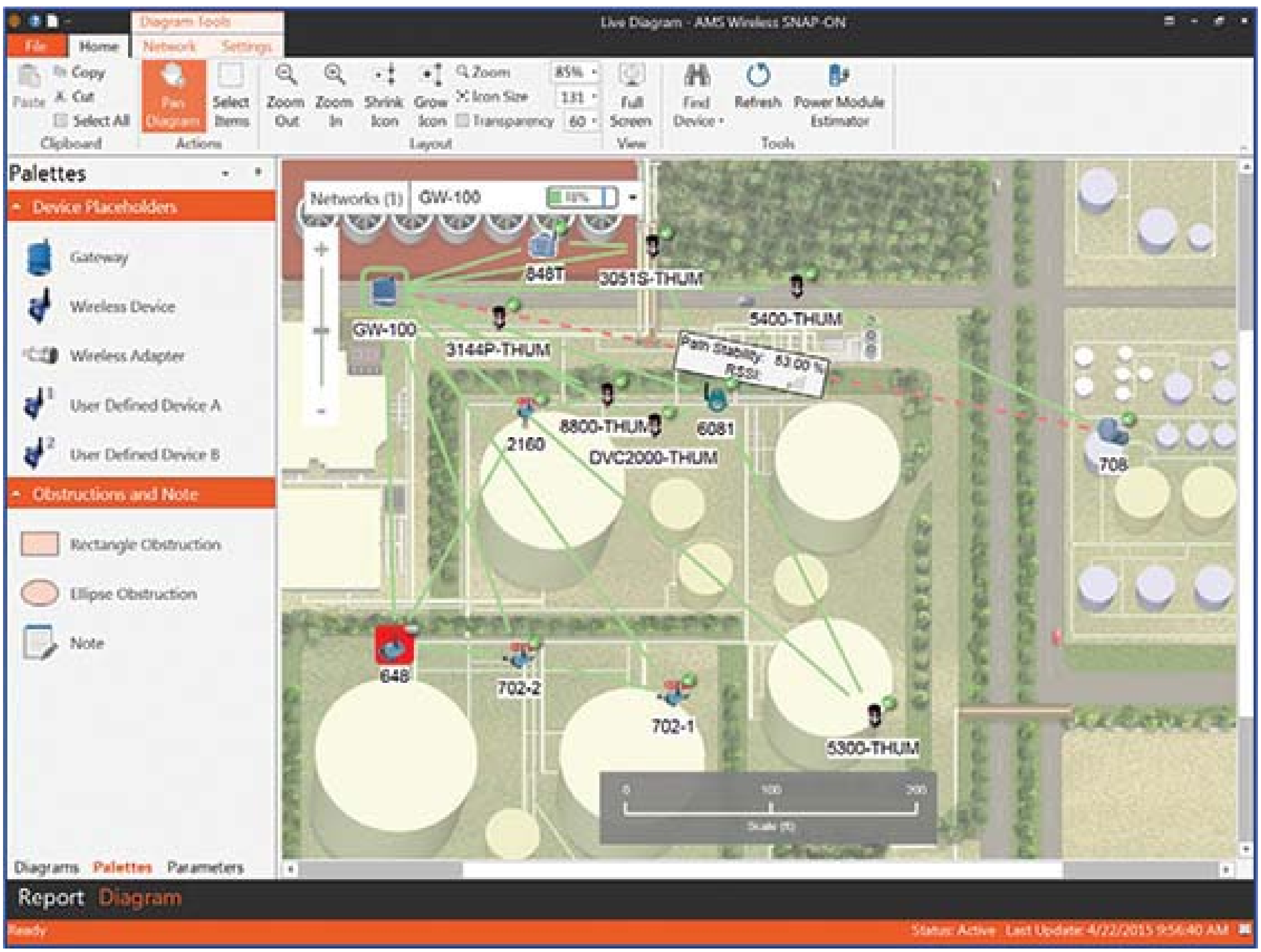


*Figure 3. Process plant plot plans can be uploaded to Emerson's AMS Wireless SNAP-ON software, and the wireless network can then be overlaid on these plans. The software can be used to check design validity, and to monitor networks after installation. (Courtesy of Emerson Process Management)*

***Factory Acceptance Test (FAT)***

The key deliverable of a wireless system FAT is verification of the integration of data from WirelessHART instruments into the host system via the gateway. Field device are not required for the FAT. The wireless network design does not need to be tested at the factory if network design recommendations are implemented. The conservative nature and ability to fortify the network upon installation with repeaters ensures high confidence of reliable operation.

The basic requirements for a FAT are:

- an integration specification with the BPCS, the historian and business systems
- an approved test plan, test procedure and acceptance criteria in a similar format to the testing of any packaged interface

If desired, a proof of concept test to demonstrate system functionality can be performed, but this should be part of an acceptance test but performed early in the design process.

## Fortify

Emerson's wireless planning tool, or a similar tool from another supplier, can be used to verify the wireless network complies with basic design and range rules. If any issues are detected, solutions to strengthen designs include:

- Adding repeaters, which are simply wireless devices used as reinforcing radios in the network.
- Placing gateways in locations that maximize connections within the network. Working with the application administrator to identify all potential gateway integration points is a useful process to determine optimal gateway locations.

Planning tools can also be used to stress test the network and identify weak spots. This can be done by reducing the effective range against which all the design recommendations are tested. This process builds confidence in the design.

For example, a medium density process unit has an effective range of 250 feet. Reducing the effective range by 10% to 225 feet might reveal no violated design recommendations, and a 10% increase in the confidence of the design is achieved.

Suppose the effective range is then reduced by 200 feet, and a design recommendation is found to be out of compliance. We can then manage design risk by being satisfied with the 10% additional confidence from the second step, or choose to further fortify the network.

For most process units, designing a network with 30 wireless instruments or more creates a highly resilient network, and the design recommendations can only be violated if the effective ranges for stress testing are reduced well below 50 feet. This distance is far below typical required performance in even the most dense process units.

## Conclusion

This is the second of a five-article series on wireless instrumentation and infrastructure. This article covered wireless device system planning, design, test and commissioning. For more detail on these subjects, please see Reference 2.

The first article showed how wireless can be used to cut operating expenses in capital-constrained environments. It ran in Automation.com's Wireless quarterly e-newsletter on 7-28-15 as the lead item: http://www.automation.com/enews/wireless_connectivity/Wireless2015-July.htm

The next three articles in this series will be published in the upcoming issues of automation.com's Wireless Quarterly as follows:

Article 3, Jan 2016, Wireless Configuration. Describes alarm configuration practices and integration options for gateways. Discusses host integration, redundant and secondary measurements, and wireless PID Control.

Article 4, Apr 2016, Reliability and Maintenance of Wired versus Wireless Networks. Discusses reliability and maintenance issues.

Article 5, Jul 2016, Adding to Existing Wireless Networks. A detailed discussion of how to add instruments to existing wireless networks.

Upon conclusion of this five-article series, the reader will be prepared to justify, design, install and maintain wireless instrumentation and wireless networks.

References:


1. Power Module Life Estimator: http://www3.emersonprocess.com/rosemount/PowerModuleLifeCalculator/Default.aspx

2. System Engineering Guidelines, IEC 62591 WirelessHART, May 2014 Revision 04: http://www2.emersonprocess.com/siteadmincenter/PM%20Central%20Web%20Documents/EMR_WirelessHART_SysEngGuide.pdf


## About the Author


Mr. Shamsi has been an automation professional for 25 years and his career spans a broad range of industries, in roles from technical leader to project management. He presently works for Emerson Process Management where he directs Emerson's global wireless consulting and execution solutions on large capital projects. He specializes in working with clients and contractors to implement technology solutions to improve operational efficiency.



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