

## **Instrumentation and Control**

### **Program Overview**

#### **Program Description**

The Instrumentation and Control (I&C) Program develops solutions to an array of I&C challenges confronting new and operating nuclear power plants, including equipment aging and obsolescence, digital upgrades, information access, human performance, and regulatory compliance. Through I&C advances in wireless communications, on-line monitoring, digital systems, and information management, nuclear plants can maximize benefits from existing equipment, modify I&C systems to reduce operations and maintenance costs, increase human performance, enhance safety, and contribute to effective new plant design and operation.

#### **Industry Needs and Issues Addressed**

- Improved management of I&C aging and obsolescence
- More effective use of digital technology and information
- Greater understanding of human performance and viability of evolving technologies (for example, visualization) in nuclear environments
- Technology to maintain existing components and systems; support component, system, multi-system, and plant-wide modifications; and support new plant requirements
- Solutions to improve equipment reliability and plant capacity at reduced costs
- Resolution of technical and regulatory impediments to I&C and control room improvements in operating plants and for designing and licensing new plants
- Strategies for reducing the costs and maximizing the benefits of I&C replacements and improvements

#### **Impact**

- Direct cost savings
  - On-line equipment condition assessment reduces maintenance costs
  - Wireless technology expands data and voice communications without pulling cable
  - Digital equipment evaluation and qualification enable commercial solutions to come to market
  - Simplification strategies reduce I&C modification costs
- Avoided costs
  - Digital upgrade lessons learned for avoiding costly mishaps
  - Cost-effective simulation alternatives for design, testing, and training during modifications
  - On-line monitoring-based predictive maintenance for avoiding unneeded maintenance
- Improved decisions
  - Control room human factors guidelines
  - Improved information access and visualization
  - Visualization enhanced approaches for tacit knowledge capture and training
- Regulatory compliance
  - Generic resolution of regulatory issues for new and operating plants
  - Risk-informed defense-in-depth and diversity assessment guidance
  - Guidelines and training for electromagnetic interference testing and digital upgrades

### **Key Accomplishments**

- Various draft industry position papers developed as part of the Nuclear Energy Institute's (NEI's) Digital I&C and Human Factors Working Group: minimum inventory of human-system interfaces; computerized procedures and associated automation and soft controls; manual operator actions as acceptable defensive measures for common-cause failures; susceptibility of digital devices and components to common-cause failures; defensive measures and diversity attributes to protect against digital common-cause failures; current methods to model digital systems in a probabilistic risk assessment (PRA)
- Plant application of on-line monitoring for calibrating interval extensions for safety-related instruments
- Control room and human-system interface guidelines
- Guidance on I&C strategies for plant-wide and fleet-wide cost reduction
- Guidelines for performing defense-in-depth and diversity assessments for digital upgrades
- Demonstration of wireless technology for equipment condition assessment
- Nuclear Regulatory Commission (NRC) safety evaluation reports on various guidelines/requirements (digital platforms, commercial off-the-shelf components, electromagnetic interference testing)
- Nuclear Regulatory Commission regulatory issues summary on guidelines for licensing digital upgrades

### **Current Year Objectives**

- On-line equipment condition assessment:
  - Integration of empirical modeling applications with vibration monitoring applications
  - Review of field experience with on-line monitoring for calibration interval extension
- Wireless sensor application guideline
- Technical reports and technical papers for submittal to NRC to address technical and regulatory issues identified by NEI Digital I&C and Human Factors Working Group for new plants and modifications of operating plants: minimum inventory of human-system interfaces; computerized procedures and associated automation and soft controls; methodology to determine acceptability for manual operator actions; protection against digital common-cause failure by combining defensive measures and diversity attributes; applying probabilistic risk assessments and risk insights to digital I&C
- Defense-in-depth and diversity evaluation case study
- Evaluation of operating experience data on digital system failures
- Insights and best practices based on digital upgrade operating experience
- Guidance for selecting and applying tools for tacit knowledge elicitation and presentation
- Lessons learned from modernization strategies

### **Industry Involvement**

- Estimated 2009 funding: \$2.3

### **Program Technical Lead**

Joseph Naser, 650-855-2107, [jnaser@epri.com](mailto:jnaser@epri.com)

## Summary of Projects

Project Number	Project Title	Value
	Instrumentation and Control Aging and Obsolescence (base)	Addresses issues associated with aging and obsolescence management, such as aging mechanisms, techniques for extending the useful life of existing equipment, and planning and requirements definition for replacements and upgrades through collaborative research and development
	Instrumentation and Control Aging and Obsolescence (supplemental)	Addresses issues associated with aging and obsolescence management, such as aging mechanisms, techniques for extending the useful life of existing equipment, and planning and requirements definition for replacements and upgrades through single or small group utility-supported research, development, and application
	Instrumentation and Control Improvements to Increase Reliability and Capacity and Reduce Costs (base)	Addresses I&C improvements such as better accuracy and tighter control, but more importantly, looks at updated I&C capabilities beyond traditional monitoring and control, and thereby improve plant financials. Examples are self-diagnostics and calibration, on-line monitoring, automated data collection and analysis for fleet-wide management of support functions through collaborative R&D.
	Instrumentation and Control Improvements to Increase Reliability and Capacity and Reduce Costs (supplemental)	Addresses I&C improvements such as better accuracy and tighter control, but more importantly, looks at updated I&C capabilities beyond traditional monitoring and control, and thereby improve plant financials. Examples are self-diagnostics and calibration, on-line monitoring, automated data collection and analysis for management of support functions by utility supported research and development (R&D) and application.
	Regulatory and Technical Issues for Instrumentation and Control (Base)	Addresses issues that impede or delay implementation of I&C-related improvements or new plant license approvals. Most have both technical and regulatory aspects. Examples include coping capability for software common-cause failure, design and regulatory acceptance criteria for digital control rooms, and electromagnetic interference (EMI) testing through collaborative research and development.
	Regulatory and Technical Issues for Instrumentation and Control (supplemental)	Addresses issues that impede or delay implementation of I&C-related improvements or new plant license approvals. Most have both technical and regulatory aspects. Examples include coping capability for software common-cause failure, design and regulatory acceptance criteria for digital control rooms, and EMI tests by utility supported research, development, and application.

## Project Descriptions

### Instrumentation and Control Aging and Obsolescence (base) (060634)

#### Issue

Nuclear plants pursuing extended operation will inevitably replace much of their aging and obsolete instrument and control (I&C) systems. These replacements will likely be phased in over several years, demanding careful planning and maintenance practices for both existing and replacement systems. Further, the transition to digital technology presents many new challenges for nuclear utilities and their traditional suppliers, and industry guidance is needed. For example, the digital systems being implemented now are expected to become obsolete far more rapidly than their analog predecessors, and this should be anticipated in the long-term planning.

#### Description

This project focuses on key issues impacting the technical and financial success of maintaining existing I&C systems and the transition to updated I&C systems. Research addresses aging and obsolescence and ways to more effectively replace systems and equipment when it is no longer feasible to cope with problems with existing systems and equipment. Current activities include developing guidance and technology transfer mechanisms based on lessons learned to help eliminate inadvertent plant trips and other undesired events caused by costly "learning curve" errors made with digital upgrades. The project will develop a set of expert guides to capture knowledge related to I&C topics so that knowledge will be available to less experienced staff even after resident experts are no longer available. Generic requirements also are being developed for safety system digital upgrades to help utilities develop bid specifications and evaluate proposed new systems.

#### Value

- Avoid problems made in the past and avoid associated costs:
  - Inadvertent plant trips caused by unanticipated and undesired behaviors of new digital I&C systems
  - Design system problems discovered during installation and testing, when costs to correct are high
  - Life-cycle maintenance process issues after installation with high costs and limited redress
- Enable early detection of failure precursors, reducing the likelihood of inadvertent trips, potential equipment failures, and unnecessary safety system actuations caused by aging or other problems
- Allow less experienced staff to perform at a higher level more rapidly through knowledge capture in I&C expert guides

#### How to Apply Results

Members apply lessons learned to refine internal procedures for plant modifications and ensure that potentially problematic issues are specifically addressed at the earliest possible point in the plant modification process and tracked through implementation. I&C expert guides are available for less experienced staff to gain knowledge learned by others from years of experience. Members can use generic conceptual designs to inform system upgrades, including realistic performance requirements and vendor evaluations.

**2009 Products**

Product Title & Description	Planned Completion Date	Product Type
<b>Digital Upgrade Good Practices Based on Operating Experience – Supplemental Case Study Modules:</b> Technical transfer and training modules that use operating experience examples to illustrate specific digital upgrade pitfalls and approaches for avoiding them	12/23/2009	Technical Resource
<b>Obsolescence Management for Digital Systems:</b> Digital systems become obsolete faster than analog equipment because of the rapidly evolving underlying hardware and software technologies. As a result, suppliers have much shorter product lifetimes and customer support cycles. This deliverable will provide guidance on managing future digital obsolescence.	12/23/2009	Technical Report
<b>I&amp;C Expert Guideline on Topic TBD:</b> First in a series of practical guidance documents to help transfer the knowledge of existing I&C experts. The purpose of these documents is to capture I&C knowledge, experiences, and best practices and disseminate them throughout the nuclear power industry to support both operating plants and to help designs for new plants.	12/23/2009	Technical Report

**Future Year Products**

Product Title & Description	Planned Completion Date	Product Type
<b>Digital Upgrade Good Practices Based on Operating Experience – Supplemental Case Study Modules:</b> Technical transfer and training modules that use operating experience examples to illustrate specific digital upgrade pitfalls and approaches for avoiding them	2010	Technical Resource
<b>I&amp;C Expert Guideline on Topic TBD:</b> Second in a series of practical guidance documents to help transfer the knowledge of existing I&C experts. The purpose of these documents is to capture I&C knowledge, experiences, and best practices and disseminate them throughout the nuclear power industry to support both operating plants and to help designs for new plants.	2010	Technical Report
<b>Description and Use of I&amp;C Project Database:</b> Technical update that explains how to access and search the I&C Project database, which will contain information on completed digital upgrades	2010	Technical Update
<b>Digital Upgrade Good Practices Based on Operating Experience – Supplemental Case Study Modules:</b> Technical transfer and training modules that use operating experience examples to illustrate specific digital upgrade pitfalls and approaches for avoiding them	2011	Technical Resource
<b>I&amp;C Expert Guideline on Topic TBD:</b> Third in a series of practical guidance documents to help transfer the knowledge of existing I&C experts. The purpose of these documents is to capture I&C knowledge, experiences, and best practices and disseminate them throughout the nuclear power industry to support both operating plants and to help designs for new plants.	2011	Technical Report

## **Instrumentation and Control Aging and Obsolescence (supplemental) (061379)**

### **Issue**

Nuclear plants pursuing extended operation will inevitably replace much of their aging and obsolete instrument and control (I&C) systems. These replacements will likely be phased in over several years, demanding careful planning and maintenance practices for both existing and replacement systems. Further, the transition to digital technology presents many new challenges for nuclear utilities and their traditional suppliers, and industry guidance is needed. For example, the digital systems being implemented now are expected to become obsolete far more rapidly than their analog predecessors, and this should be anticipated in the long-term planning.

### **Description**

This project focuses on key issues impacting the technical and financial success of maintaining existing I&C systems and the transition to updated I&C systems. Research addresses aging and obsolescence and ways to more effectively replace systems and equipment when it is no longer feasible to cope with problems with existing systems and equipment. Current activities include developing guidance and technology transfer mechanisms based on lessons learned to help eliminate inadvertent plant trips and other undesired events caused by costly “learning curve” errors made with digital upgrades. The project will develop a set of expert guides to capture knowledge related to I&C topics so that knowledge will be available to less experienced staff even after resident experts are no longer available. Generic requirements also are being developed for safety system digital upgrades to help utilities develop bid specifications and evaluate proposed new systems. Additional supplemental funded opportunities will be identified in this area to address plant needs.

### **Value**

- Avoid problems made in the past and avoid associated costs:
  - Inadvertent plant trips caused by unanticipated and undesired behaviors of new digital I&C systems
  - Design system problems discovered during installation and testing, when costs to correct are high
  - Life-cycle maintenance process issues after installation with high costs and limited redress
- Develop generic requirements for digital reactor protection systems/engineered safety features actuation systems to help plants prepare plant-specific requirements and bid specifications with greater confidence and with less time and cost to address aging and obsolescence

### **How to Apply Results**

Members apply lessons learned to refine internal procedures for plant modifications and ensure that potentially problematic issues are specifically addressed at the earliest possible point in the plant modification process and tracked through implementation. Members can use generic conceptual designs to inform system upgrades, including realistic performance requirements and vendor evaluations.

---

## 2009 Products

---

Product Title & Description	Planned Completion Date	Product Type
<b>Generic Requirements for Upgrading RPS/ESFAS for CE Plants to Address Obsolescence:</b> This project will prepare a generic requirements specification for a reactor protection/safeguard logic system for Combustion Engineering pressurized water reactor plants. These requirements will be made as generic as possible to be independent of the implementation platform and are follow-on to the requirements for Westinghouse plants (EPRI 1003044).	12/23/2009	Technical Report

---

## Instrumentation and Control Improvements to Increase Reliability and Capacity and Reduce Costs (base) (052363)

### Issue

Existing plant I&C equipment and functionality do not accommodate up-to-date features and techniques that can reduce costs and increase availability, reliability, and capacity. Typical analog front-line control systems have many single points of failure that can cause multi-million dollar plant trips; digital replacements are dual- or triple-redundant, virtually immune to single hardware failures. More accurate instruments can enable the plant to run at higher power while maintaining safety margins. More precise control can extend the lives of large hardware components, like feedwater heaters. Expanded capabilities of I&C equipment and emerging technologies can streamline many plant tasks and procedures to reduce operations and maintenance costs, while improving reliability and extending component lifetimes. Examples of such benefits include calibration interval extension, on-line equipment condition assessment, self-testing and diagnostics, and greatly improved access and presentation of plant data.

### Description

On-line monitoring work provides integrated advancements for instrument calibration assessment, equipment diagnostics/prognostics, and equipment failure probability and risk assessment. Wireless technology work develops and maintains guidelines for the safe, reliable implementation of wireless sensor and networking technology power plant applications. I&C strategies work develops methods to define, justify, and implement plant I&C modernization strategies that maximize benefits of modernization subject to realistic budget constraints. Tacit knowledge work tests whether visualization technologies can improve and make easier the capture of tacit knowledge for experts and enhance the transfer of the expert knowledge to others. The experience and lessons learned from the use of digital instruments in other industries can help improve requirements specifications, implementation, and operation.

### Value

- Improve work efficiency of plant engineers through the use of automated on-line monitoring tools
- Improve plant equipment reliability by providing more information on equipment condition
- Improve instrument monitoring, allowing extension of instrument calibration intervals
- Reduce I&C upgrade costs and improve the business case by taking advantage of simplification and standardization
- Reduce cost of adding sensors by using wireless technology rather than cabling to support equipment condition assessment and other applications
- Improve efficiency and reduce cost associated with capturing tacit knowledge from experts and presenting it to others

**How to Apply Results**

On-line monitoring products will be applied by using the guidance and lessons learned to improve current and future on-line monitoring software implementations. The wireless technology products will serve as guidance when planning and implementing wireless sensors and networking technology. The I&C strategies products will provide information on risks, benefits, and challenges for obsolescence management and for I&C modernization that can be used for planning and the business case. Results from the tacit knowledge capture task will be used to determine where and how visualization can be used to benefit the capture and dissemination of expert tacit knowledge.

**2009 Products**

Product Title & Description	Planned Completion Date	Product Type
<b>I&amp;C Modernization Strategies, 2009 Update:</b> This report will provide lessons learned from application of the 2007 I&C Strategies guideline to selected plants.	12/23/2009	Technical Report
<b>Wireless Technology: Sensor Networks in Nuclear Power Plants:</b> Wireless technology has been used in industrial facilities, including nuclear power plants, for several years. Several key hurdles, including security, reliability, and network topology, must be addressed. In 2009, wireless sensor networks for monitoring will be demonstrated, with solutions to key hurdles documented.	12/23/2009	Technical Report
<b>Integrating Thermal Performance with Empirical Monitoring Applications:</b> On-line performance monitoring applications utilize thermodynamics to detect operating inefficiencies. On-line equipment monitoring applications utilize data filtering routines to detect equipment abnormalities. The 2009 goal is to identify the correct approach to using thermodynamic models alongside empirical models.	12/23/2009	Technical Update
<b>Prognostics and Health Management System Design for Power Plant Equipment:</b> Prognostics and health management systems, which have been designed and applied in other industries such as defense, will be applied to a power plant component. This product will summarize this application and address the tagging of failure modes in the Preventive Maintenance (PM) Basis Database for prognostic analysis.	6/30/2009	Technical Report
<b>Requirements for Digital Instruments in Nuclear Power Plants:</b> In nuclear power plants, digital instruments must eventually replace analog instruments. In 2009, the use of digital instrumentation in other industries will be surveyed and results published.	12/23/2009	Technical Update

**Future Year Products**

Product Title & Description	Planned Completion Date	Product Type
<b>Integrating Thermal Performance with Empirical Monitoring Applications:</b> On-line performance monitoring applications utilize thermodynamics to detect operating inefficiencies. On-line equipment monitoring applications utilize data filtering routines to detect equipment abnormalities. In 2010, the goal is to implement the approach identified in the 2009 work.	2010	Technical Report

Product Title & Description	Planned Completion Date	Product Type
<b>Requirements for Digital Instruments in Nuclear Power Plants:</b> In nuclear power plants, digital instruments must eventually replace analog instruments. Guidance including requirements must be specified. In 2010, requirements will be specified for the use of digital instrumentation.	2010	Technical Report
<b>Wireless Technology: Network Configuration for Optimal Security and Reliability:</b> Wireless technology has been used in industrial facilities, including nuclear power plants, for several years. Several key hurdles, including security, reliability, and network topology must be addressed. In 2010, networking options, best practices, and design considerations will be documented in the form of guidelines.	2010	Technical Report
<b>Guideline for Improving Dependability of Critical-to-Production Equipment:</b> Approaches to identify the most critical equipment and systems for plant operability, corresponding digital services that could have a strong impact on plant availability, and practical ways to improve the dependability of critical equipment and systems	2010	Technical Report
<b>Data Acquisition and Local Processing Requirements for Implementation of Smart Component Instrumentation:</b> In 2008, the Smart Component project will demonstrate sensors on an existing component. However, the sensors will provide data on a temporary basis. This project will address a crucial need—determining the data acquisition and local processing requirements for permanently installed sensors for component monitoring.	2011	Technical Report

## Instrumentation and Control Improvements to Increase Reliability and Capacity and Reduce Costs (supplemental) (052366)

### Issue

Existing plant I&C equipment and functionality do not accommodate up-to-date features and techniques that can reduce costs and increase availability, reliability, and capacity. Typical analog front-line control systems have many single points of failure that can cause multi-million dollar plant trips; digital replacements are dual- or triple-redundant, virtually immune to single hardware failures. More accurate instruments can enable the plant to run at higher power while maintaining safety margins. More precise control can extend the lives of large hardware components, like feedwater heaters. Expanded capabilities of I&C equipment and emerging technologies can streamline many plant tasks and procedures to reduce operations and maintenance costs, while improving reliability and extending component lifetimes. Examples of such benefits include calibration interval extension, on-line equipment condition assessment, self-testing and diagnostics, and greatly improved access and presentation of plant data.

### Description

On-line monitoring work provides integrated advancements for instrument calibration assessment, equipment diagnostics/prognostics, and equipment failure probability and risk assessment. Wireless technology work develops and maintains guidelines for the safe, reliable implementation of wireless sensor and networking technology power plant applications. I&C strategies work develops methods to define, justify, and implement plant I&C modernization strategies that maximize benefits of modernization subject to realistic budget constraints. Additional supplemental funded opportunities will be identified in this area to address plant needs.

**Value**

- Improve work efficiency of plant engineers through the use of automated on-line monitoring tools
- Improve plant equipment reliability by providing more information on equipment condition
- Improve instrument monitoring, allowing extension of instrument calibration intervals
- Reduce I&C upgrade costs and improve the business case by taking advantage of simplification and standardization
- Reduce cost of adding sensors by using wireless technology rather than cabling to support equipment condition assessment and other applications

**How to Apply Results**

On-line monitoring products will be applied by using the guidance and lessons learned to improve current and future on-line monitoring software implementations. The wireless technology products will serve as guidance when planning and implementing wireless sensors and networking technology related to on-line monitoring. The I&C strategies products will provide information on risks, benefits, and challenges for obsolescence management and for I&C modernization that can be used for planning and the business case.

**2009 Products**

Product Title & Description	Planned Completion Date	Product Type
<b>On-Line Monitoring for Calibration Interval Extension of Safety-Related Instruments: Application Results:</b> British Energy has successfully demonstrated the application of on-line monitoring for extending instrument calibration intervals. A 2006 report, and technical updates in 2007 and 2008, document results. This product will consolidate all reports on the subject into a single package.	12/23/2009	Assembled Package
<b>On-Line Monitoring for Instrument and Equipment Health Monitoring: Guidance for Implementation and Technical Considerations:</b> This product will document the considerations and implementation guidance necessary to address key regulatory questions and enable successful instrument calibration interval extension.	12/23/2009	Technical Update
<b>Plant-Specific I&amp;C Strategy Assessment:</b> Technical Resource document providing feedback on the current plant-specific I&C modernization strategies and recommendations on applying selected portions of the <i>2007 I&amp;C Strategies Guideline</i>	12/23/2009	Technical Resource

**Future Year Products**

Product Title & Description	Planned Completion Date	Product Type
<b>Plant-Specific I&amp;C Strategy Assessment:</b> Technical Resource document providing feedback on the current plant-specific I&C modernization strategies and recommendations on applying selected portions of the <i>2007 I&amp;C Strategies Guideline</i>	2010	Technical Resource

Product Title & Description	Planned Completion Date	Product Type
<b>Plant-Specific I&amp;C Strategy Assessment:</b> Technical Resource document providing feedback on the current plant-specific I&C modernization strategies and recommendations on applying selected portions of the <i>2007 I&amp;C Strategies Guideline</i>	2011	Technical Resource

## Regulatory and Technical Issues for Instrumentation and Control (Base) (052365)

### Issue

The nuclear industry is transitioning from analog to digital technology, and for both operating and new plants there are several I&C-related issues for which the available technical and regulatory guidance is unclear, incomplete, or evolving. Examples include defense-in-depth and diversity (software common-cause failure) and various design considerations for digital control rooms. Having to develop technical guidance and resolve unsettled regulatory issues as part of an I&C upgrade or a licensing submittal significantly increases the costs and risks associated with the project and can introduce substantial delays.

### Description

This project seeks to resolve key issues on an industrywide basis, focused in three areas. The first covers various activities to address technical and regulatory issues in I&C and human factors for operating plants and new plants. Currently, emphasis is resolving issues identified by a joint effort between the NEI Digital I&C and Human Factors Working Group and the Nuclear Regulatory Commission. The second area involves guidance for evaluating field programmable gate array (FPGA)-based systems for safety applications that will be submitted for regulatory review. The third area addresses guidance for the use of plant simulator and alternative simulation devices for meeting engineering design and evaluation needs for operating plant modifications and new plant designs.

### Value

- Facilitate shift toward more predictable licensing process for operating plant modernization through generic resolution of digital I&C and human factors technical and regulatory issues.
- Reduce the risk, cost, and time for regulatory approval of license amendment requests and new plant operating licenses through generic resolution of digital I&C and human factors technical and regulatory issues.
  - For operating plants, avoiding uncertainty and delays in regulatory reviews can save years on schedules and millions of dollars per upgrade project in extra work to address issues and requests for additional information (RAIs) during regulatory reviews.
  - For new plants, unresolved regulatory issues can add months to years to the schedule and result in significant lost revenue opportunities, on the order of \$1 million per day.
- Reduce the risks and costs of implementing field programmable gate array based safety systems.
- Enable acceptable application of plant simulators and alternate simulation devices for engineering design and evaluation through early user input on new designs and earlier evaluations of new designs for operating plants and new plants.

### How to Apply Results

Report summarizing work with NEI Working Group's Human Factors Task Force, I&C Technical Issues Task Force, and Digital Probabilistic Risk Assessment (PRA) Task Force to develop industry-proposed issues resolution and gain regulatory acceptance. Utilities, suppliers, and third parties will use these generic solutions for design and license submittals to reduce licensing risk, cost, and time for operating plant license amendment requests and new plant combined construction and operating licenses. The

Nuclear Regulatory Commission will use the technical guidance to develop review and acceptance criteria. Guidance on evaluation of field programmable gate array based safety systems will allow nuclear plant staff to carry out activities acceptable to the regulator for reducing implementation costs and risks. Early use of plant simulators and alternative simulation devices will improve designs and reduce potential costly redesigns.

## 2009 Products

Product Title & Description	Planned Completion Date	Product Type
<p><b>Protecting Against Digital Common Cause Failure – Combining Defensive Measures and Diversity Attributes:</b> Technical report providing guidance for performing and reviewing defense-in-depth and diversity evaluations, expanding on the industry position paper developed for the NEI Working Group on Digital I&amp;C and Human Factors Issues.</p>	6/30/2009	Technical Report
<p><b>Minimum Inventory of Human-System Interfaces:</b> This technical report represents the industry position on the minimum inventory of human-system interfaces developed for the NEI Digital I&amp;C and Human Factors Working Group. The report 1) describes a process that can be used to identify the minimum inventory human-system interfaces and their design requirements for both new plants and modification of operating plants, 2) addresses in detail various design requirements for minimum inventory human-system interfaces, and 3) discusses options for implementing the minimum inventory human-system interfaces and provides associated guidance.</p>	12/23/2009	Technical Report
<p><b>Computerized Procedures: Design and Implementation Guidance for Procedures, Associated Automation and Soft Controls:</b> This technical report represents the industry position on computerized procedures developed for the NEI Digital I&amp;C and Human Factors Working Group. The report provides 1) general design implementation guidelines for computerized procedures, addressing topics such as human factors engineering design, quality assurance, verification and validation, configuration management, and transitioning to backup procedures; 2) additional guidelines for the design of procedure-based automation, interaction between the operator and the automation, and automation hold points; and 3) guidelines for the design of soft controls that may be integrated with computerized procedures.</p>	12/23/2009	Technical Report
<p><b>Applying PRA Methods to Digital Instrumentation and Control – Insights from a Pilot Application:</b> Guidance for the treatment of digital I&amp;C in probabilistic risk assessments, including use of simplified risk methods and application of risk methods to address specific digital issues such as defense-in-depth and diversity. The technical report will expand on the industry position papers developed for the NEI Working Group on Digital I&amp;C and Human Factors Issues.</p>	12/23/2009	Technical Report
<p><b>Guideline on Evaluating FPGAs for Safety System Applications:</b> Non-rewritable field programmable gate arrays offer an alternative to microprocessor-based platforms for safety applications. The report will describe design, implementation, and qualification guidance for field programmable gate arrays.</p>	12/23/2009	Technical Report
<p><b>Simulation Methods to Support Design and Evaluation During Control Room Modernization Steps:</b> Technical report providing additional guidance for simulation methods supporting engineering design and evaluation during control room modernization. This report will expand a 2008 report by providing additional information on using simulation for design and testing.</p>	12/23/2009	Technical Report

Product Title & Description	Planned Completion Date	Product Type
<p><b>Human Factors Control Room Guidelines Revision:</b> The Electric Power Research Institute's (EPRI's) <i>Human Factors Guidelines</i> (Technical Report 1010042) are providing the basis for industry position reports to address control room and human-system interface issues for new plants and for modernization of operating plants. The guidelines also are being used as the basis for plant-specific guidelines support. This product will update the guidelines to reflect results of the NEI Digital I&amp;C and Human Factors Issues Working Group activities and feedback from plant-specific guidelines support.</p>	12/23/2009	Technical Report

**Future Year Products**

Product Title & Description	Planned Completion Date	Product Type
<p><b>NEI Working Group Digital I&amp;C Issues Industry Approach for Resolution:</b> Technical and regulatory issues concerning design and use of digital I&amp;C in operating plant upgrades and for new plant licensing are being identified by the NEI Working Group I&amp;C Issues Task Force and Nuclear Regulatory Commission. EPRI will take the lead on issue resolution as requested by the NEI Digital I&amp;C and Human Factors Issues Working Group.</p>	2009	Technical Report

**Regulatory and Technical Issues for Instrumentation and Control (supplemental) (061263)**

**Issue**

The nuclear industry is transitioning from analog to digital technology, and for both operating and new plants there are several I&C-related issues for which the available technical and regulatory guidance is unclear, incomplete, or evolving. Examples include defense-in-depth and diversity (software common-cause failure) and various design considerations for digital control rooms. Having to develop technical guidance and resolve unsettled regulatory issues as part of an I&C upgrade or a licensing submittal significantly increases the costs and risks associated with the project and can introduce substantial delays.

**Description**

Project activities fall into three areas. The first covers various support activities to address technical and regulatory issues in I&C and human factors for operating plants and new plants. The second area addresses the generic pre-qualification of a field programmable gate array based replacement system for safety applications that will be submitted for regulatory review. The third area includes technology transfer of EPRI-developed products through training classes (EMI/RFI [radio frequency interference] qualification, digital I&C upgrades, control room modernization) and plant-specific support.

**Value**

- Facilitate shift toward more predictable licensing process for operating plant modernization through generic resolution of digital I&C and human factors technical and regulatory issues.
- Reduce the risk, cost, and time for regulatory approval of license amendment requests and new plant operating licenses through generic resolution of digital I&C and human factors technical and regulatory issues.
  - For operating plants, avoiding uncertainty and delays in regulatory reviews can save years on schedules and millions of dollars per upgrade project in extra work to address issues and requests for additional information (RAIs) during regulatory reviews.
  - For new plants, unresolved regulatory issues can add months to years to the schedule and result in significant lost revenue opportunities, on the order of \$1 million per day.
- Reduce the risks and costs of implementing digital safety applications through generic pre-qualification of digital platforms for safety applications.
- Increase the number of viable digital platforms through generic pre-qualification.
- Develop and offer training classes to encourage technology transfer and industry interaction.
- Convene subject matter experts to speed the learning curve and improve technical guidance.

**How to Apply Results**

Nuclear power plants, suppliers, and third parties can implement generic solutions for design and license submittals to reduce licensing risk, cost, and time for operating plant license amendment requests and new plant combined construction and operating licenses. Plant staff can participate in training classes and interface with subject matter experts to apply EPRI products to plant-specific issues for digital systems, control rooms, and human system interfaces. The generically pre-qualified field programmable gate array-based digital platform will be available for nuclear plant safety applications.

**2009 Products**

Product Title & Description	Planned Completion Date	Product Type
<p><b>Toshiba Non Rewritable FPGA-Based Replacement System Generic Qualification Report for Submittal to NRC For Pre-Qualified Platform Review – Non-Proprietary Version:</b> Generic qualification report for submittal to Nuclear Regulatory Commission on the Toshiba field programmable gate array-based replacement system for nuclear power plant applications, including safety applications. This is similar to generic pre-qualification of the Common Q, Teleperm XS, and Tricon platforms done previously.</p>	12/23/2009	Technical Report
<p><b>Plant-Specific Defense-in-Depth and Diversity Strategy Assessment:</b> Technical resource document providing feedback on current plant-specific defense-in-depth and diversity (D3) strategies and recommendations on applying selected portions of the regulatory and industry guidance on D3 issues.</p>	6/30/2009	Technical Resource
<p><b>Control Room Planning Including Human Factors Support for Digital Systems:</b> Plant-specific support, as requested by members, is provided by experts to reduce the costs and risks associated with control room modernization. Support is provided in several areas, such as planning, requirements, and evaluation, and helps nuclear power plants come up to speed faster on human factors guidelines. Support will take into account the latest human factors guidance based on industry positions for which EPRI took the lead in developing for the NEI Digital I&amp;C and Human Factors Issues Working Group.</p>	12/23/2009	Technical Resource

Product Title & Description	Planned Completion Date	Product Type
<b>Digital I&amp;C Upgrade Training Classes:</b> Three-to-four-day training course on the latest technical and regulatory issues affecting digital I&C (for example, 10 CFR 50.59, commercial grade dedication, defense-in-depth and diversity, and software verification and validation), based on various EPRI, regulatory, and industry guidance. Lessons learned would be integrated into plant processes and procedures as needed.	12/23/2009	Technical Resource
<b>EMI/RFI Qualification Training Classes:</b> One-and-a-half-day training course on technical and regulatory issues regarding electromagnetic compatibility and qualification testing. Participants use the training for new employees and to integrate lessons learned into plant processes and procedures as appropriate.	12/23/2009	Technical Resource
<b>Control Room Modernization Training Classes:</b> This three-and-a-half-day training class addresses control room modernization, including the latest human factors guidance.	12/23/2009	Technical Resource
<b>Future Year Products</b>		
Product Title & Description	Planned Completion Date	Product Type
<b>Control Room Planning Including Human Factors Support for Digital Systems:</b> Plant-specific support, as requested by members, is provided by experts to reduce the costs and risks associated with control room modernization. Support is provided in several areas, such as planning, requirements, and evaluation, and helps nuclear power plants come up to speed faster on human factors guidelines. Support will take into account the latest human factors guidance based on industry positions for which EPRI took the lead in developing for the NEI Digital I&C and Human Factors Issues Working Group.	2010	Technical Resource
<b>Control Room Modernization Training Classes:</b> This three-and-a-half-day training class addresses control room modernization, including the latest human factors guidance.	2010	Technical Resource
<b>EMI/RFI Qualification Training Classes:</b> One-and-a-half-day training course on technical and regulatory issues regarding electromagnetic compatibility and qualification testing. Participants use the training for new employees and to integrate lessons learned into plant processes and procedures as appropriate.	2010	Technical Resource
<b>Digital I&amp;C Upgrade Training Classes:</b> Three-to-four-day training course on the latest technical and regulatory issues affecting digital I&C (for example, 10 CFR 50.59, commercial grade dedication, defense-in-depth and diversity, and software verification and validation), based on various EPRI, regulatory, and industry guidance. Lessons learned would be integrated into plant processes and procedures as needed.	2010	Technical Resource

Product Title & Description	Planned Completion Date	Product Type
<p><b>Plant-Specific Defense-in-Depth and Diversity Strategy Assessment:</b> Technical resource document providing feedback on current plant-specific defense-in-depth and diversity (D3) strategies and recommendations on applying selected portions of the regulatory and industry guidance on D3 issues</p>	2010	Technical Resource
<p><b>Control Room Planning Including Human Factors Support for Digital Systems:</b> Plant-specific support, as requested by members, is provided by experts to reduce the costs and risks associated with control room modernization. Support is provided in several areas, such as planning, requirements, and evaluation, and helps nuclear power plants come up to speed faster on human factors guidelines. Support will take into account the latest human factors guidance based on industry positions for which EPRI took the lead in developing for the NEI Digital I&amp;C and Human Factors Issues Working Group.</p>	2011	Technical Resource
<p><b>Control Room Modernization Training Classes:</b> This three-and-a-half-day training class addresses control room modernization, including the latest human factors guidance.</p>	2011	Technical Resource
<p><b>EMI/RFI Qualification Training Classes:</b> One-and-a-half-day training course on technical and regulatory issues regarding electromagnetic compatibility and qualification testing. Participants use the training for new employees and to integrate lessons learned into plant processes and procedures as appropriate.</p>	2011	Technical Resource
<p><b>Digital I&amp;C Upgrade Training Classes:</b> Three-to-four-day training course on the latest technical and regulatory issues affecting digital I&amp;C (for example, 10 CFR 50.59, commercial grade dedication, defense-in-depth and diversity, and software verification and validation), based on various EPRI, regulatory, and industry guidance. Lessons learned would be integrated into plant processes and procedures as needed.</p>	2011	Technical Resource
<p><b>Plant-Specific Defense-in-Depth and Diversity Strategy Assessment:</b> Technical resource document providing feedback on current plant-specific defense-in-depth and diversity (D3) strategies and recommendations on applying selected portions of the regulatory and industry guidance on D3 issues</p>	2011	Technical Resource