Adoption of Wireless for Safety

Jay Werb  
Technical Director  
ISA100 Wireless Compliance Institute

Questions and comments to: jayw@isa100wci.org

2015 Process Control and Safety Symposium  
Houston TX  
Communication Session  
11 November 2015 09:00 – 10:30
Adoption of Wireless for Safety
Session Overview

• Adoption of Industrial Wireless in General Usage Classes

• Design Principles for Wireless Safety Loosely Derived from ISA84 WG8 Draft

• Four Case Studies
  • Tank Farm Gas Monitoring
  • Gas Detection, Safety System Integration (SIL-2)
  • Time Critical Perimeter Monitoring
  • Tank Farm Safety Compliance

• Q&A, Discussion
Co-Presenters

Carsten Buschmann
Dräger Safety AG
Software Engineer
Research & Development
Gas Detection Instruments

Tim LeFevre
Honeywell Process Solutions
Global Marketing Manager
Safety Systems
Adoption of Industrial Wireless Classic Model

Christensen innovation model adapted for industrial wireless

Courtesy AIW LLC
### Commonly Cited Benefits of Wireless Instrumentation

| Cost Savings                                                                 | • Up to 90% of installed cost of conventional measurement technology can be for cable conduit and related construction.  
|                                                                             | • Typically: 1/5 the time, 1/2 the cost.  
|                                                                             | • New and scaled applications are now economically feasible. |
| Improved Reliability                                                       | • Wired sensors may be prone to failure in difficult environments.  
|                                                                             | • Wireless can add redundancy to a wired solution. |
| Improved Visibility                                                        | • Condition monitoring (equipment)  
|                                                                             | • Process monitoring |
| Improved Control                                                           | • Add wireless to existing processes for more optimal control. |
| Improved Safety                                                            | • Safety related alarms |
# Legacy ISA100 Usage Class Examples

## Safety

<table>
<thead>
<tr>
<th>Class</th>
<th>Usage</th>
<th>Criticality</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Emergency action</td>
<td>Always critical</td>
<td>Safety interlock, Emergency shutdown, Automatic fire control</td>
</tr>
</tbody>
</table>

## Control

<table>
<thead>
<tr>
<th>Class</th>
<th>Usage</th>
<th>Criticality</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Closed loop Regulatory control</td>
<td>Often critical</td>
<td>Direct control of primary actuators, High frequency cascades</td>
</tr>
<tr>
<td>2</td>
<td>Closed loop Supervisory control</td>
<td>Usually non-critical</td>
<td>Low frequency cascade loops, Multivariable controls, Optimizers</td>
</tr>
<tr>
<td>3</td>
<td>Open loop control</td>
<td>Human in the loop</td>
<td>Manual flare, Remote opening of security gate, Manual pump/valve adjustment</td>
</tr>
</tbody>
</table>

## Monitoring

<table>
<thead>
<tr>
<th>Class</th>
<th>Usage</th>
<th>Consequences</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Alerting</td>
<td>Short-term consequences</td>
<td>Event-based maintenance, Battery low indicator, Asset tracking</td>
</tr>
<tr>
<td>5</td>
<td>Logging Downloading/uploading</td>
<td>No immediate consequences</td>
<td>History collection, Preventative maintenance rounds, Sequence of events (SOE) reporting</td>
</tr>
</tbody>
</table>

“Classes 1 through 5 and optionally class 0.”
Top Usage Classes for Wireless Instrumentation

- Automated Safety Instrumented Functions
- Control
  - Open Loop
  - Closed Loop
- Alerts & Alarms
  - Process
  - Safety
- Monitoring & Compliance
  - Condition
  - Process

Timeliness:
- Hours
- Minutes
- Seconds

Courtesy AIW LLC
Industrial Wireless in 2015
Major Applications

• Process Monitoring & Control
• Asset Health Monitoring & Analytics
• Safety Related Alarms
Applications
• Temperature
• Pressure
• Flow
• pH
• Dissolved O₂
• Valve Position
• Etc…

Wireless Requirements
• Highly Scalable Network
• Low and Deterministic Latency
• Flexible Configuration
• Predictable Battery Life
• Multi-Vendor Interoperability
Asset Health Monitoring & Analytics

Applications
- Vibration
- Corrosion
- Steam Trap
- Etc…

Wireless Requirements
- Scalability with wide range of data rates
- Prioritize data flows
- Support for large waveforms
- Flexible network configuration
Safety Related Alarms

**Applications**
- Gas Detection
- Fire Prevention
- Level Detection
- Safety Showers
- Etc…

**Wireless Requirements**
- Controlled Quality of Service
  - Diagnostics!
- Low and Deterministic Latency
- Layered Open Architecture
  - e.g. ProfiSAFE
Adoption of Wireless for Safety
Design Principles
Adoption of Wireless for Safety Design Principles

- ISA84 WG8 (Draft)
  Purpose and Focus of the Technical Report
- Latency and Availability
- Network Design Common Best Practices
- Security Matrix
- Denial of Service
- Some Other Considerations

The following slides are derived from recent ISA84 WG8 drafts, and other materials. This is not intended as a summary of ISA84 WG8. Emphasis and summaries might not match WG intent. Author’s involvement in ISA84 WG8 has been minimal.
Title
Guidance for Application of Wireless Sensor Technology
To Non-SIS Independent Protection Layers

Purpose

• “This Technical Report was developed to document guidance and considerations to users for application and implementation of wireless sensor technologies for fully non-SIS process Independent Protection Layers. The guidance provided is not intended for the use of wireless as a SIF.”

• “This TR provides guidance to demonstrate the wireless system is sufficiently robust to support meeting the requirements of a Non-SIS IPL.”
Scope of ISA84 WG8

- Automated Safety Instrumented Functions
- Control
- Alerts & Alarms
- Monitoring & Compliance

Timeliness:
- Hours
- Minutes
- Seconds

- Open Loop
- Closed Loop
- Process
- Safety

Courtesy AIW LLC
ISA84 WG8
Focus

• “For the purposes of this Technical Report it is assumed that the risk analysis team has already determined that the protection layer comprised of an alarm with operator action generated from a wireless transmitter meets the specificity and independence criteria. Instead the Technical Report will focus on providing information on how to establish a design that satisfies the dependability and auditability criteria for an alarm with operator action that is generated from a wireless transmitter.”

• “...Risk reduction claimed is less than 10.”
Latency, Availability

Latency
• “Wireless sensor network data latency is the time between the acquisition of a measurement value and the delivery of that data via the wireless network to a gateway.”

Availability
• Percentage of values received within the required response time. Can be measured per device or for an overall system.

Sidebar
• An exception may be a late-arriving alarm, or a stale state.
• Be alert for freshness requirements at times when there is no alarm.

Figure 3 SRA

Figure 4 Unavailable SRA
Mesh Networks
Latency Considerations

- Neighborhood: ±1 second
- City Streets: ±10 seconds
- On Ramp: ±1 second
- Highway: ±0.1 second
Wireless publications are commonly acknowledged hop-to-hop, but not end-to-end.

Rely on field device’s clock for timestamp, freshness, etc.
Request-Response

Field Device

Wireless Network

Gateway

- OK
- OK
- OK

Wireless may be considered a black channel.

Timestamp, freshness, etc are based on interrogation clock in this diagram.

Another example of request-response will be shown in a case study later in this presentation.
Hybrid (Example)

Field Device

Wireless Network

Gateway

Publish heartbeat periodically.

Alarms are transmitted immediately. Acknowledged by gateway to squelch re-transmission.
Network Design
Common Best Practices

“... it is critical to closely adhere to manufacturer’s best practices when designing and laying out a wireless sensor network.”

- Conservative communication range
- Reporting Rates
  - Device and router battery capacity
  - Wireless channel capacity
  - Infrastructure capacity
- Centrally located infrastructure
- Control hop depth
- Path redundancy (Infrastructure and/or mesh)
- Avoid bottlenecks
- Use network layout and simulation tools
- Documentation!!!

Design network with plenty of margin, and monitor that margin carefully.

Derived from ISA84 WG8 draft.
## Security Matrix

<table>
<thead>
<tr>
<th></th>
<th>Authentication</th>
<th>Verification</th>
<th>Encryption</th>
<th>Access Control</th>
<th>Key Management</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Integrity Check</td>
<td>Time</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Sniffing</strong></td>
<td></td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td><strong>Tampering</strong></td>
<td></td>
<td>✔️</td>
<td>✔️</td>
<td></td>
<td>✔️</td>
</tr>
<tr>
<td><strong>Spoofing</strong></td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td><strong>Replay Attack</strong></td>
<td>✔️</td>
<td>✔️</td>
<td></td>
<td></td>
<td>✔️</td>
</tr>
<tr>
<td><strong>Routing Attack</strong></td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td><strong>DoS Attack</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✔️</td>
</tr>
<tr>
<td><em>See Next Slide</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Authentication, Integrity Check, TAI, and Encryption are generally features of an interoperable communication standard such as ISA100 Wireless. User should not be able to disable or mis-apply these features.

Access Control and Key Management generally involve adherence to manufacturer’s best practices.

*Similar table is in ISA84 WG8 draft.*
Denial of Service

Radio standards and implementations should apply a variety of techniques to operate reliably in the presence of interference.

- Unintentional interference ≈ coexistence
- Intentional interference ≈ denial of service attack

Common strategies

- Spread spectrum modulation
- Multipath routing
- Channel blacklisting
- LBT Disable (Listen Before Talk)
  - LBT may be required due to regulations, policies, or coexistence with other systems
  - LBT is configurable in ISA100 Wireless
  - Regulations and/or policies may allow LBT to be disabled only at reduced power
- Diagnostics!!!
  - For example, LBT backoff counts
- Proven in Use
Some Other Considerations

Gateway-Host Communications
- Use well-known standards for Gateway-Host communications
- Security considerations for Gateway (ISA99)

Human Interface
- General ISA84 considerations, e.g. alarm management
- Large numbers of wireless devices may raise concerns about alarm floods

Battery Management
- Battery life should exceed instrument’s natural service interval
- Avoid network configurations and processes that randomize battery life

Data Quality Diagnostics
- Early detection and prevention of stale data conditions
- Include information about health & timeliness of wireless sensor data
- General device diagnostics (e.g. NAMUR 107)

Network Diagnostics
- Include ample margin in the wireless design.
- Real-time recovery from reduced margin, while meeting availability targets.
- Diagnostics, HMI, processes for systematic loss of margin.
Four Case Studies

**GasSecure**
- Tank Farm Gas Monitoring
- Gas Detection, Safety System Integration (SIL-2 example)

**Honeywell**
- Time Critical Perimeter Monitoring
- Tank Farm Safety Compliance

Carsten Buschmann
Dräger Safety AG
Software Engineer
Research & Development
Gas Detection Instruments

Tim LeFevre
Honeywell Process Solutions
Global Marketing Manager
Safety Systems
Wireless Gas Detection Systems in the Context of Safety Critical Applications

SIL2 and Non-SIL Application Case Studies

Process Safety and Control Symposium, Houston, Nov 11th 2015, Dr. Carsten Buschmann
SIL2 Compliant Systems on Top of Standard Wireless Protocols

Non-SIL

Regular ISA100.11a

Modbus

Any ISA100 compliant gateway

GW

SIL2

SIL2 controller with PPROFINET

Wired PPROFINET

Any ISA100 compliant gateway with PPROFINET

PROFIsafe over ISA100.11a

GW

Ethernet/Modbus
Bandwidth Reserved for Fast Response

- Request
- Fast response in case of gas
- Delayed response normally
Wireless System Options

Duocast
Remote Tank Farm
Gas Monitoring System

- Installed: March 2013
  - 7 Detectors
  - 1 Gateway

- Highlights:
  - Remote area
  - Very easy installation (half day)
  - Integration to Honeywell TDC 3000
Upgrade Project

- Replace wired combustible detectors
- 73 units GasSecure GS01
- Integrated into Siemens S7 control system
- Sixteen fire zones
- 90-95% reduction in installation time
- 80% cost saving compared to wired
Typical GS01 Detector Placement
Enclosed Fire Zones with one Gateway per Zone

Layout – Cellar Deck (Fire Zones)

CD1B = 3 GS01
CD2 = 2 GS01
CD3B = 7 GS01
CD4/M8 = 8 GS01
CD6/M6 = 5 GS01
CD9 = 9 GS01
CD12 = 10 GS01
Study by EPC Showed Significant Savings with Wireless

<table>
<thead>
<tr>
<th>Description</th>
<th>Conventional Solution</th>
<th>Wireless Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wired Detector, IR Line</td>
<td>23</td>
<td>9</td>
</tr>
<tr>
<td>Wired Detector, IR Point</td>
<td>45</td>
<td>8</td>
</tr>
<tr>
<td>Wireless Detector, IR Point</td>
<td>0</td>
<td>67</td>
</tr>
<tr>
<td>Wireless Router</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Removal Catalytic</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>New Multicore Cable</td>
<td>1720 m</td>
<td>0 m</td>
</tr>
<tr>
<td>New Field Cable</td>
<td>3545 m</td>
<td>1370 m</td>
</tr>
<tr>
<td>Field Cable Removal</td>
<td>0 m</td>
<td>60 m</td>
</tr>
<tr>
<td>Junction Boxes</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Cable Tray</td>
<td>641 m</td>
<td>164 m</td>
</tr>
<tr>
<td>Cables through MCT</td>
<td>31</td>
<td>2</td>
</tr>
</tbody>
</table>
Wireless Detectors Increase Safety with Higher Coverage and Reduce System Costs by 60-80%

Easy installation, increased flexibility…

…and reduced system costs

- Installation & engineering
- Other HW (cables)
- Detectors

Wireless

Wireless Gas Detection Systems | Dr. Carsten Buschmann | 11.11.2015
Thank you for your attention.

Dr. Carsten Buschmann
Software Engineer
Research & Development
Gas Detection Instruments

Dräger Safety AG & Co. KGaA
Revalstraße 1
23560 Lübeck, Germany
Tel +49 451 882-6914
Fax +49 451 882-76914
carsten.buschmann@draeger.com
www.draeger.com
Adoption of Wireless for Safety Case Studies

ISA100 Wireless
Honeywell OneWireless™
Tim LeFevre - Honeywell

• 25+ year career working for major suppliers of process control (DCS/PLC), safety, and instrumentation.

• Consulted with clients around the world on the best practices of implementing systems designs that meet ISA, IEC, and NFPA standards.

• As Global Customer Marketing Manager for Honeywell based in Houston, TX, Mr. LeFevre strives to make customers aware of innovative solutions that have been implemented around the world.
## Case Study 1
### Perimeter Monitoring – Time Critical

#### LNG Facility in Middle East - Brownfield

<table>
<thead>
<tr>
<th>Challenges</th>
<th>Solution</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Alarming system</td>
<td>• FDAP based ISA100 Wireless network with XYR6000 Universal Transmitters and solar power panels.</td>
<td>• Improved site safety system within budget.</td>
</tr>
<tr>
<td>for detection of</td>
<td></td>
<td>• 3 seconds alarming requirement met.</td>
</tr>
<tr>
<td>gas leaks without</td>
<td></td>
<td>• Compliance to government regulations for HSE.</td>
</tr>
<tr>
<td>extensive cabling.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Meet 3 seconds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>alarm requirement.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Project FAT Results

- FAT successfully completed March 2014.

- The wireless solution consistently delivered an activation time of 2.9 seconds with the horns and beacons activating simultaneously.

- The system met and exceeded the stringent customer requirement of 3 seconds.

- The customer put the system through rigorous tests that were beyond the scope of the FAT, to display redundancy, fail-over and network stability.

- The wireless system withstood all their tests and attempts to show flaws and displayed its resilience and ruggedness.

- The system has been installed and commissioned at the customer site in June 2014
Network Topology Screenshot
## Case Study 2
### Meeting Safety Compliance

#### Tank Farms across India - Brownfield

| **Challenges** |  
|----------------|---
| • Secondary level tank gauging to meet safety compliance - M B Lal recommendations |  
| • 49 locations spread out around the country |  
| • Require end to end solution within budget |  

| **Solution** |  
|--------------|---
| • Honeywell Enraf Flexline ISA100 with OneWireless Network using FDAPs |  
| • Total 90 FDAPs, 98 WDMs and over 550 Enraf FlexLine ISA100 Wireless radar gauges being deployed across the 49 locations |  

| **Results** |  
|-------------|---
| • Compliance within budget and project schedule |  
| • Consistent deployment across all sites |  
| • Comprehensive solution to meet requirement |
Wireless for Tank Gauging

SmartRadar FlexLine
- Meshing capability
- Seamless integration with Entis Pro / Engauge / CIU
- Suitable for custody transfer (W&M approved)
- Highest accuracy over 75m (250 feet)
- Also transmits other local tank measurements over ISA100 Wireless
- Software upgrade over the air
- Provisioning over the air
- Safety Integrity Level: SIL2 certified

Wireless Field Interface
- Able to connect existing gauging equipment to ISA100 Wireless network
- Zone1 capable hub
- Support for 854, 97x, 873, 811 GPU, 877 indicator
- Seamless integration with Entis Pro / Engauge / CIU
- Freedom of selecting appropriate gauge (Radar or Servo)
OneWireless Terminal Solution

Wireless applications beyond tank gauging

- Gas Leak Monitoring
- Safety Shower Monitoring
- Vibration Monitoring
- Valve Position Monitoring
- Personnel Safety Monitoring
- Mobile Applications
- Remote Area & Perimeter Video Monitoring

Tank gauging
Overfill alarming
Process monitoring
Floating roof monitoring
Architecture
Wireless Devices Used

- Enraf SmartRadar FlexLine
- Enraf AlarmScout
- OneWireless Network
- ISA100 Field Instruments
Wireless Devices Used

• OneWireless Adaptor
• Field Advisor
• GasSecure GS01
• Honeywell Analytics XNX
Summary

- **Case Study 1**: Solar powered gas leak detection. With ISA100 Wireless, Honeywell was able to meet the “near real-time” alarm requirement of 3 sec to comply with government regulations.

- **Case Study 2**: Improve safety with secondary tank gauging. Multiple brownfield locations, difficult to wire. ISA100 enables Honeywell Enraf to communicate wirelessly.

- With ISA100 Wireless Standard, Honeywell is able to design and integrate a wide range of devices including other wireless manufacturers devices.
Observations

- International customers implementing wireless as part of their safety solutions. Using wireless for alarming to an operator.
- Interest in SIL 2 rated devices, but not required yet for wireless applications. Seeing manufacturers move towards SIL2 certification of wireless devices.
- In some cases customers are taking on some of the implementation of wireless installations. Requires good project management and flexibility by supplier.
- Supplier must be able to demonstrate reliability, robustness and performance of system during FAT.
- Once installed, many customers are expanding their systems to add additional devices.
- Software tools help to monitor the system and devices.
THANK YOU

For Your Attention!