
US Department of Energy Light Water Reactor Sustainability Program – Advanced Instrumentation, Information and Controls R&D Overview



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*Idaho Falls, Idaho
October 28, 2015*

Light Water Reactor Sustainability R&D Program





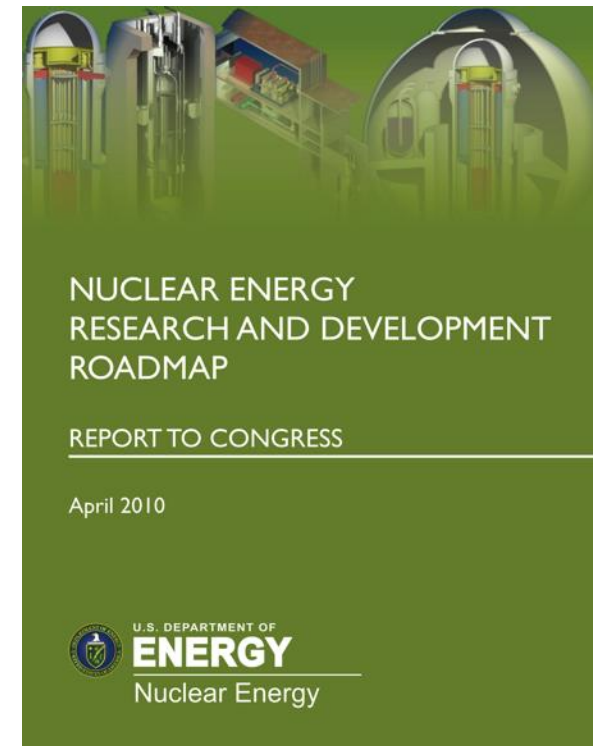
US Department of Energy Light Water Sustainability Program Goals and Scope

■ Goals

- Develop the fundamental scientific basis to understand, predict, and measure changes in materials and systems, structures and components (SSCs) as they age in environments
- Apply this knowledge to develop and demonstrate methods and technologies that support safe and economical long-term operation of existing reactors
- Research new technologies that enhance plant performance, economics, and safety

■ Scope

- Materials Aging and Degradation
- Risk-Informed Safety Margin Characterization
- Advanced Instrumentation, Information, and Control Systems Technologies
- Reactor Safety Technologies*



**A new pathway within the LWRS Program*

- **Develop, demonstrate, and enable the deployment of new digital technologies for instrumentation and control architectures**
 - Significantly reduce the technical, financial, and regulatory risk of instrumentation, information, and control system modernization and refurbishments by demonstrating new technologies and operational concepts in actual nuclear power plant settings
- **Provide monitoring capabilities to enhance the continued safe, reliable, and economic operation of the nation's operating nuclear power plants**
- **Develop capabilities to support long-term nuclear power plant operations and management**



Industrial Engagement

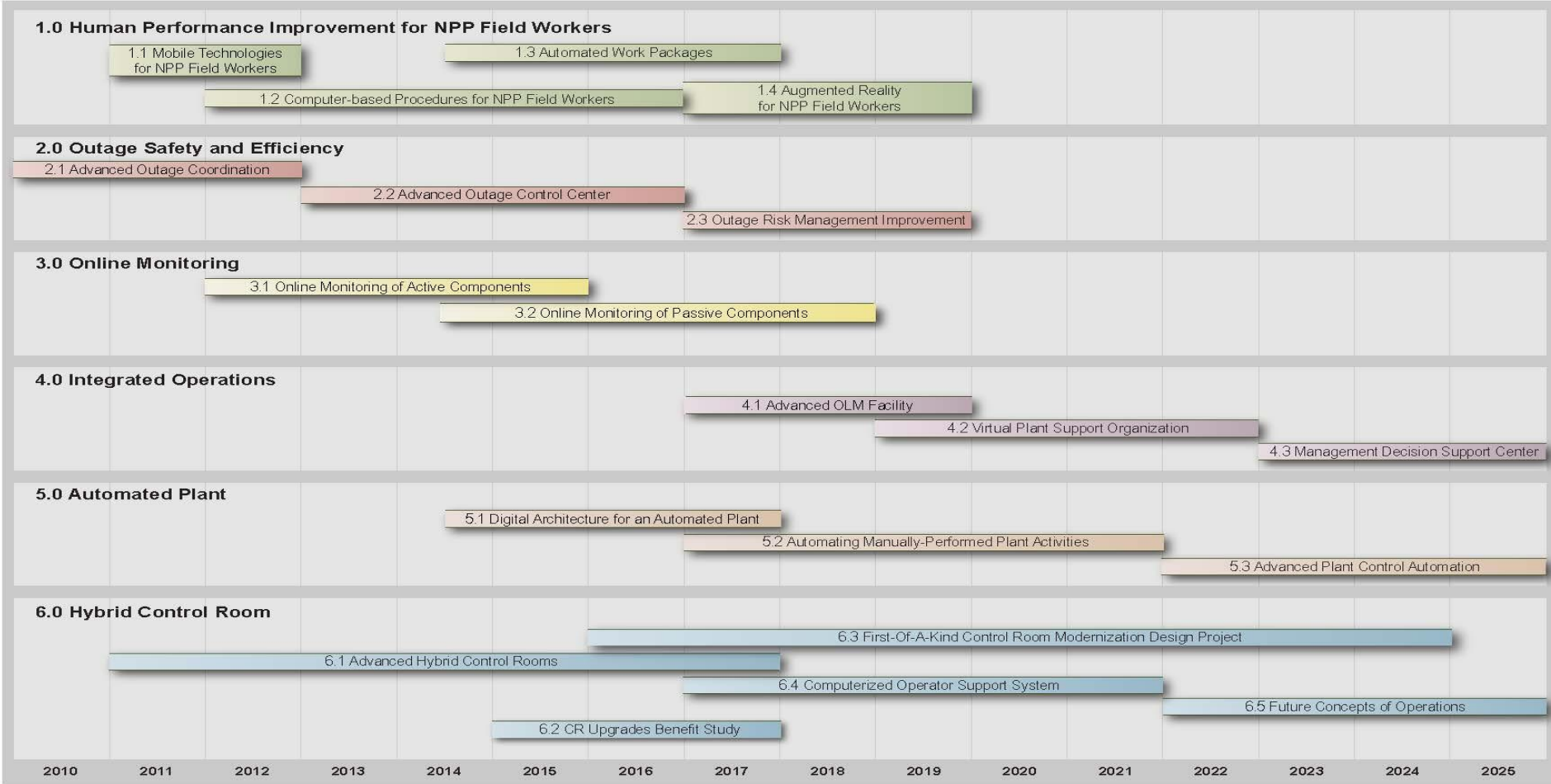
The purpose of the Working Group is to define and sponsor research projects that will collectively enable significant plant performance gains and minimize operating costs as part of the larger national effort to ensure long-term sustainability of the LWR fleet. The Working Group Charter is as follows:

- Develop agreements with host utilities to demonstrate near-term beneficial digital applications that improve performance at lower cost.
- Obtain funding for projects through LWRS program funding and industry cost-sharing.
- Coordinate project development among research organizations associated with the U.S commercial nuclear industry, to the degree practical, to minimize duplication of effort.





Incremental Modernization Strategy



Advanced Instrumentation, Information, and Control Systems

■ Address long-term aging and reliability concerns of existing II&C technologies:

- Establish a strategy to implement long-term modernization of II&C systems.
- Develop, test, and deploy advanced technologies.
- Promulgate technologies, lessons learned, and foster industry standardization.
- Develop advanced condition monitoring technologies to monitor, detect, and characterize aging and degradation



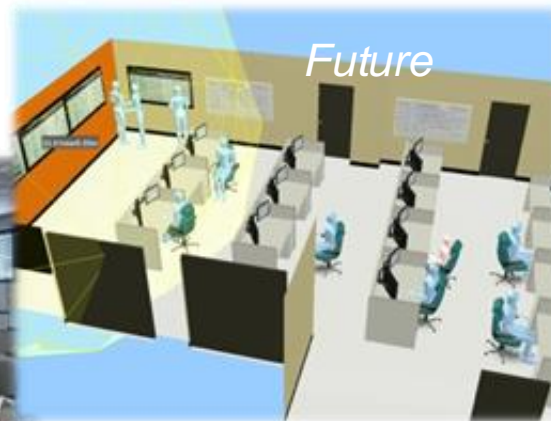
Advanced Outage Control Center

- **Objective: Improve management of nuclear power plant outages by developing an advanced outage control center (OCC) and supporting technologies to achieve real-time coordination and oversight of many distributed efforts**
- **Successful pilot projects with Exelon, Palo Verde Nuclear Generating Station have spread to many other plants**
- **Implemented an improved process for managing emergent issues using collaboration software**
 - The new process and collaboration tools were put to the test when a leak was identified on one of the reactor vessel bottom-mounted instrumentation (BMI) nozzles
 - These new tools were used to coordinate and document every aspect of the inspections, recovery planning, and repair



Advanced Outage Control Center

- Expanding the use of the technology to plant status displays and satellite command centers
- LWRS Program staff continues to work with utilities to develop advanced outage technologies to improve safety and efficiency.
- Expanding into mobile technologies for field workers and real-time outage risk management – and working with other utilities & sites: Farley, Prairie Island, Sequoyah, St. Lucie.



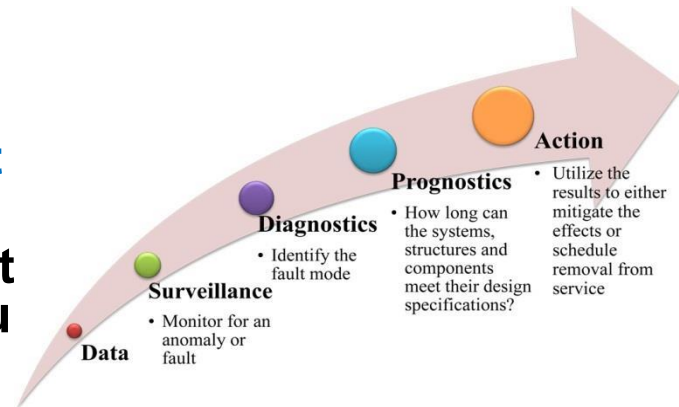
Online Monitoring of Active Components

Objective

- Develop fleet-wide **diagnostic** and **prognostic** capabilities to enable equipment condition monitoring from **fault signatures**
- Supports analysis of long-term component behavior, related risk, and remaining useful lifetime (RUL) estimation
- Components: Generator step-up transformers (GSUs), Emergency diesel generators, and Induction Motors

Impact

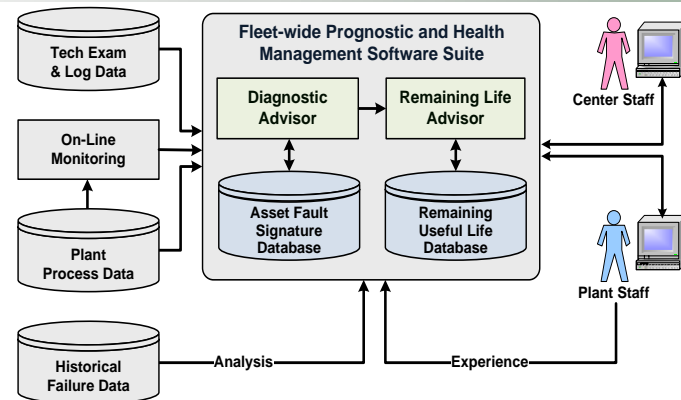
- Fleet-wide monitoring will **enable early detection of degradation** that could lead to life-limiting damage
- **Predictive maintenance** capabilities would **reduce the cost** of manual diagnostic work



Generator Step-Up Transformer

Research Activities

- **Developed, implemented, and validated** twenty-three (23) diagnostic models for GSUs in the EPRI's Fleet-Wide Prognostic and Health Management (FW-PHM) Suite software
- **Implemented** two (2) established prognostic models for GSUs in the FW-PHM Suite
- **Demonstrated** diagnostic and prognostic capabilities of the FW-PHM Suite
 - Utility Working Group Meetings, Idaho Falls, Idaho, August 2014
 - EPRI's Fleet-Wide Monitoring Interest Group Meeting, Albuquerque, New Mexico, October 28-29, 2014
- **Exelon and Duke** are lead utilities

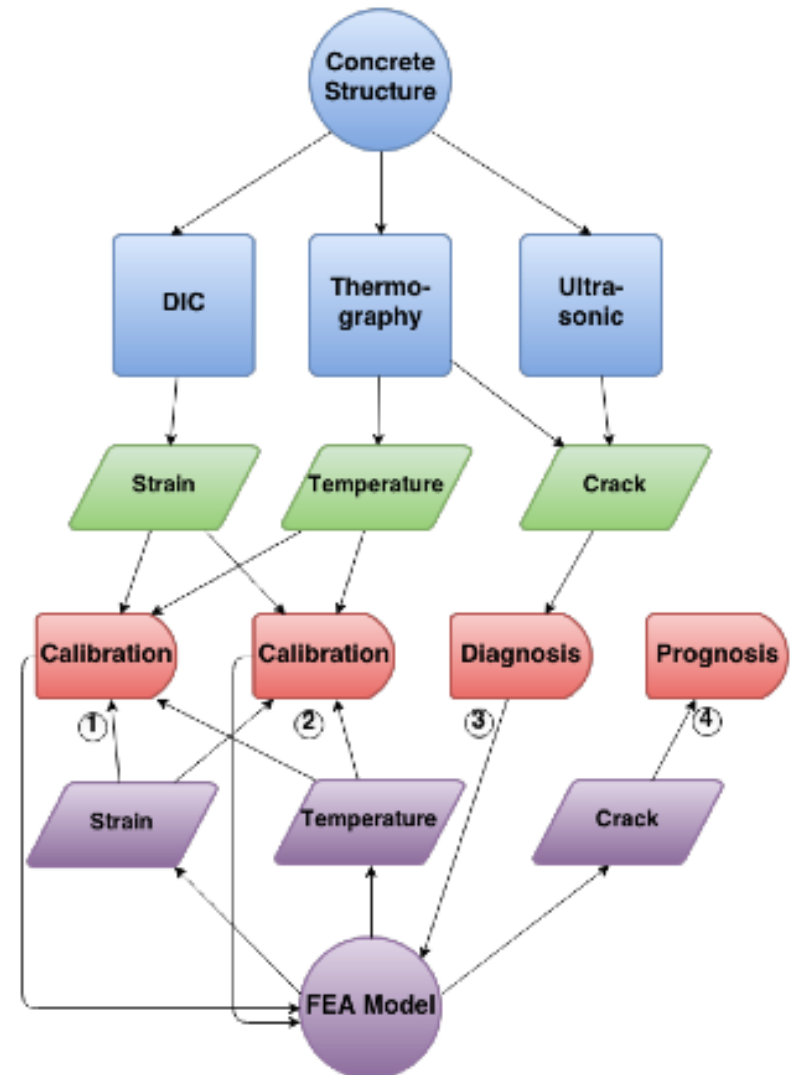


Objective

- **Integrate models** from materials science with data from **plant operation** to monitor the performance of physical systems as they age.
- Supports long term operation by providing real time information to inform future material models and **plant aging assessments** using dynamic PRA (e.g., risk informed safety margin assessments)
- Components: **Concrete**, specifically alkali-silica reaction (ASR); **Flow Assisted Corrosion** of piping.

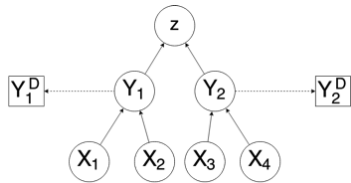
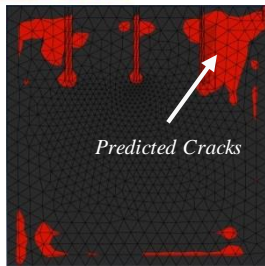
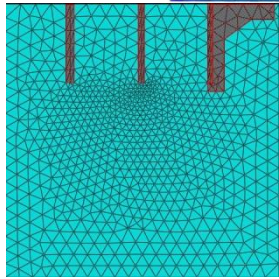
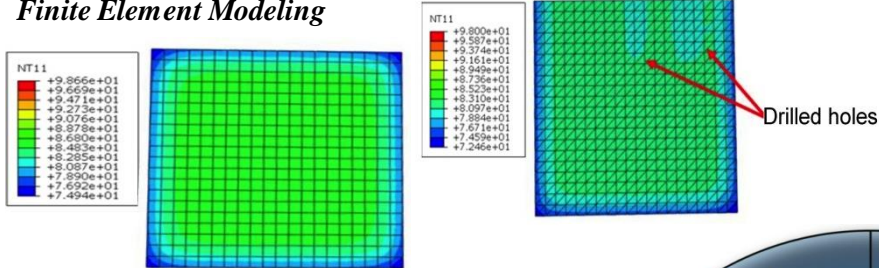
Impact

- Improved models of **material behavior** during long term operation.
- **Enhanced monitoring** capabilities to detect **indicators of degradation** earlier than without advanced sensors (goal)

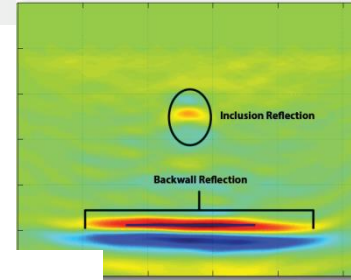
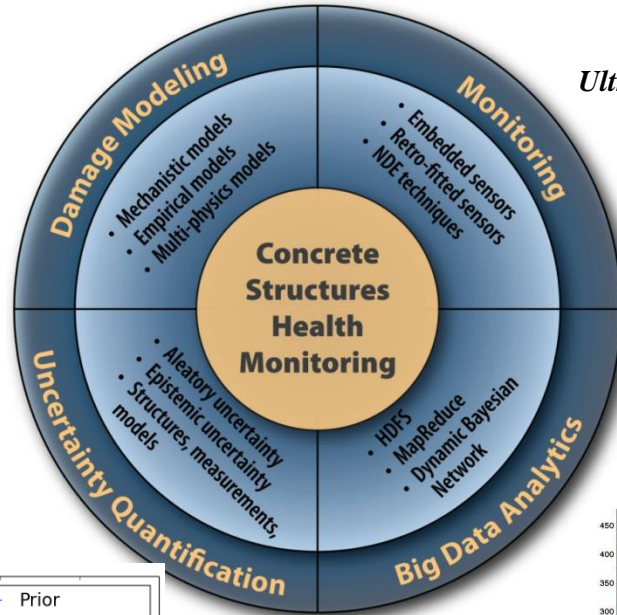
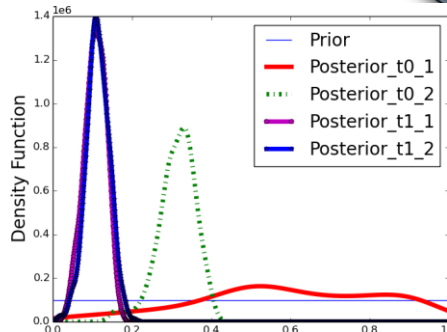


Example of Full Field Imaging

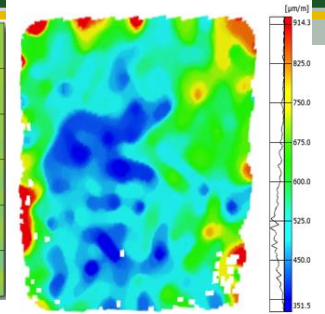
Finite Element Modeling



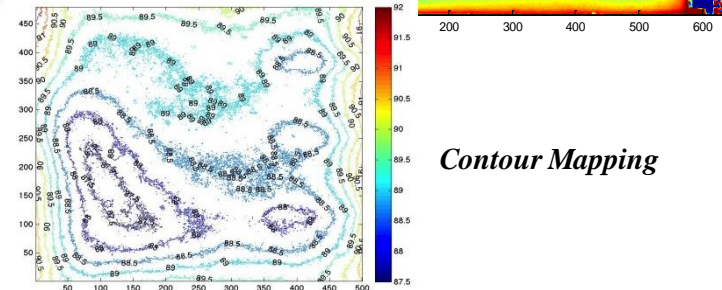
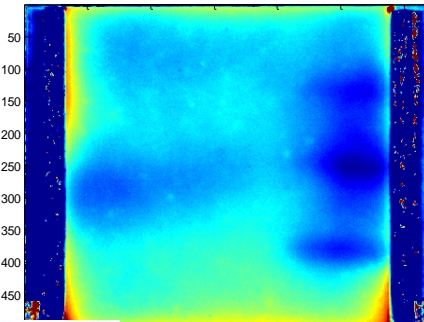
Bayesian network



Ultrasound Imaging



Digital Image Correlation



Contour Mapping



Computer-Based Procedures (CBPs)

■ Research goal

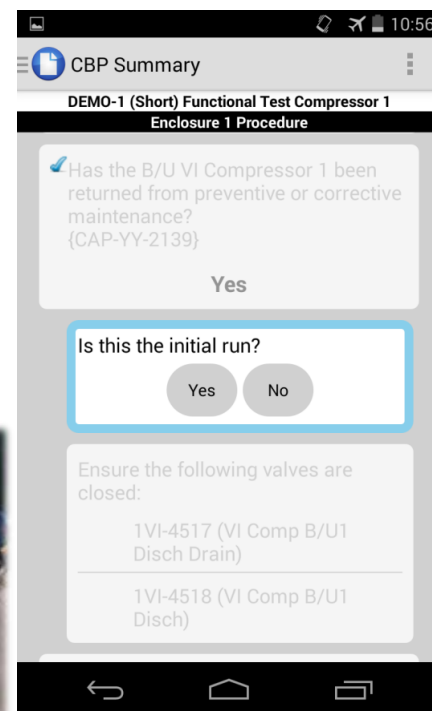
- Migrate from paper-based procedure delivery systems to **interactive**, **context aware** computer-based procedures.

■ Standardizing design of CBP technologies, to enable

- Using multiple sources of disparate information and present it in a succinct and easily comprehensive manner
- Human error reduction and increased work efficiency
- Maintaining field workers focus on task at hand

■ Provides new capabilities such as:

- **Automatic** job aids (e.g., calculations) and **place-keeping**;
- Digital correct **component verification**;
- **On demand** just in time training and info (e.g., photos, videos);
- **Real time** plant configuration and status control.



Hybrid Control Rooms

Goal

- Enable **needed upgrades** of main control rooms

The State of Control Room Upgrades at US Plants:

- None of current plants in US has upgraded main control room yet.
- Utilities have pursued mainly like-for-like, piecemeal replacements to date to avoid regulatory impacts to capital plans.
- Limited experience to leverage for upgrade process.

Two main activities:

1. Control Room **Modernization** projects;
2. Control Room **Upgrade Benefits** research.

Impacts

- Development of **industry experience** and **guidance** on control room modernization;
- Developing **momentum for investment** and improved **technology deployments**.

