Instrumentation and Control

Program Overview

Program Description

Instrumentation and control (I&C) systems affect all areas of plant operation and can profoundly impact plant reliability, efficiency, and operations and maintenance (O&M) costs. Plants are facing changes that involve serious I&C-related challenges. Equipment is getting older, cost-effective operation is more critical, and new plants are being planned.

Electric Power Research Institute's (EPRI's) Instrumentation & Control (I&C) Program provides the technical bases to apply advanced I&C and information technologies so that existing and new nuclear plants can tap into functionality and capabilities underutilized to date in the nuclear sector. These capabilities will enable nuclear plants to maintain safe operation while managing I&C obsolescence with higher equipment reliability and personnel productivity.

Three initiatives support the I&C Program mission:

1. Improved digital system implementation
2. Enhanced equipment reliability and plant productivity
3. Continued life-cycle management

Research Value

Research results from the Instrumentation and Control Program enable nuclear plants to realize direct and indirect cost savings, to make technically sound system and component-level decisions, and to comply with regulatory requirements. Instrumentation and Control Program participants gain access to the following:

- Regulatory compliance support such as the generic resolution of regulatory issues for new and operating plants, risk-informed defense-in-depth and diversity assessment guidance, cyber-security guidance, and guidelines for electromagnetic interference testing and digital upgrades.
- Technical evaluations for new technologies in nuclear applications, such as programmable controllers, “smart” sensors, and wireless communications.
- Guidance in setting up automated asset and equipment-monitoring systems that will improve overall plant reliability.
- Improved decisionmaking tools such as control room human factors guidelines, improved information access and visualization, and visualization-enhanced approaches for tacit knowledge capture and training.
- Training, operating experience, and lessons learned on I&C replacement projects that will enable plants to avoid costly mishaps and electromagnetic interference events and to implement plant strategies to cost-effectively manage I&C obsolescence.

Approach

The I&C Program is designed around three main initiatives:

- Digital System Implementation – Develop the technical bases to support the licensing of I&C and human system interface (HSI) replacement systems with nuclear regulators; develop guidelines for implementing new I&C, information, and HSI technologies in nuclear applications; and document operating experience and lessons learned.
- Enhanced Reliability & Improved Productivity – Reduce costly downtime and repairs by integrating new technology and techniques such as remote monitoring, wireless communication, early prognosis, and data visualization into operating and new nuclear plants. Adopt simulation and visualization technologies

to streamline tasks such as training, maintenance planning, and testing, while reducing the likelihood of information overload and human error.

- Continued I&C Life-Cycle Management – Develop technical basis to support a "design for replacement" approach to reduce the costs and risks of future replacements as new systems are implemented. Because of rapid technology evolution, new digital I&C systems will be replaced one or more times before the plant's end of life. Provide knowledge transfer on technical areas and best practices.

Accomplishments

EPRI's Instrumentation and Control Program has provided much of the fundamental basis supporting digital implementation in the nuclear industry and in identifying and overcoming many of the barriers to implementing newer technology. These include the following:

- Developed technical guidelines for using field programmable gate arrays (FPGAs) in nuclear safety-related applications.
- Developed technical guidelines for implementing cyber-security requirements as part of digital system life cycle.
- Obtained Nuclear Regulatory Commission approvals in safety evaluation reports on various guidelines/requirements (digital platforms, commercial off-the-shelf components, electromagnetic interference testing)
- Drafted key industry position papers on various topics, including inventory of human-system interfaces; computerized procedures and associated automation and soft controls; and susceptibility of digital devices and components to common cause failures.
- Established guidelines and demonstrated use of wireless technology for equipment condition assessment
- Demonstrated plant application of on-line monitoring for calibration interval extension for safety-related instruments.
- Demonstrated integrated 3-D modeling and visualization tools to capture plant worker knowledge that otherwise would be lost to attrition.
- Developed guidance on I&C strategies for plant-wide and fleet-wide cost reduction

Current Year Activities

I&C Program R&D for 2010 will focus on digital system implementation, equipment reliability, plant productivity, and life-cycle management. Specific efforts will include the following:

- Continue developing technical bases to allow implementation of safety-related digital I&C with low regulatory and economic risk.
- Pilot large-scale on-line monitoring in a critical-to-operation system.
- Develop training modules for implementing cyber-security technical solutions.
- Update computer-based training modules on implementing digital I&C to facilitate utility application with reduced cost and greater convenience.

Estimated 2010 Program Funding

$1.8 million

Program Manager

Robert Austin, 704-595-2029, raustin@epri.com

Summary of Projects

Project Number	Project Title	Description
41.06.01a	I&C Modernization Interest Group (supplemental)	The I&C Modernization Interest Group provides two workshops per year to promote discussion and resolution of problematic digital I&C implementation issues and development of new solutions, guidance, and training materials when needed.
41.06.01b	I&C Monitoring Interest Group (Supplemental)	The Monitoring Interest Group meets twice per year to discuss the latest progress in centralized on-line monitoring. The meeting includes a member roundtable to discuss open issues in the application of fleet-wide monitoring tools. As part of the roundtable, gaps that can be addressed by research projects are formulated into additional supplemental projects, to be carried out separately from the interest group. A website bulletin board will provide a forum for correspondence among members as well as an archive of meeting materials and links to related projects.
41.06.01c	I&C Maintenance & Life Cycle Management Interest Group (supplemental)	Instrumentation & control (I&C) maintenance and life-cycle management has emerged as a critical reliability issue for operating nuclear plants. The I&C Maintenance & Life Cycle Management Interest Group provides participants with implementation support for I&C maintenance and life-cycle management programs and a forum for sharing experiences and identifying research needs to address emerging problems.
41.06.01e	Instrumentation and Controls Obsolescence Management Strategy -- Application Support	The I&C Obsolescence Management Strategy project provides expert support to help utilities develop or refine their plant-specific modernization strategies.
41.06.01f	Digital I&C Upgrades - On-Site Training Class	The project provides an onsite four-day seminar for review and discussion of technical and regulatory issues related to digital instrumentation and control equipment.
41.06.01g	Electromagnetic Interference (EMI) Qualification for Digital Upgrades - On-Site Training Class	The project will provide an onsite two-day seminar for review and discussion of technical and regulatory issues related to EMI compatibility and qualification for digital upgrades.
P41.06.01.01	I&C Improved Digital System Implementation (Base)	Research activities in this project aim to develop the technical bases to support the licensing of I&C and human system interface (HSI) replacement systems with nuclear regulators; develop guidelines for implementing new I&C, information, and HSI technologies in nuclear applications; and document operating experience and lessons learned.
P41.06.01.02	I&C Improvements to Enhance Equipment Reliability and Plant Productivity (base)	Research activities in this project aim to reduce costly downtime and repairs by integrating new technology and techniques such as remote monitoring, wireless communication, early prognosis, and data visualization into operating and new nuclear plants. The project also develops simulation and visualization technologies to streamline tasks such as training, maintenance planning, and testing, while reducing the likelihood of information overload and human error.

Project Number	Project Title	Description
P41.06.01.03	I&C Continued Life-Cycle Management(base)	Because of rapid technology evolution, new digital I&C systems will be replaced one or more times before the plant's end of life. Research activities in this project aim to develop the technical basis to support a "design for replacement" approach to reduce the costs and risks of future replacements as new systems are implemented. This project also provides knowledge transfer on technical areas and best practices.

I&C Modernization Interest Group (supplemental)

Key Research Question

Digital upgrades at several plants have involved significant unanticipated costs due to problems coping with various implementation issues. Examples of problematic issues with digital upgrades include unanticipated behaviors of digital equipment, software verification and validation, configuration management, evaluation of failure modes and effects, commercial grade dedication, and inadequate vendor oversight. Adverse impacts have included the following:

- Large increases in vendor and utility staff costs
- Significant project delays - as much as one or two refueling cycles
- Plant trips
- Extended outages to correct problems
- Additional engineering to correct problems
- Increased regulatory scrutiny

The problems are typically caused by inadequate knowledge and processes, both at the utility and their suppliers, which prevent the utility staff from managing the issues cost-effectively. In some cases, emerging instrumentation and control (I&C) and human-system interface (HSI) technologies include standard features that can eliminate or mitigate problems.

Approach

Many nuclear plant operators have requested Electric Power Research Institute (EPRI) assistance in improving their knowledge base and plant programs for managing the problematic issues associated with digital upgrades. In some cases, industry guidance and good practices already exist, but have not been broadly communicated and are not widely practiced. In other cases, practical guidance for utility engineers is simply not available.

This project coordinates two interest group meetings per year. Each meeting is dedicated to one or two specific application issues that are proving problematic for current digital upgrade projects, topics such as ensuring high reliability in non-safety systems, performing failure modes and effects analyses (FMEA) for digital systems, vendor interaction and oversight, and factory acceptance testing. Participants propose meeting topics, share plant experiences, discuss lessons learned, and identify areas that need additional research or guidance for utility engineers. Where appropriate, participants request new guidance and/or technical transfer mechanisms to provide practical, useful tools to plant engineers.

Impact

This interest group develops and promulgates practical guidance that will help utilities anticipate, detect, and mitigate potential problems before they result in expensive learning-curve events that can cost millions of dollars for a single occurrence. It provides technical transfer of the latest industry and EPRI guidance on key issues and opportunities to identify current and future research needs for solutions that will smooth the

transition to digital instrumentation and control (I&C) and ensure its long-term viability. Specific technical benefits include the following:

- Practices that will improve utility handling of problematic digital system issues.
- Practices that will increase utility engineers' ability to detect and manage weaknesses in suppliers' designs and processes for key issues, such as failure analysis, software verification and validation, and software configuration management.
- Technologies, strategies, and guidance that enable plant engineers to ensure long-term obsolescence management of digital systems using 'design for replacement' approaches.
- Practical guidance and training materials for utility engineers.

How to Apply Results

Members will incorporate the lessons learned, guidelines, and training materials generated in this project into their processes, procedures, and training for digital upgrades.

I&C Monitoring Interest Group (Supplemental)

Key Research Question

The advancing state of centralized on-line monitoring (COLM) provides a broad range of technical solutions to asset management. Several early adopters have progressed to establishing and operating fleet-wide monitoring control centers, but the industry has much to learn with respect to best practices, implementation challenges, and problem resolution. Sharing of such information among users could accelerate COLM application and value.

Approach

The Monitoring Interest Group provides a forum for high-level technical information exchange, distribution of current information, identification of common problems and barriers, identification of needed actions by members and the Electric Power Research Institute (EPRI), and a platform for introducing COLM technology to new adopters. The interest group will serve as the gateway for supporting the development and distribution of EPRI technologies.

Impact

Participation in the Monitoring Interest Group will further the use of COLM in the nuclear power industry. Research and development advances for COLM in the nuclear industry lag behind those in the generation sector. Greater interaction and sharing of lessons learned with participants in the generation sector's Fleet-wide Monitoring Interest Group will support faster distribution and application of the technology in the nuclear sector.

How to Apply Results

The meeting activities will highlight application results. Attendance at the meeting will provide technology implementation opportunities through sharing of information, experience sharing, and technology transfer.

I&C Maintenance & Life Cycle Management Interest Group (supplemental)

Key Research Question

Aging or poorly maintained instrumentation and control (I&C) systems have resulted in numerous plant trips and power derates and compelled nuclear plants to take repair or replacement actions to maintain plant availability and reliability. The Institute of Nuclear Power Operations has identified I&C components, in particular circuit cards, as an "Area of Improvement" at many plants. Because of the time and resources required to replace older I&C systems with modern systems, it may never make business sense in some instances to upgrade these systems. Plants will have to maintain existing systems long past the period where

effective vendor support is available. In addition, replacement systems will require maintenance and life-cycle planning for eventual replacement as well.

Approach

Many nuclear plant operators have requested Electric Power Research Institute (EPRI) assistance in developing programs for managing I&C obsolescence focused on maintaining existing components. The I&C Maintenance & Life Cycle Management Interest Group provides a forum for exchanging plant experience and supporting the implementation of advanced I&C maintenance and life-cycle management technology, focusing on programmatic and generic considerations rather than specific component issues. The group ensures that EPRI research and guidance documents respond to, and evolve with, the expanding knowledge base regarding I&C maintenance and life-cycle management.

Impact

I&C system and component failures are expected to increase as plants age, unless aging is carefully managed. This broad-based interest group provides many benefits:

- Broad cross-section of operating experience from which to capture lessons learned.
- Identification of high-priority research activities to resolve I&C maintenance and life-cycle planning issues.
- Opportunity to advise EPRI on I&C research to ensure activities address industry needs.

How to Apply Results

Members will apply the results of this project in developing effective I&C maintenance and life-cycle management programs to maintain existing I&C systems and components.

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
I&C maintenance & life cycle management group meeting, 2 per year	12/23/10	Workshop, Training, or Conference
I&C maintenance & life cycle management group projects as selected by I&C-MIG members	12/23/10	Technical Report

Instrumentation and Controls Obsolescence Management Strategy – Application Support

Key Research Question

Driven primarily by obsolescence issues, most operating nuclear power plants are gradually replacing and upgrading their aging analog instrumentation and control (I&C) equipment as they plan for license extension and prepare for decades of continued operation. Practical considerations and resource limitations generally dictate that the transition to modern digital I&C be staged over many years and several refueling outages, which raises questions regarding how best to prioritize and sequence the upgrades. Currently, most plants upgrade system by system, focusing on the areas of highest perceived risk to near-term plant operability.

System-by-system upgrades, designed without attention to the desired endpoint vision and striving to minimize implementation costs, often exclude features and capabilities needed to fully realize the cost-benefit potential of I&C modernization. Because the overall cost of I&C modernization can exceed $100 million, each plant should develop and maintain a comprehensive integrated strategy that maximizes the benefits of modernization, reduces implementation costs where possible, and carefully manages aging and obsolescence problems to ensure high plant reliability during the transition.

Approach

Many nuclear plant operators have requested Electric Power Research Institute (EPRI) assistance in developing plant and utility-specific modernization strategies. This project will help utilities develop or refine their plant-specific modernization strategies. A base-funded EPRI project has developed extensive guidance on developing I&C modernization strategies (EPRI 1018109), stressing a resource-constrained approach that will apply to most plants. Important considerations include developing underlying tenets that will define the endpoint vision, identifying significant contributors to the cost-benefit case, and reducing implementation costs. This project will help utilities apply the most up-to-date results from the base-funded work to address their plant-specific issues. Subject-matter experts will work with utility engineers and managers to apply I&C strategies to plant-specific issues and prepare plant engineers to maintain and update the strategy as needed over the remaining plant life.

Impact

- Develop utility-specific underlying tenets for the modernization strategy.
- Develop the endpoint vision for the I&C architecture and operating concepts.
- Gather system-specific data to support strategy development.
- Help develop a draft strategy document, or review and comment on an existing one.
- Identify potential risks and long-term “traps” associated with continuing with the current modernization strategy.
- Identify and evaluate utility procedures that increase the costs of modernization and recommend processes that could be targeted for improvement. For example, poor requirements specifications can result in over-specification, requiring performance characteristics that are not really needed by the plant, but which significantly increase costs.
- Identify cultural elements that increase the costs of modernization and recommend changes that could be considered. For example, some upgrade tasks should be performed by the utility in-house to decrease life-cycle costs and improve reliability of software-based equipment (for example, development, maintenance, and configuration management of application software).
- Recommend how to plan for digital system obsolescence within the modernization strategy. For example, the use of open system I&C architecture approaches may offer significant life-cycle savings compared to using monolithic, single-vendor solutions.

How to Apply Results

Members will use the results of the project as a starting point for their detailed long-term I&C obsolescence management strategy.

Digital I&C Upgrades - On-Site Training Class

Key Research Question

Digital upgrades at several plants have involved significant unanticipated costs due to problems coping with various implementation issues. Examples of problematic issues upgrades include unanticipated behaviors of digital equipment, software verification and validation, configuration management, evaluation of failure modes and effects, commercial grade dedication, and inadequate vendor oversight. Adverse impacts have included the following:

- Large increases in vendor and utility staff costs
- Significant project delays - as much as one or two refueling cycles
- Plant trips
- Extended outages to correct problems
- Additional engineering to correct problems
- Increased regulatory scrutiny

The problems are typically caused by inadequate knowledge and processes, both at the utility and their suppliers, which prevent the utility staff from managing the issues cost-effectively. A framework for implementing digital upgrades now exists, but practical experience is sparse, and the existing guidance is voluminous and has proven difficult to communicate efficiently. In recent years, this situation has been exacerbated by staff reductions, changing job assignments, and declining training budgets.

Approach

For several years, the Electric Power Research Institute (EPRI) has been developing guidelines to address problematic technical and regulatory I&C-related issues. Many nuclear plant operators have requested EPRI assistance in preparing their staffs and processes to properly handle the new technology. EPRI has responded by developing a training seminar to help utilities efficiently bring people up to speed on the latest issues and guidance affecting the implementation of digital upgrades in nuclear plants. Specific topics include the following:

- Major steps of a digital upgrade process
- Differences between analog and digital equipment
- Potential pitfalls in developing and communicating requirements
- Failure and risk analysis issues
- Verification and validation (V&V) (IEEE 1012-1998)
- Licensing and current regulatory issues
- Commercial grade dedication and “critical digital review”

Impact

This four-day training seminar is designed to help nuclear utilities prepare their engineers and plant processes to successfully implement digital upgrades, addressing the key technical and licensing issues. The training is based on the EPRI guidelines on implementing digital upgrades, along with relevant standards, regulatory guides, and other technical references.

Where appropriate, the training relates recommended practices to the corresponding Nuclear Regulatory Commission (NRC) inspection criteria found in NUREG 0800, the updated Standard Review Plan (SRP). The course intersperses topic-based lectures with hands-on exercises to ensure the students can apply what they have learned. The seminar includes a detailed notebook for future reference and uses several EPRI technical reports and guidelines.

How to Apply Results

Members will incorporate the lessons learned, guidelines, and training materials generated in this project into their processes, procedures, and training for digital upgrades.

Electromagnetic Interference (EMI) Qualification for Digital Upgrades - On-Site Training Class

Key Research Question

Today, many utilities are upgrading to modern digital technologies to take advantage of improved performance and reliability capabilities. These upgrades also are driven by the growing problems of obsolescence, difficulty in obtaining parts, and increased maintenance cost of existing analog equipment. To successfully upgrade, utilities must ensure that new digital equipment will operate reliably. Utilities undertaking digital upgrades have been required to conduct extensive, site-specific electromagnetic surveys to demonstrate that electromagnetic interference (EMI) and electromagnetic compatibility (EMC) problems will not affect the operation of sensitive electronic equipment.

EMI qualification of digital equipment going into the plants continues to be an area where many plants are in a learning mode, getting processes and personnel up to speed on the issues and resolution methods. Various guidance documents are available from the Electric Power Research Institute (EPRI), the Nuclear Regulatory

Commission (NRC), and standards organizations, but this guidance needs to be converted into practical training for nuclear plant engineers.

Approach

Many nuclear plant operators have requested EPRI assistance in preparing their staffs and processes to properly handle the new technology. EPRI has developed a training seminar to help utilities efficiently bring people up to speed on the latest issues and guidance affecting the EMC of equipment in nuclear plants. Specific topics include the following:

- Procurement design and specification development
- Location selection to minimize the effects of EMI
- Recommended EMI susceptibility tests
- Industry standards and regulatory guidance
- Installation methods to minimize EMI
- Maintenance of EMI immunity
- Troubleshooting techniques
- EMI examples

Impact

This technical seminar provides practical information to utilities developing a program to ensure that digital equipment is electromagnetically compatible with a power plant emissions environment. It also assists them with preventing EMI problems that are associated with the installation of digital equipment. Participants develop an understanding of how EMI affects power plant equipment, review techniques to minimize and limit EMI, and learn how to develop specifications for equipment susceptibility testing. The content of previously published EPRI technical reports and the latest EPRI and NRC guidance will be reviewed. The seminar includes a detailed notebook that provides text, references, and copies of the presenter's slides. Several EPRI technical reports and guidelines will be used in support of the seminar.

How to Apply Results

Members will incorporate the lessons learned, guidelines, and training materials generated in this project into their processes, procedures, and training for EMI qualification and management of EMC in the plant.

I&C Improved Digital System Implementation (Base) (052365)

Key Research Question

The nuclear industry is transitioning from analog to digital technology, and for both operating and new plants there are several instrumentation and control (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 project costs and risks and can introduce substantial delays.

Approach

Recognizing that the plant of tomorrow – and the workforce of tomorrow – will demand advanced I&C and human-system interface (HIS) technology, the transformation to digital systems is inevitable. Such a transformation will equip the workforce with tools to drive improvements in plant design, operation, and maintenance. Electric Power Research Institute (EPRI) research identifies new I&C & HSI technology for the nuclear industry and develops the technical bases necessary for use in nuclear plants.

Specific research activities include the following:

1. Provide technical bases in support of licensing efforts for nuclear safety-related I&C systems
2. Develop improved safety and non-safety capabilities and establish the technical bases for their implementation
3. Develop guidelines to address new issues that arise due to technology advances (such as cyber security and electromagnetic interference)
4. Develop guidelines reflecting operating experience and lessons learned from implementing digital I&C systems

Impact

- 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.
- 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.
- Reduce the risks and costs of implementing field programmable gate-array-based safety systems.
- Reduce the risks and costs of implementing cyber security programs.
- Feed operating experience and lessons learned into design and maintenance processes to avoid past mistakes and leverage past successes.

How to Apply Results

Research results and interactions with industry groups such as the Nuclear Energy Institute (NEI) enable nuclear plant owners and operators to identify, evaluate, and resolve outstanding technical issues. 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.

I&C Improvements to Enhance Equipment Reliability and Plant Productivity (base) (052363)

Key Research Question

Existing plant instrumentation and control (I&C) equipment and functionality do not accommodate up-to-date features and techniques that can reduce costs and enhance reliability and productivity. 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 via simulation and visualization.

Approach

Tapping into the capabilities of advanced I&C, human-system interface (HIS), and information technologies can increase reliability and productivity while supporting safe, cost-effective, long-term nuclear plant operation. By integrating new technology and techniques such as remote monitoring, wireless communication, early prognosis and data visualization into design, operation, and maintenance practices, nuclear plants can reduce costly downtime and repairs. Digital I&C, HIS, and information technologies also allow greater personnel productivity with expected smaller future workforces.

Adoption of simulation and visualization technologies, for example, can streamline tasks such as training, maintenance planning, and testing, while reducing the likelihood of information overload and human error. This research area will identify, develop, and demonstrate advanced I&C technologies that offer enhanced equipment reliability and plant productivity.

Impact

- 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 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 along with simulation and visualization of design and work planning

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 implementations. The wireless technology products will serve as guidance when planning and implementing wireless sensors and networking technology. 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.

I&C Continued Life-Cycle Management (base) (060634)

Key Research Question

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 long-term planning.

Approach

Because I&C systems experience such rapid technology evolution, life-cycle management and maintenance is essential. With the expected long lifetimes of nuclear plants, many new digital I&C systems will have to be replaced one or more times before the plant's end of life. As new systems are implemented, the ability to "design for replacement" can reduce the costs and risks of future replacements. Further, I&C-related industry experience and expertise must be continuously re-incorporated into technology application guidelines and training programs to ensure effective I&C deployment across the nuclear plant life cycle. Through feedback loops such as user groups, advanced technology forums, and knowledge transfer, the nuclear industry can retain an active and successful role in managing I&C challenges and opportunities for the long term.

Impact

- Avoid problems and costs associated with the following:
  - Inadvertent plant trips caused by unanticipated and undesired behaviors of new digital I&C systems
  - Design issues discovered during installation and testing, when costs to correct are high
  - Life-cycle maintenance process issues discovered when correction is difficult and expensive
- Allow less experienced staff to perform at a higher level more rapidly through knowledge capture in I&C expert guides and courses.

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 & training are available for less experienced staff to gain knowledge learned by others from years of experience.