Strategy for Implementation of Fixed and Mobile Wireless Technologies in Crowded and Confined EMI Environments of Nuclear Power Plants

Presented by:

Ryan O'Hagan

Sr. Project Manager, AMS Corporation

Chad Kiger

EMC Engineering Manager, AMS Corporation

October 13, 2016

We test the I&C Systems of Nuclear Power Plants

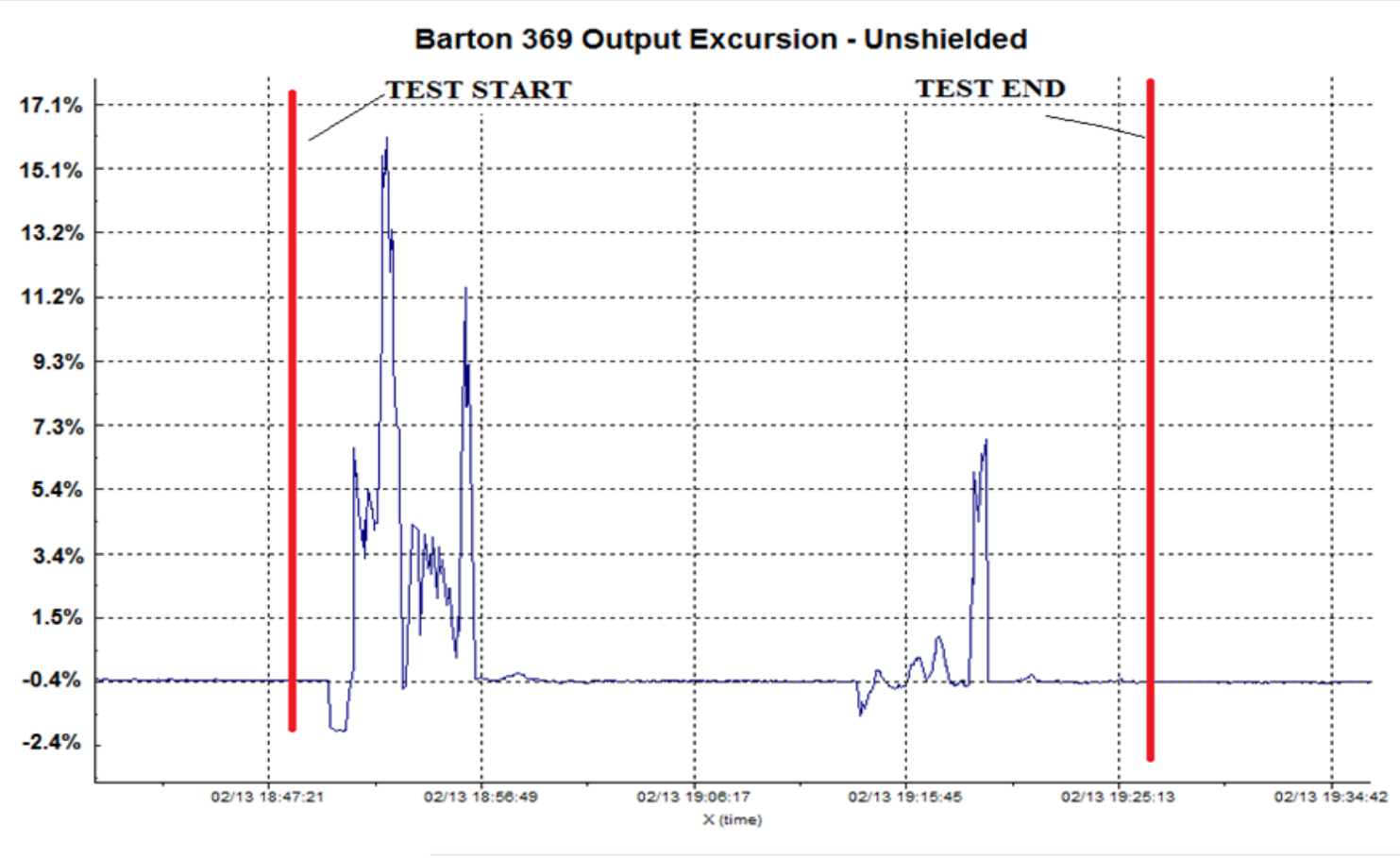
Background: The Usage of Wireless Devices in Nuclear Power Plants

- **Two Way Radios**
  - Used near sensitive plant equipment caused plant excursions
- **Prevention Techniques**
  - Exclusion Zone distance around plant equipment
  - Forbid wireless devices in certain areas from plant

Allowing the Usage of Wireless Devices and Cell Phones at Diablo Canyon

- **Project Motivation**
  - On-site Fire
  - Emergency Personnel could not use wireless
  - Estimated efficiency gains of $6M/yr in maintenance department
- **AMS Work Scope**
  - Walkdown
  - Characterization
  - Immunity Testing

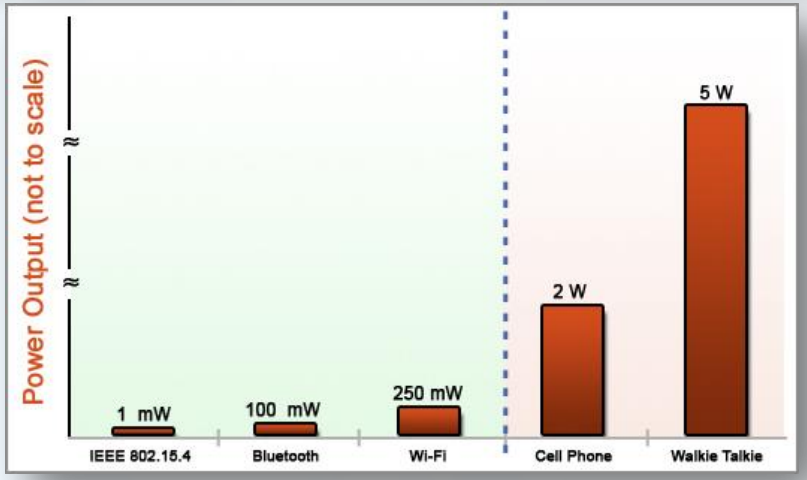
Pressure Transmitter EMI Vulnerability



Exclusion zones have historically been used when implementing wireless technologies

- **Exclusion Zone Distance**
  - Based on power output of device
  - Does not account for frequency
  - Can be reduced significantly through testing
- **Wireless Testing**
  - Different modulation schemes
  - Vary power output for comparison to wireless devices

Wireless Device	Distance (Feet)
iPad 4	8
iPad Mini	6
Cell Phone	9
Laptop Computer	3
Dosimeter	1
Wireless Vibration Sensor	2
Walkie Talkie	13



Background: Current Industry Stand and Approach

- **NEI's "The Nuclear Promise"**
  - Redesign Nuclear Power Plant Process to Improve Efficiency
  - Reduction of cost by 30 percent in two years
  - Equipment condition monitoring a priority

- **EMC** is one of the main barriers to wireless implementation in nuclear power plants. EMC site surveys **are often used** to address this concern

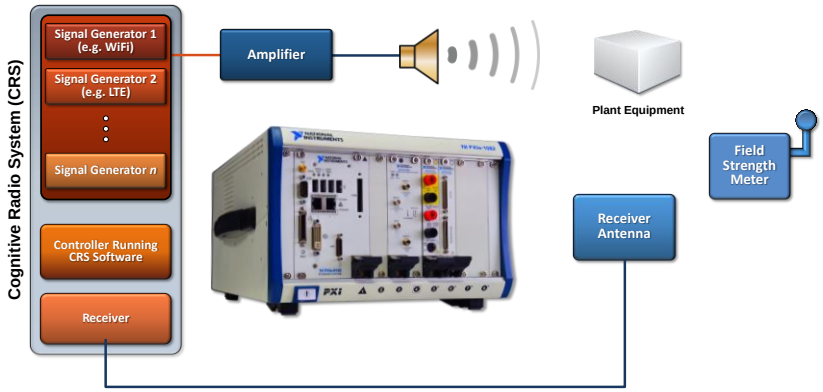
U.S. DEPARTMENT OF ENERGY
Nuclear Energy

Strategy for Implementation of Fixed and Mobile Wireless Technologies in Crowded and Confined EMI Environments of Nuclear Power Plants

Chad Kiger/ Analysis and Measurement Services Corporation

Technology Summary

The goal of the Phase II project is to develop a system that establishes objective exclusion distances for safe and widespread use of wireless devices in nuclear power plants. Referred to as a Cognitive Radio System (CRS), the product of this project will be a light-weight portable unit that can be carried around a plant to test for radiated immunity and wireless co-existence. It will transmit and receive electromagnetic waves to establish distances at which existing plant equipment will not be affected by wireless signals and that multiple wireless devices in the same area will not interfere with each other.



Key Personnel

Chad Kiger, Chris Lowe, Zack Crane, Brad Headrick, Keith Ryan, Josh Cole, Jonathan Caughron, Mehrad Hashemian, Ryan O'Hagan

Program Summary

Period of Performance:

Start Date: 6/9/2014 End Date: 7/27/2017

Key Milestones & Deliverables	
Year 1 Phase I	• Evaluate equipment to wireless vulnerabilities • Develop test method to assess immunity of equipment
Year 2 Phase II	• Define the requirements of CRS • Design and build CRS
Year 3 Phase II	• Test CRS • Implement CRS in a nuclear power plant

Technology Impact

This technology offers to make the usage of wireless devices a possibility in that exclusion distances in almost all nuclear power plants are still overly conservative and thereby severely limit the use of wireless devices in most areas of the plant. Studies have shown that the usage of wireless devices in an nuclear power plant increases efficiency gains which leads to cost savings.

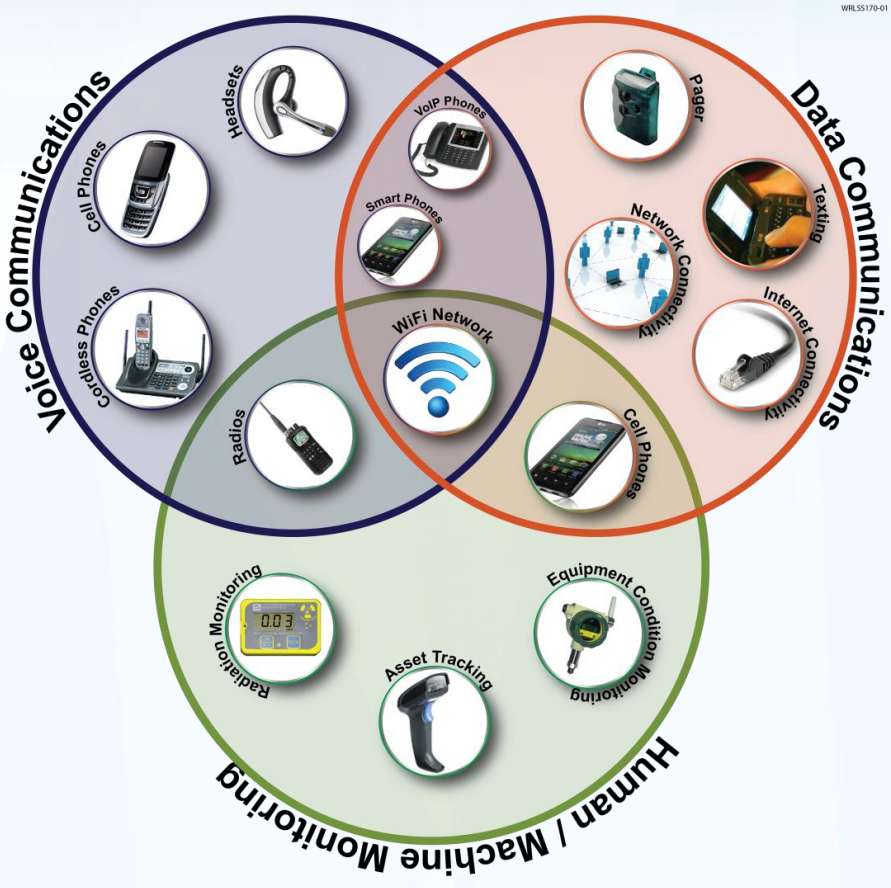
Support the Implementation of Wireless Technologies into Nuclear Power Plants

Technical Approach

Significant Barriers in the use of wireless technologies in nuclear power plants:

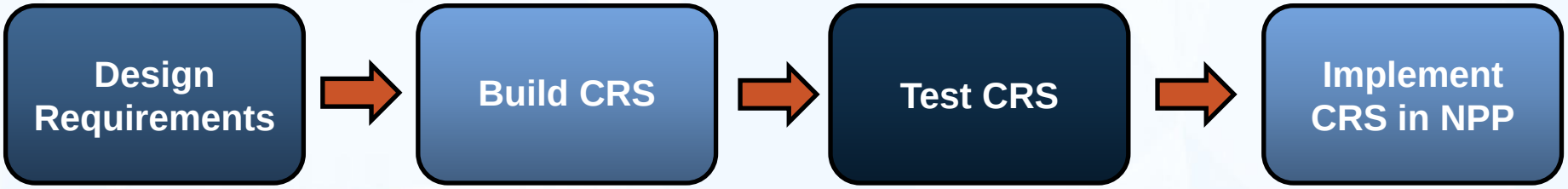
1) Electromagnetic compatibility (EMC) which refers to the ability of plant equipment **to withstand wireless transmissions.**

2) Coexistence which refers to the ability of various wireless devices to **operate in the presence of one another.**

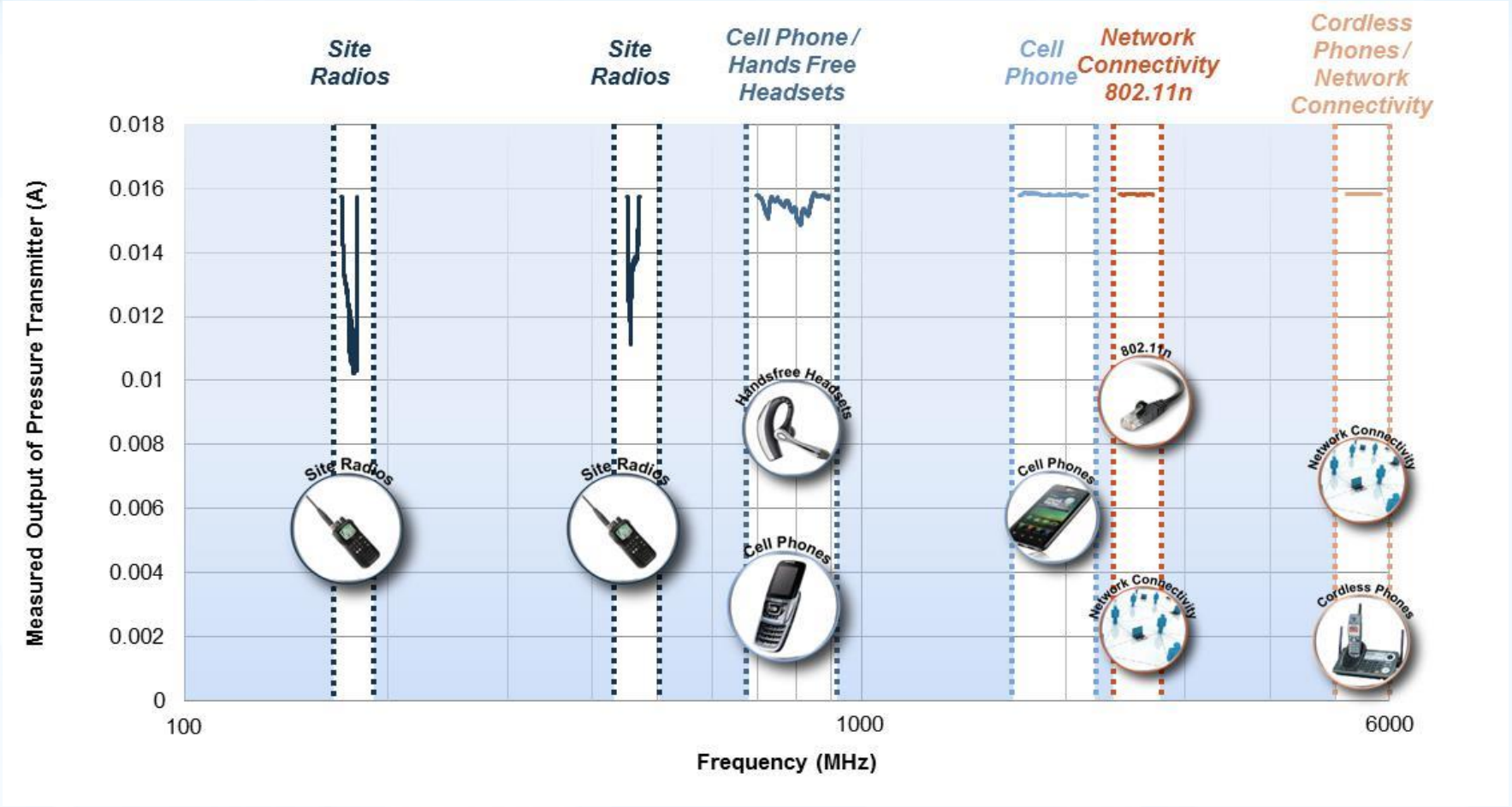


Wireless Coexistence Technical Objectives Overview

1. Establish Functional Requirements for Cognitive Radio System
2. Build the Cognitive Radio System
3. Replicate EMI/RFI Environment of a Plant for CRS Testing
4. Perform Testing at Simulated Plant Environment to Qualify CRS
5. Develop Methods and Procedures for In-Plant Testing using CRS
6. Demonstrate CRS in a Nuclear Power Plant
7. Collaborate with Other Experts and Develop Commercialization Strategy
8. Determine How CRS Can Help Address Cyber Security and Reliability

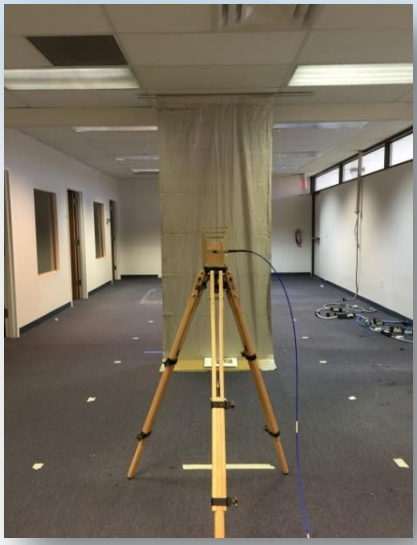


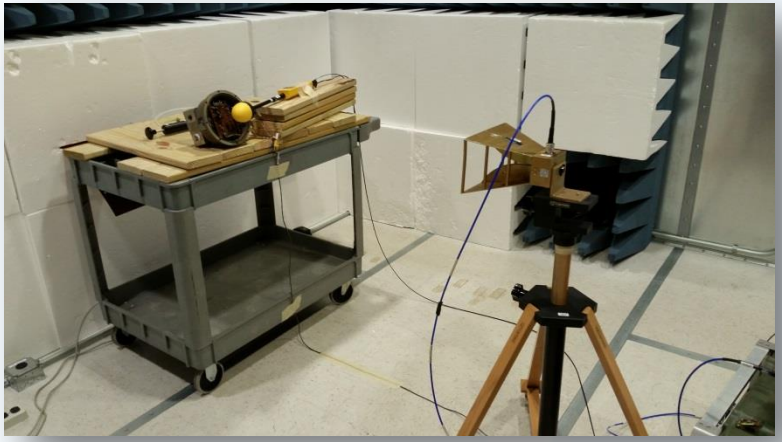
Phase I: Transmitter Testing to EMC Testing Standards Reveals Vulnerabilities

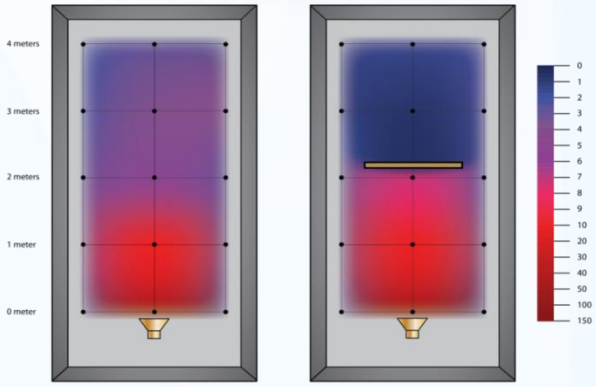


Phase I and Phase II: Addressing Concerns of In-Situ Immunity Testing

- Distance from equipment under test
- Shielding of surrounding equipment
- Reflections from metallic surfaces



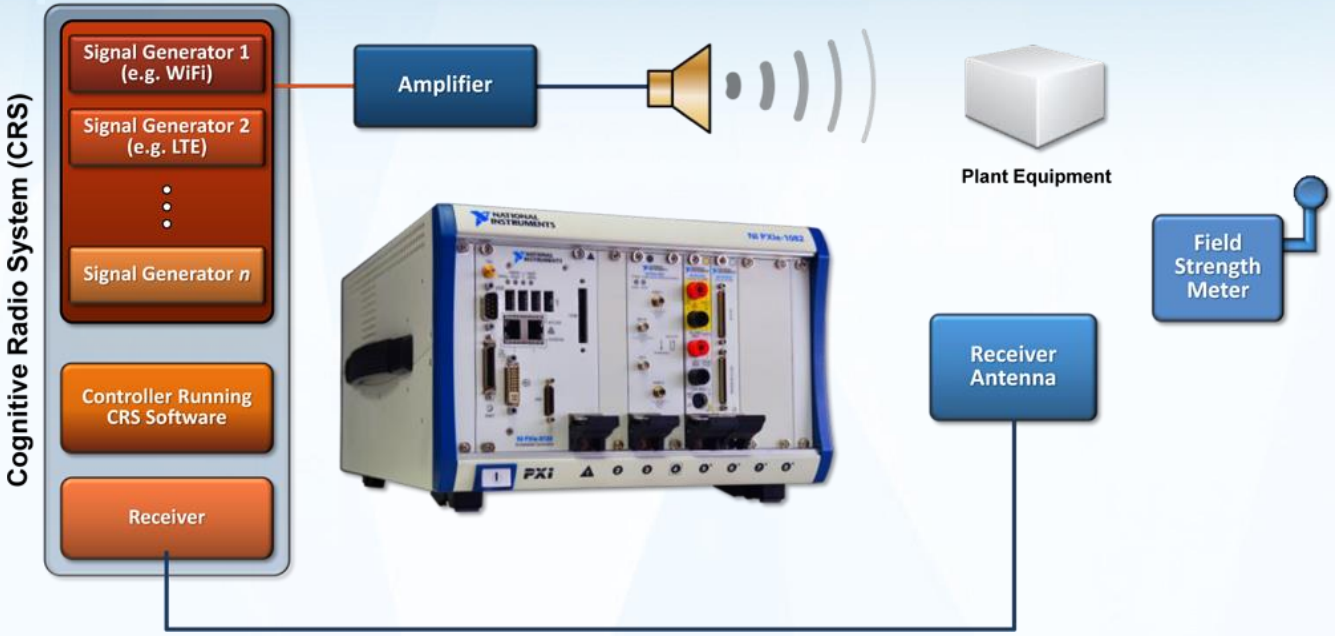




No Shielding

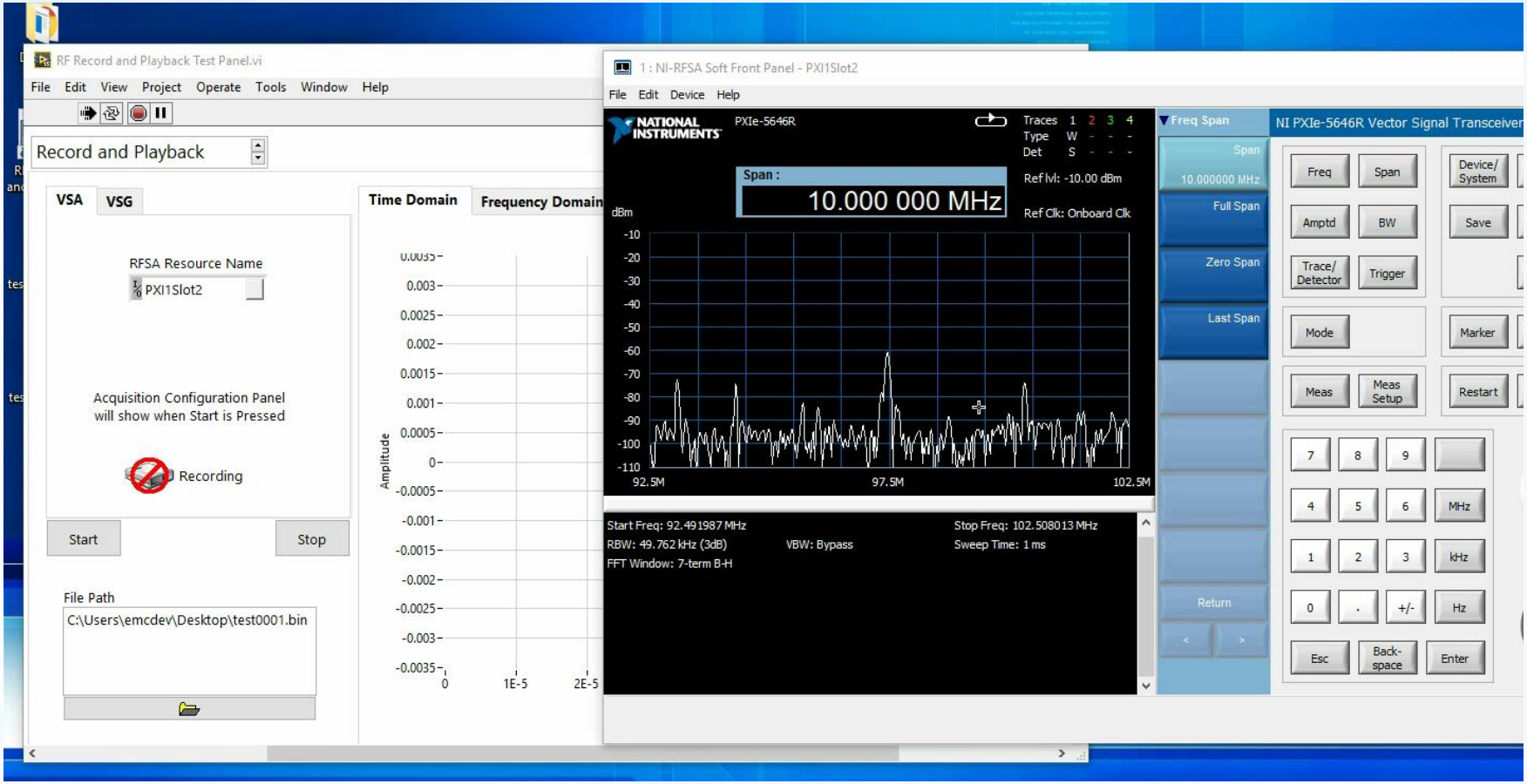
EM Cloth Shielding

Phase II: AMS has developed a Cognitive Radio Testing System



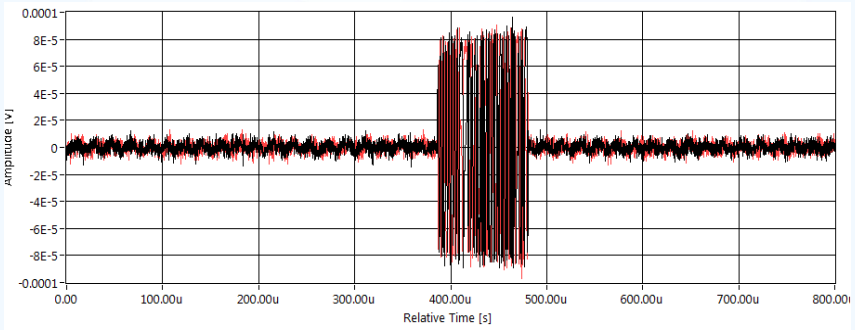
- Vector signal transceiver(s)
- Signal conditioning devices
- Antennas
- Field probes

Phase II: Recording RF Spectrum for Playback



WirelessHART Evaluation for Deployment in Plants

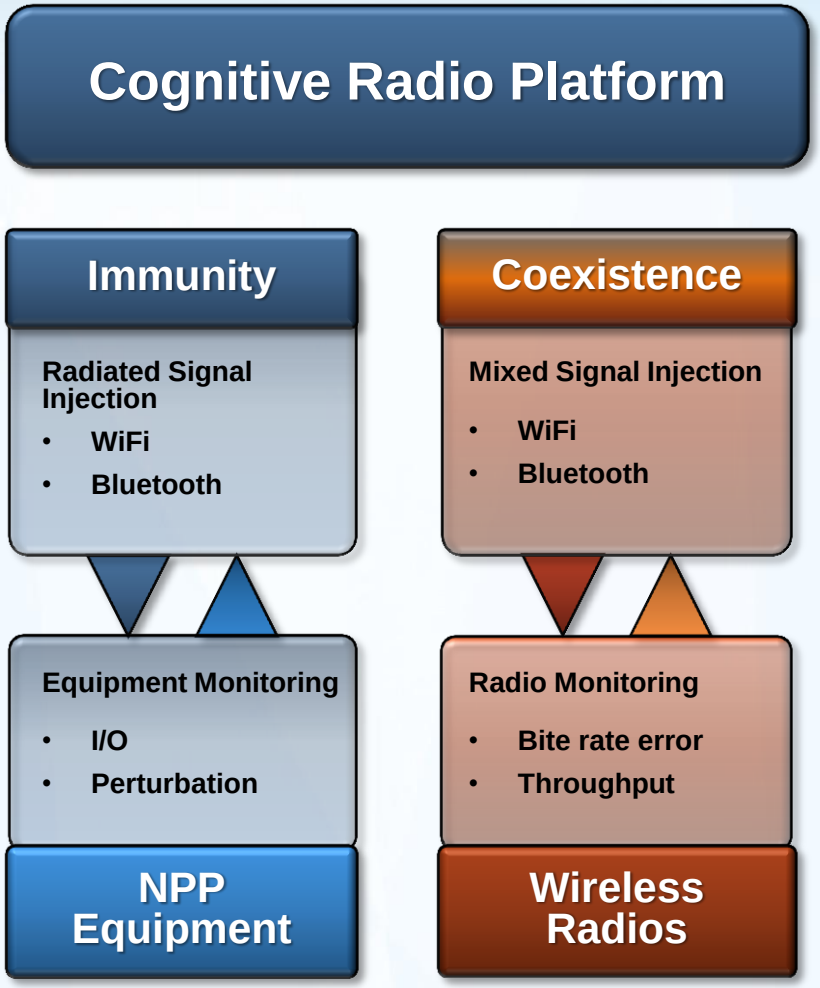
- Emerson WirelessHart Gateway (802.15.4)
  - Installed wireless instrumentation on AMS flow loop
  - Recorded communication with Cognitive Radio Test System to be used for future playback
  - Performed susceptibility testing on transmitter and base station to record performance degradation



Wireless Coexistence Technical Progress – Standards and Guidance

Wireless Coexistence Future Plans

- Finish Construction of System
  - Signal Monitoring of analog circuits
- Mapping Capabilities
  - Recording of spectrum over time with different triggering
- Coexistence with CRS
- Implement in Nuclear Power Plants (Host utility identified)



ACKNOWLEDGMENTS AND DISCLAIMER

This material herein is based upon work supported by the Department of Energy, Office of Nuclear Energy, under the Small Business Innovation Research program under contract DE-SC0011856. This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.