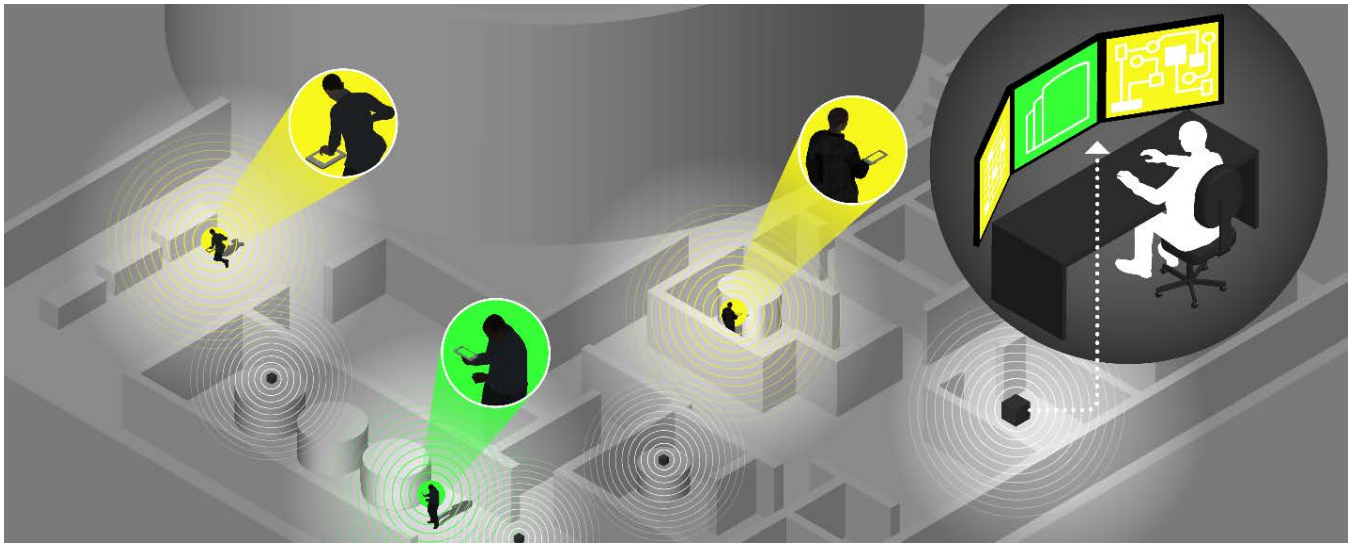
A Wireless Eye in Nuclear Plants



EPRI Investigates Automated, Real-Time Monitoring with Wireless Sensors

By Brent Barker

Nuclear power plants have achieved high levels of performance, safety, and reliability. With a new EPRI initiative, they now have opportunities to improve their operational efficiency using advanced technologies to automate monitoring, inspection, and other tasks. Many of these technologies have already been deployed in other industries and in coal- and natural-gas-fired power generation.

EPRI's initiative aims to advance these technologies for nuclear plants *without* sacrificing the plants' historic high safety and reliability.

"By identifying opportunities to improve plant instrumentation and monitoring technologies, equipment maintenance strategies can be optimized, making nuclear power competitive in this changing energy environment," said Howard Nudi, manager for nuclear engineering and equipment reliability at Duke Energy.

Distributed Antenna Systems

Historically, nuclear plants have relied on conventional handheld radios for communications and on wired sensors for data. Now, some plants are considering the installation of Wi-Fi networks. However, the plant infrastructure is so complex and the walls so thick that signals don't transmit readily. Even with multiple access points, signal strength degrades rapidly. Plants typically have little to no cellular coverage.

EPRI Senior Technical Leader Nick Camilli is investigating the use of cellular long-term evolution (LTE) networks and distributed antenna systems to amplify and distribute radio frequencies. Such systems can be a cost-effective wireless solution, as demonstrated by their successful application in large hotels, subways, and tunnels.

"Distributed antenna technology brings a flexible wireless platform to support voice communications, equipment monitoring, and other new technologies that the industry is adopting," said Camilli. "It can enable a faster, more efficient work execution process and increase the mobility of maintenance workers using handheld tablets and other digital devices."

Radiating cables can augment distributed antenna systems. These slotted coaxial cables extend up to several hundred feet and operate as a single antenna, enabling signals to propagate along their length. They can be snaked around equipment and into voids and "shadow areas" where traditional wireless signals cannot reach.

"Power plants will likely use a combination of point-source antennas and radiating cables, depending on the coverage requirements and building structures," said Camilli.

Relative to conventional Wi-Fi, distributed antenna systems can operate at lower frequencies, which propagate more widely and penetrate more extensively. This is key in nuclear power plants, with walls 2–3 feet thick and filled with rebar. "We're looking at frequencies in the 700–800 megahertz range, well below the 2,400 megahertz of conventional Wi-Fi," said Camilli. "Our testing has proven that these systems can produce coverage 2–3 times stronger than Wi-Fi."

Camilli and his team examined the feasibility of a distributed antenna system at two nuclear plants that are being decommissioned.

"We focused our testing in the auxiliary building and containment," said Camilli. "Because we were using lower frequencies, we were able to generate more coverage with fewer components. Both pilot demonstrations have proven that distributed antenna systems have the flexibility and reliability to address the needs of nuclear facilities with different plant designs and configurations."

DISTRIBUTED ANTENNA SYSTEMS:
BETTER WIRELESS COVERAGE WITH LOWER FREQUENCY

EPRI's evaluation of a distributed antenna system at the Crystal River nuclear plant revealed that lower frequency wireless signals penetrate power plant structures significantly better than higher frequency signals. This graphic compares signal coverage at 730 megahertz (left) with coverage at 2130 megahertz (right). The radiating cable propagates the signal. Yellow and green areas have higher signal strength while red and blue areas have weaker strength. Distributed antenna systems have the potential to support automated equipment monitoring, voice communications, and other advanced digital technologies that the nuclear industry is adopting.

Monitoring and Automation

Using a communications backbone of distributed antenna systems, many formerly manual and periodic inspections could now be done continuously with wireless sensors feeding data to an automated monitoring system. The software is programmed to detect abnormalities and performance deviations and signal the need for intervention and maintenance.

“You could still get the high reliability that nuclear plant operators have come to expect, but do so with less labor in the field,” said EPRI Senior Program Manager Rob Austin.

For example, each month technicians measure vibration in turbines and other rotating equipment and schedule maintenance if readings are too high.

“Alternatively, you could install a wireless vibration sensor on the equipment and measure it 24/7, giving you an early warning of an imminent problem,” said Austin. “You may not save on the maintenance itself, but you would on the personnel time required to take the measurement. Multiply that by the number of components being manually inspected, and you can save significant time and labor.”

In 2016, Austin and utility technical advisors developed a five-part plan to help accelerate the adoption of automated, wireless performance monitoring:

1. Develop a strong, quantifiable business case.
2. Create a step-by-step implementation guide for utilities.
3. Assess commercially available wireless sensors, and provide guidance on the most effective locations.
4. Assess commercially available statistical analysis tools for integrating equipment performance data from wireless sensors and guiding maintenance priorities.
5. Maintain cyber security.

At Catawba Nuclear Station, Duke Energy is installing this wireless sensor technology and is consolidating the data in Charlotte, North Carolina. The utility will use the technology to closely monitor equipment performance and health, while reducing the frequency of maintenance and inspection tasks. Based on these tests, it will assess plant reliability and apply lessons across its 11-unit nuclear fleet.

“As we gain confidence with non-safety-related components, we will be able to extend automated monitoring to more critical components,” said Austin. “The U.S. Nuclear Regulatory Commission recommends that plants use risk-informed in-service inspection as much as possible to prioritize maintenance activities, and real-time monitoring can help with that.”

Advanced Tools for Maintenance Workers

In addition to deploying wireless sensors and automated monitoring, nuclear plants can reduce labor costs and optimize maintenance with effective digital tools and resources for workers.

With 3-D graphics technology, EPRI is developing interactive applications that can be loaded on a laptop as well as interactive PDFs with embedded videos and animations. These can help workers complete maintenance and inspection tasks more efficiently and effectively, improving plant safety and reliability.

"If I can see a picture of all the parts of a component, understand how they are put together, and listen to a seasoned expert explaining how the component works, I can learn much faster and more thoroughly than I can by reading a five-part description in a report," said EPRI Senior Program Manager Jim Heishman.

An EPRI app for the Terry Turbine enables the user to view the component from every angle, along with its internal and external features. With EPRI's app for the medium-voltage K-Line circuit breaker, users can disassemble and reassemble the component in the proper sequence. "This circuit breaker is a marvel of mechanical engineering, with 1,500 parts," said Heishman. "For training purposes, a virtual reality model helps workers to understand the operation and maintenance tasks more clearly."

A third example is the air-operated valve. "We selected this valve for app development because a few years ago the industry faced a significant problem with an air-operated regulating valve in plant feedwater systems that was causing plants to reduce power or trip offline," said Heishman. "The app explains how the valve works and how to maintain it, and it provides troubleshooting and diagnostics to identify causes of degradation."

Key EPRI Technical Experts

Rob Austin, Nick Camilli, Jim Heishman