Digital I&C Implementation at New Plants

ISSUE STATEMENT

Operating nuclear plants are gradually transitioning much of their aging and obsolete instrumentation and control (I&C) equipment from analog to digital technology. However, despite significant safety, reliability and performance advantages, its acceptance and use have been slow to develop in the nuclear power industry. Plants have experienced significant unanticipated costs, delays and operating events associated with digital system implementations. As a result, the risks associated with I&C upgrades are often judged to be greater than the risks of continuing to operate with obsolete analog equipment.

DRIVERS

Several factors drive the need for a comprehensive plan to resolve issues currently discouraging the implementation and successful application of digital I&C in nuclear plants, including:

Negative Experiences with Digital Implementations: Digital upgrades at several plants have incurred significant unanticipated costs due to problems such as inadvertent plant trips, extended outages to correct start-up issues, project delays and cancellations. Key factors include inexperience with digital technology and the need for a paradigm shift to foster awareness of the issues and adapt utility and vendor processes, organizations and skill sets accordingly.

Regulatory Uncertainty: Licensing uncertainty on key issues has resulted in open-ended regulatory reviews with significant delays and increased project costs. Many plants now avoid digital implementations that involve unsettled regulatory issues or prior acceptance by the regulator.

Increasing Performance and Reliability Demands: Aging analog systems are becoming less reliable and more difficult to maintain, while expectations for equipment reliability and plant availability are increasing. Analog I&C plants have many single point vulnerabilities that could be eliminated using digital technology, with corresponding improvements in reliability and safety. Further, new operating conditions associated with power uprates could introduce functions and I&C performance requirements (e.g., accuracy, response time) that require digital technology capabilities.

Obsolescence: In many cases the old analog equipment has become difficult or impossible to maintain. Suppliers have discontinued support, spare parts are no longer available, and expertise on the old equipment has been lost through attrition and retirement. License renewal and extended fuel cycles exacerbate this problem. Further, while it is possible to extend the lives of some analog I&C systems for many years using enhanced maintenance practices and reverse-engineered replacement parts, this approach becomes more costly and less effective over time. Also, it typically cannot provide key digital technology benefits, such as performance improvements and elimination of single point vulnerabilities.

RESULTS IMPLEMENTATION

Upon completion of this work, nuclear utilities, their key equipment suppliers and system integrators will be prepared to cost-effectively implement and maintain digital I&C in all types of plant applications. Digital I&C implementation will become routine, and most plants will have long range plans for I&C obsolescence management. Utility engineers will have convenient access to all needed guidance and training on the technical and regulatory issues. Utility processes and personnel will address the technical, programmatic and ‘digital’ issues with predictable costs and schedules and with minimal risk of unexpected and undesired behaviors.

Also, the regulatory environment for digital I&C will be well-understood and stable; it will consider the safety significance of I&C in the context of overall plant risk, and will allow I&C solutions that are practical, cost-effective and well-engineered to meet safety and reliability goals. Regulatory reviews will have demonstrated cost and schedule predictability, with timely resolution of requests for additional information and issuance of safety evaluation reports. The review process will not create unacceptable project and schedule risks.
EPRI products will include technical reports, guidelines and companion training modules to help resolve the issues described above, addressing topics such as failure analysis, cyber security, software common-cause failure, human factors engineering, configuration management and lessons learned from operating experience. EPRI will make its computer-based training (CBT) modules available for use through INPO-WANO on-line training systems by the end of 2011, with additional modules later if needed. Much of this material will also be applicable to new plants and will be used accordingly. EPRI will also provide technical input to inform regulatory issues under the existing EPRI/NRC memorandum of understanding.

Industry Oversight: Organizations such as INPO and WANO will make the EPRI digital I&C CBT modules available to utility engineers. They will also ensure that utility engineers maintain competence on digital issues, that utility processes are updated to address specific digital system concerns such as configuration management and common-cause failure, and that the processes are being applied appropriately. Industry operating experience will be monitored to detect emerging digital I&C issues and share lessons learned.

Regulatory Interfaces: Organizations such as the Nuclear Energy Institute will use EPRI results in assessing regulatory uncertainty concerns, such as the content and timing of information needed in licensing submittals involving digital upgrades, and the possible update of existing regulator-endorsed guidance on common-cause failure in critical non-safety applications. Pilot application projects will be used to demonstrate the utility of proposed solutions and regulatory guidance.

Utilities/Suppliers: Utilities will apply EPRI and INPO guidelines and training materials along with relevant regulatory guidance and industry standards to develop and maintain proficiency in managing digital I&C, from specification to design evaluation, implementation, operation and maintenance, and obsolescence management planning. They will require suppliers, integrators and contractors to apply these materials on an as-needed basis. In some cases, operating plants may elect to wait for key regulatory and project issues to be resolved via new plant builds, and then apply the proven solutions and experience to reduce regulatory, cost and schedule risks.

PROJECT PLAN

EPRI will develop its guidance and training modules on a topic-by-topic basis, using technical advisory groups (TAG) comprised of knowledgeable utility, INPO, NEI and industry representatives. The TAGs will guide product development and act as reviewers and contributors to ensure that the products have appropriate scope, detail and practical utility for their intended users. Products will be updated on an as-needed basis as new information and operating experience become available, and new technical and regulatory issues come to light. When appropriate, EPRI products may be forwarded to others, for example to NRC for endorsement, to the Advisory Committee on Reactor Safeguards (ACRS) for information, to standards organizations for incorporation into their guidance, to NEI for use in supporting regulatory positions, and to INPO for training or further distribution through their channels.

Topic prioritization will be based on input from the I&C Integration Committee. Preference will generally be given to products with greater near term need/impact and/or broader applicability across reactor types and countries. Specific topics of interest will include:

- Computer-based training modules
- Failure analysis of digital systems
- Protecting against common-cause failure (CCF)
- Design and use of field programmable gate arrays (FPGA) in high integrity applications
- Lessons learned and case studies based on operating experience in U.S., Korea, Canada, France, Japan, etc.
- Human factors engineering (HFE) for digital interfaces
- Cyber security
- Application of risk methods to digital equipment
- Electromagnetic compatibility (EMC)
- Technical bases for resolution of regulatory issues (e.g., CCF, HFE, cyber, risk, EMC, failure analysis)
RISKS

I&C modernization competes with other issues that may need more immediate attention to maintain plant safety and operability. The regulatory environment may represent the most significant risk if progress is not made in finding practical, cost-effective resolutions to key issues. New builds will likely lead operating plants on some key issues; if their efforts falter, there will be a corresponding adverse impact on operating plant I&C modernization.