

MODERNIZATION TECHNOLOGY ASSESSMENT

MTA Number	MTA-EN-009		
Title			
Digital Safety-Related Instrumentation and Control (I&C) System Modernizations			
Description			
The safety related protection systems of nuclear power plants are almost entirely based on legacy analog equipment. There have been some partial replacements of the original analog non-safety related control systems in nuclear power plants, but the control systems remain mostly analog. Unlike many of the other systems consisting primarily of mechanical components in a power plant, the legacy I&C systems are obsolete, as the original manufacturers have dropped analog control and protection equipment from their product lines and now provide current control and protection systems that are digital. This shift from analog to digital has resulted in a challenging and expensive endeavor to re-engineer and manufacture new form, fit, and function replacement analog modules. Safety related I&C protection systems are complex. Much of the routine system testing involves verifying proper operation of groups of many individual electro-mechanical components to ensure the correct protective action is taken by the plant when the necessary conditions exist. This routine testing is time consuming and requires a team of trained I&C technicians to perform. This routine testing (and maintenance when required) requires the temporary bypass (i.e., disabling) of one of the redundant protection channels, shifting the system into a less reliable state to account for the bypassed channel. The modernization of these obsolete analog plant protection systems to digital will leverage the self-diagnostic and self-test features that are inherent to the digital solution, reducing the requirements for manual testing through automatic system checks, the overall component count (increasing reliability), the time that undetected failures exist through rapid detection with self-diagnostics, the time a protection channel is disabled for testing, and the number of technicians required to perform routine testing. This reduction in purchased materials, complexity, time, and required test and maintenance personnel provides the return on investment for the upgrade. Combined with the rising costs and decreasing supply of replacement components, maintaining legacy analog I&C systems is growing more expensive year by year. Though the complete replacement of a legacy I&C system requires a substantial up-front investment in planning and cost, the upgrade is projected to provide a sizeable return on investment over the life of the replacement system.			
Benefits			
Benefits Estimate		Level 3 – Annualized benefits are expected to be greater than \$5 million per year.	
Benefits Description		• Increased day-to-day reliability of the plant protection system through a reduction in time protection channels are inoperable. • Reduced time and cost for routine testing and maintenance. • Reduced time and cost for system repairs with higher reliability equipment. • Increased availability of replacement components by leveraging commercial off-the-shelf components.	

Costs and Schedule	
Cost	Level 1 – Greater than \$5 million. The cost for upgrading a safety related I&C system is expected to be more than \$80M for two units based on a pilot replacement effort which is still in progress. The effort was the first of its kind and the cost was much greater than expected. The cost of future endeavors is expected to be reduced through the implementation of lessons learned in a simplified, up-front license process, use of pre-qualified platforms with current Safety Evaluation Reports, and vendor selection processes. Note: Included in the cost estimate is the cost to pursue the NRC license amendment request (LAR).
Schedule	More than three years Total time may require 4 or 5 years to complete – this includes preparation for implementation and installation which may require an extended outage to complete the installation.
Scope Context	One two-unit plant. The specific scope for this digital upgrade is the I&C for Plant Protection System (reactor trip and engineered safety features systems)
Risks	
With substantial up-front cost, one of the greatest risks is a reliable return on investment. A positive ROI for digital I&C upgrades is realized over the course of years and relies on the continued operation of the plant. The US industry has only one plant's experience and guidance for navigating NRC's approval process, which has not yet been exercised. There is a risk with excessive NRC cycling through the relatively new regulatory guidance regarding digital I&C upgrades for safety related systems. There is little to no US operational experience to assist in improving the overall design, upgrade, and commissioning processes. Modern digital systems will require the appropriate cybersecurity measures to be implemented and require IT and I&C resources to maintain and operate.	
Administrative Items	
Date	12/14/21
Functional Area Where Benefits Will Be Realized	Engineering Operations Maintenance Supply Chain
Reference Implementation Guidance	Plant Modernization Business Case: Digital Safety-Related Instrumentation and Control (I&C) System Modernization (EPRI 3002020579) Digital Engineering Guide: Decision Making Using Systems Engineering (EPRI 3002011816) Business Case Analysis for Digital Safety-Related Instrumentation & Control System Modernizations (INL/EXT-20-59371)
Industry SME	EPRI - Matt Gibson Contact: NuclearPlantMod@epri.com
Previous Implementation	Please contact EPRI for implementation examples and contacts.
Implementation Enablers	N/A

SWEEP Score	• Cost - Level 1 – The first-of-a-kind digital plant protection system modernization is expected to cost more than \$80 million to implement for a two-unit plant. For future units, costs are expected to decrease. • Savings – Level 3 – Greater than \$5 million per year. • Payback – Level 1 – Payback period will be on the order of years and depend on the cost reduction for nth-of-a-kind implementation. For the first-of-a-kind plant, the payback period is expected to be over 15 years. • Technical Readiness – Level 2 – The technology is commercially available and pilot programs are starting. • Licensing Readiness – Level 3 – No regulatory change is required (the regulatory change has been implemented), but the implementation will require a LAR for each upgrading plant and unit. • Implementation Proficiency – Level 2 –The technology should be implemented by sites with experience with digital control systems.
Applicability	All reactor types All geographic regions
Keywords	Digital upgrade; instrumentation & control; reactor protection; safety-related; reliability; modernization
Business Case Analysis Cross-Reference	Plant Modernization Business Case: Digital Safety-Related Instrumentation and Control (I&C) System Modernization (EPRI 3002020579)

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