INL/EXT-14-33177

Light Water Reactor Sustainability Program

Advanced Instrumentation, Information, and Control Systems Technologies

Digital Architecture Project Plan

September 2014

U.S. Department of Energy

Office of Nuclear Energy

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Ken Thomas
Idaho National Laboratory

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FIGURES

ACRONYMS

CS	Cyber Security
DCS	Digital Control System
DOE	Department of Energy
EMC	Electromagnetic Compatibility
EPRI	Electric Power Research Institute
II&C	Instrumentation, Information, and Control
INL	Idaho National Laboratory
IT	Information Technology
I&A	Infrastructure and Applications
I&C	Instrumentation and Control
LWR	Light Water Reactor
LWRS	Light Water Reactor Sustainability
MOU	Memorandum of Understanding
NITSL	Nuclear Information Technology Strategic Leadership
NPP	Nuclear Power Plant
NSIAC	Nuclear Strategic Issues Advisory Committee
RD&D	Research, Development, and Demonstration
R&D	Research and Development
SQA	Software Quality Assurance
TAG	Technical Advisory Group

Digital Architecture Project Plan

1. Introduction

The U.S. nuclear power industry is significantly challenged with cost pressure as the rise of cheap natural gas has dramatically altered the electric generation market. This comes at a time when the industry is having to make substantial investments in safety improvements, such as those driven by Fukushima issues, that do not increase generation capacity or lower costs. The closing of Kewaunee Nuclear Station is an example of a solid, well-run nuclear plant being squeezed out of the electric generation market. [1]

Many other industries that have faced these kinds of pressures have had to restructure their business models to survive. In most cases, they have used new technologies to automate and streamline large portions of their operations. Some have been able to both improve operational reliability and quality while lowering cost.

There are many technologies available to the nuclear power industry to improve efficiency in plant work activities. These range from new control room technologies to those for mobile field workers. They can make a positive impact on a wide range of performance objectives – increase in productivity, human error reduction, validation of results, accurate transfer of data, and elimination of repetitive tasks.

It is expected that the industry will more and more turn to these technologies to achieve these operational efficiencies to lower costs. At the same time, this will help utilities manage a looming staffing problem as the inevitable retirement wave of the more seasoned workers affects both staffing levels and knowledge retention.

A barrier to this wide-scale implementation of new technologies for operational efficiency is the lack of a comprehensive digital architecture that can support the real-time information exchanges needed to achieve the desired operational efficiencies.

1.1 Digital Architecture

Digital Architecture is a term for the collection of information technology (IT) capabilities needed to support and integrate a wide-spectrum of real-time digital capabilities for nuclear plant performance improvement.

Even in today's more modernized nuclear power plants, the digital architecture for I&C systems typically extends only to the major protection and integrated controls systems. Data architectures to support plant work processes are intentionally separate due to cyber security concerns. No comprehensive data schema is available that relates all plant functions in the context of their real-world relationships, thereby defining the needed data interfaces to conduct plant functions and support activities in an integrated manner. This architecture would define the following:

- Systems that need to be integrated for robust plant protection and control
- Types of data busses and interfaces

- Cyber security requirements
- Failure and recovery requirements
- Necessary segmentation of the overall architecture to ensure independence of function and defense-in-depth
- Data relationships that are required to support plant functions, plant systems, plant processes, and plant worker activity
- External interfaces to enable remote operations and support activities; either at a fleet or industry level.

This project will define an advanced digital architecture that will accommodate the entire range of system, process, and plant worker activity to enable the highest degree of integration, thereby creating maximum efficiency and productivity. This pilot project will consider a range of open standards that are suitable for the various data and communication requirements of a seamless digital environment. It will map these standards into an overall architecture to support the II&C developments of this research program.

For the most part, this is an extension of the IT architecture already in place to serve business and process applications in a nuclear plant. However, there are emerging technologies that will need additions or enhancements to the IT architecture to support these applications in an acceptable manner. For example, this would include wireless communications throughout the plant to support mobile devices for field workers. There would need to be enough bandwidth to support data intensive applications and video streaming for real-time collaboration among remote parties. There will need to be seamless information transfer among systems that are now relatively isolated; for example, mobile devices receiving real-time data from plant I&C systems. And this digital architecture must conform to all policy and regulatory restraints, such as those involved in cyber security.

Foundational to this integration of digital technologies is a plant digital architecture that can provide the needed connectivity to support the large number and variety of concurrent work activities that are conducted in a nuclear plant, especially during outages. It must span what are today separate domains of the plant I&C systems and the plant work processes without compromising the integrity and security of these systems. It must further extend to the emerging mobile technologies to enable new levels of automation in field work activities.

1.2 Developing an Industry Consensus

It is recognized that different nuclear operating companies and their respective plants are in different starting positions with regard to digital architecture. And it is also recognized that the different companies have different outlooks and goals with respect to how much digital implementation they want to pursue. Yet, it is important that some degree of industry consensus be developed in this area for a couple of reasons. One is that the industry is in position to share best practices and pool the expertise and wisdom of many organizations in how to best achieve the optimum digital architecture. The second is in regard to the regulatory environment, where it is of concern. It is better to have standardized approaches in the industry which can be proven to meet regulatory requirements, rather than have each operating company pursue this independently.

To pursue this, several organizations with interest in this development met in July at the Nuclear Information Technology Strategic Leadership (NITSL) 2014 Workshop held in Dallas, Texas July 14-17. This included the NITSL Infrastructure and Application (I&A) Committee, the Idaho National Laboratory representing the Department of Energy's Light Water Reactor Sustainability (LWRS) Program, and the Electric Power Research Institute (EPRI). Information on the background and interests of these organizations is found in Section 2.0 of this report.

It was agreed by these organizations to work together to pursue the development of a guidance document for a nuclear power plant digital architecture. Each organization has a unique contribution to make in this regard and brings complementary resources to the effort. Collectively, this group will be designated a Technical Advisory Group (TAG). Each member of the TAG would participate as they are able in the following ways:

- Provides review of products and coordinates such reviews within each respective organization.
- Participates in technical working meetings to formulate requirements, concepts, and proposed technical approaches.
- Provides draft documents of assigned topics for milestone reports.
- Provides access to company organizations and information as needed for the technical work of the project.
- Hosts benchmark visits and other meetings with technical experts within the respective companies.

In all, collaboration between NITSL, EPRI, and the LWSRP II&C Pathway could be a major impetus to the adoption of beneficial digital technologies for operating nuclear plants. The effort would serve to collect operating experience and best practices for a robust digital architecture for integrated plant applications. The results of this project would likely have a positive impact on operational performance for the operating nuclear plants and provide a forward path for continuous business improvement.

2. Background

The Digital Architecture project will be conducted by three organizations that are individually involved in technology developments to improve nuclear plant operations. These are:

- The U.S. Department of Energy (DOE) [through work on the Light Water Reactor Sustainability Program - Instrumentation, Information, and Control (II&C) Systems Technologies Pathway, being conducted by Idaho National Laboratory]
- Nuclear Information Technology Strategic Leadership (NITSL)
- Electric Power Research Institute (EPRI).

This proposed collaboration began in July of 2013 when the LWRS Program – II&C Pathway was invited by NITSL to present its research program objectives and activities during the 2013 NITSL

Workshop held in Detroit, Michigan. The presentation resulted in interest on the part of the NITSL Infrastructure and Applications (I&A) Committee for a follow-up meeting with the II&C Pathway to learn more about the pilot projects and the related technology development.

A meeting for this purpose was held at Idaho National Laboratory on February 26-27, 2014, attended by 11 representatives of NITSL and two representatives of EPRI. (Refer to Appendix A for a list of attendees) In addition to the NITSL I&A Committee, the Digital Control System (DCS) Committee and the Cyber Security (CS) Committee were also represented, as well as the NITSL Executive Committee (governance and oversight).

The pilot project technologies were presented and demonstrated for this group, which resulted in the identification of a number of common interests of the three organizations represented. There was specific interest in the proposed Digital Architecture Pilot Project, in recognition of common interests with the I&A Committee. Subsequent to this meeting, the II&C Pathway submitted a proposal the NITSL Executive Committee for collaboration in this pilot project beginning in FY 2015. The NITSL Executive Committee in turn invited the II&C Pathway to formally present the proposal to NITSL in a special meeting arranged during the 2014 NITSL Workshop, held July 13-17, 2014, in Dallas, Texas. EPRI participated in the meeting also and presented their perspectives and interest in the project. The meeting was well-attended by nuclear utilities and resulted in good input for the formulation of the Digital Architecture Pilot Project Plan.. The meeting documentation is provided in Appendices B through F.

Based on the discussion and interest in this collaboration expressed in the meeting, the NITSL Executive Committee on July 24, 2014, endorsed the project collaboration and granted INL Advisory Member status for the purposes of this project. This provides direct access to the NITSL member web site and organizational documents with no fee. This will allow the project to contribute content to the web site in support of the Digital Architecture Pilot Project as needed, and serve as an information conduit to the participating nuclear utilities for this purpose. EPRI has previously been granted Advisory Member status and therefore has the same access to NITSL documentation and web services.

The next action was for the II&C Pathway to develop a project plan for the pilot project with an expected start in the early part of FY 2015. This action has been completed with the issue of this report. A kick-off meeting for the project will be scheduled in the first quarter of FY 2015 involving the NITSL and EPRI representatives listed in Appendix G, along with any new participants that are identified.

The following sections provide information on the three participating organizations and their related programs and objectives.

2.1 Department of Energy Light Water Reactor Sustainability Program

The Light Water Reactor Sustainability (LWRS) Program is a research and development program sponsored by the Department of Energy, which is conducted in close collaboration with industry to provide the technical foundations for licensing and managing the long-term, safe and economical operation of current nuclear power plants [2]. The LWRS Program serves to help the US nuclear industry adopt new technologies and engineering solutions that facilitate the continued safe operation of the plants and extension of the current operating licenses.

Within the LWRS Program, the Advanced Instrumentation, Information, and Control (II&C) Systems Technologies Pathway conducts targeted research and development (R&D) to address aging and reliability concerns with the legacy instrumentation and control and related information systems of the

U.S. operating light water reactor (LWR) fleet. This extends to the information and technology applications that support the wide spectrum of plant support activities. The II&C Pathway is conducted by Idaho National Laboratory (INL).

The Program has two over-arching goals: (1) to ensure that legacy analog II&C systems are not life-limiting issues for the LWR fleet, and (2) to implement digital II&C technology in a manner that enables broad innovation and business improvement in the nuclear power plant operating model. These goals are addressed through a series of pilot projects to develop and demonstrate new technologies that can effect transformative change in the operations and support of nuclear plants.

A major premise of the R&D program is that significant business improvement can be achieved through the integration of plant systems, plant processes, and plant workers through the application of digital technology. For example, data from digital II&C in plant systems can be provided directly to work process applications and then, in turn, to plant workers carrying out their work using mobile technologies. This saves time, creates significant work efficiencies, and reduces errors. A major objective of the R&D program is the development of a seamless digital environment for plant operations and support by integrating information from plant systems with plant processes for plant workers through an array of interconnected technologies.

- Plant systems – beyond centralized monitoring and awareness of plant conditions, deliver plant information to digitally based systems that support plant work and directly to workers performing these work activities.
- Plant processes – integrate plant information into digital field work devices, automate many manually performed surveillance tasks, and manage risk through real-time centralized oversight and awareness of field work.
- Plant workers – provide plant workers with immediate, accurate plant information that allows them to conduct work at plant locations using assistive devices that minimize radiation exposure, enhance procedural compliance and accurate work execution, and enable collaborative oversight and support even in remote locations.

Figure 1 Seamless Digital Environment

The intent of Digital Architecture Pilot Project is to provide a long-term strategy to achieve this broad integration plant systems, plant processes, and plant workers. At the same time, the strategy must be sufficiently flexible such that does not infringe on company-specific standards and product preferences. It further needs to identify current gaps in digital infrastructure technologies and standards that will be needed for the full seamless integration that is envisioned.

2.2 NITSL I&A Committee Background

The Nuclear Information Technology Strategic Leadership (NITSL) organization is a forum to provide leadership and strategic guidance for information technology in the nuclear industry. [3]

The goal of NITSL is to be recognized by the nuclear industry as the authoritative source for leadership and strategic guidance related to nuclear business information technology and plant technology systems pertinent to safe, secure, reliable, and cost effective nuclear power generation. This goal is achieved by information sharing through benchmarks, operating experience and workshops.

The purpose of NITSL is to coordinate a consistent direction in industry-wide initiatives, and serve as an interface for communications with regulators and industry groups. NITSL is a topical area within INPO and receives their primary governance and oversight through the Institute of Nuclear Power Operations (INPO) and the Nuclear Strategic Issues Advisory Committee (NSIAC). These bodies ultimately have overall strategic direction and authority over the organization.

The current functional and topical focus areas of NITSL provide strategic direction and support for the following four (4) core process initiatives distinct to nuclear power generation:

- Software Quality Assurance (SQA)
- Cyber Security for Nuclear Power Reactors (CS)
- Digital Control Systems (DCS)
- Infrastructure and Applications (I&A)

The NITSL Executive Committee supports a Standing Committee for each of these core initiatives. Each Standing Committee has a Chairperson and Executive Sponsor. Standing Committees are expected to stay abreast of emergent regulations and best practices with the goal of providing useful products and a forum for industry wide feedback to the membership of NITSL. The NITSL Executive Committee may commission new projects and/or standing committees to address other industry needs.

2.3 Electric Power Research Institute Background

The Electric Power Research Institute, Inc. (EPRI) conducts research, development and demonstration (RD&D) relating to the generation, delivery and use of electricity for the benefit of the public. [4] A significant part of EPRI's work is in support of nuclear energy, including the development of new technologies for the currently operating nuclear fleet. EPRI serves as the primary research organization for the nuclear power industry and conducts research in virtually all aspects of nuclear plant operations and support. EPRI has conducted research in the area of digital technology for decades and has produced numerous technical reports and guideline documents in this area. Many of these are accepted by the nuclear power industry as authoritative references and preferred methodologies for the technical topics they address. Some are endorsed by the Nuclear Regulatory Commission (NRC).

Recognizing the challenges associated with pursuing commercial NPP operations beyond 60 years, the U.S. Department of Energy's (DOE) Office of Nuclear Energy (NE) and the Electric Power Research Institute (EPRI) established separate but complementary research and development programs [DOE Light Water Reactor Sustainability (LWRS) Program and EPRI Long Term Operations (LTO) Program] to address these challenges. [5] To this end, DOE-NE and EPRI executed a Memorandum of Understanding (MOU) in late 2010 to "establish guiding principles under which research activities (between LWRS and LTO) could be coordinated to the benefit of both parties." EPRI agreed to assist with the transfer of technology to the nuclear utilities by publishing formal guidelines documents for each of the major areas of development. This provides a major benefit to the LWRS research program by engaging the EPRI-sponsored industry groups and utility contacts where technical interests match up with the pilot project technologies and concepts.

In keeping with the provisions of the MOU, EPRI has contributed to and participated in many of the LWRS Program II&C pilot projects over the past four years and these collaborations are ongoing. The Digital Architecture pilot project is another such project where collaboration is mutually beneficial. EPRI recognizes that the concepts of a digital architecture are foundational to the integration of digital technologies within a nuclear plant in order to maximize improvement in plant performance and work efficiency. EPRI is able to contribute significant expertise in topics related to digital architecture. Moreover, EPRI is able to engage nuclear utility staff in the project effort through the EPRI-sponsored industry groups. For these reasons, EPRI has agreed to actively participate in the pilot project as a full research partner.

3. Objective

The objective of this project is to develop an industry consensus document on how to scope and implement the digital architecture that is needed to support a vast array of real-time digital technologies to improve NPP work efficiency, to reduce human error, to increase production reliability and to enhance nuclear safety. A consensus approach is needed because:

- There is currently a wide disparity in nuclear utility perspectives and positions on what is prudent and regulatory-compliant for introducing certain digital technologies into the plant environment. For example, there is a variety of implementation policies throughout the industry concerning electromagnetic compatibility (EMC), cyber security, wireless communication coverage, mobile devices for workers, mobile technology in the control room, and so forth.

- There is a need to effectively share among the nuclear operating companies the early experience with these technologies and other forms of lessons-learned. There is also the opportunity to take advantage of international experience with these technologies.

- There is a need to provide the industry with a sense of what other companies are implementing, so that each respective company can factor this into their own development plans and position themselves to take advantage of new work methods as they are validated by the initial implementing companies. In the nuclear power industry, once a better work practice has been proven, there is a general expectation that the rest of the industry will adopt it. However, the long-lead time of information technology infrastructure could prove to be a delaying factor.

A secondary objective of this effort is to provide a general understanding of the incremental investment that would be required to support the targeted digital technologies, in terms of an incremental investment over current infrastructure. This will be required for business cases to support the adoption of these new technologies.

4. Scope

The scope of this effort is the digital architecture to support advanced digital technologies that can improve nuclear plant operational and support activities. This includes an array of technologies to improve nuclear worker efficiency and human performance; to offset a range of plant surveillance and testing activities with new on-line monitoring technologies; improve command, control, and collaboration in settings such as Outage Control Centers and Work Execution Centers; and finally to improve operator performance with new operator aid technologies for the control room. It excludes more general business and administrative IT requirements such as financial and human resources information systems, although it will describe interfaces to these systems where needed.

5. Development Method

A multi-year effort will be conducted to define the requirements and implementation guidelines for a digital architecture that represents a consensus of the nuclear utilities and has broad applicability to the range of needs and implementation options. It is important for this development process to include adequate time for utilities to review and provide input such that this consensus is reached. It is not anticipated that there will be universal agreement on all parts of it, but rather due process will be taken to ensure that all points of view are considered and that the product represents as broad and flexible approach as practical.

Working as a team with LWRS Program, NITSL, and EPRI participation, the following tasks will be undertaken.

5.1 FY 2015 Tasks and Activities

Determine the requirements for the Digital Architecture in terms of the scope and types of I&C and IT capabilities needed to support NPP work activities employing the new digital technologies. The methodology will be to determine the expected extent of usage of advanced digital technologies within nuclear plant work activities and to derive a projection of the related I&C and IT capabilities needed to enable the features of the technologies on a production scale. It is important to note that the requirements will be stated in terms of application feature parameters rather than I&C and IT capacity and performance parameters. For example, for an automated work package application, the number of reference documents that might be requested for real-time download would be projected as opposed to the data through-put requirements to provide these downloads. These work activity parameters will be translated to estimates of I&C and IT capacity and performance requirements in a later phase of this pilot project.

To develop the requirements, a multi-day working meeting of the TAG will be held to obtain performance expectations for the range of envisioned digital technologies. Prior to this meeting, the TAG members will obtain data from their respective organizations related to the extent and frequency of usage of the technologies (e.g. the number of procedures completed on an annual basis). Standard surveys will be provided for this purpose. During the working meeting, the TAG will normalize these data for the industry and determine the operational requirements to use these technologies at full scale both during on-line and outage periods. These data will be organized into tables with explanatory information and circulated to industry stakeholders for review and comment. Finally, this information will be organized into a Digital Architecture Requirements Report as the first project milestone deliverable, to be published by March 31, 2015.

To better understand development priorities, a gap analysis will be conducted to determine where typical NPPs are today in terms of deploying the required Digital Architecture. This will be accomplished using surveys and on-site assessments with partnering nuclear utilities to determine to what extent they could support the future digital technology environment with their existing I&C and IT structure, and where gaps exist with respect to the full deployment of technology over time. This information will be compiled and summarized, along with general observations and recommendations. It will be used in the next phase of this pilot project to prioritize where focus is needed in defining and providing guidance for enhancing the digital architecture of nuclear plants. The member companies of the TAG will be solicited to serve as benchmark sites both for the surveys and on-site assessments. An effort will be made to include a range of operational circumstances such as large fleets, multi-unit sites, and single unit sites. The range would also cover various degrees of current digital technology implementations.

The approach will be to compare a station's current IT infrastructure to a projection of how well it could support the future requirements listed in the Digital Architecture Requirements Report. This will be by both the type of capability and the capacity to support full-scale implementation of the digital technologies. The information will be organized into tables for comparison among the surveyed stations. The specific identities of the stations will be withheld in any draft or final documents produced. A summary of this information will be published as the Digital Architecture Gap Analysis Report, to be published by September 30, 2015. This report will be a key input to a later project task of developing a guidance document for implementing the Digital Architecture conceptual model.

5.2 FY 2016 Tasks and Activities

A conceptual model of the Digital Architecture will be developed based on the performance requirements documented in the Digital Architecture Requirements Report. The model will relate these requirements to the corresponding IT infrastructure components and their respective capacity and performance requirements. For example, if a certain number of real-time remote collaboration sessions using streaming video are conducted concurrently, what is the required bandwidth for a wireless communication system and what is the required plant area coverage? In addition to requirements, constraints will also be identified such as electromagnetic compatibility (EMC) concerns in the vicinity of sensitive electronic equipment.

The various technical components of the conceptual model will be identified and scoped for development. The conceptual model must be flexible and modular, so that it can be implemented either partially or fully, depending on the need of the utility and the types of digital technologies they desire to implement. The conceptual model must also relate in a natural understandable manner to the existing information technology architectures found in today's operating nuclear plants.

A multi-day working meeting of the TAG will be held to develop the objectives, IT components, and representative capacities of the conceptual model. A draft conceptual model will be distributed to the TAG, Utility Working Group, and other interested contacts for review and comment. Following this, the model will be updated and completed for publication as a milestone deliverable for the pilot project.

It should be noted that this task is not dependent on completing the Digital Architecture Gap Analysis Report and could be started in FY 2015 if additional project funding and technical resources can be obtained.

5.3 FY 2017 Tasks and Activities

A guidelines document for utilities to implement the Digital Architecture Conceptual Model will be developed to assist with the scoping effort for IT upgrades for the support of targeted digital technologies. This document will reflect the combined experience and expertise of the TAG in how to assess the desired performance levels of the digital technologies and translate them to the performance requirements of the conceptual model in its implemented form. As mentioned previously, the guidelines will allow for a graded approach so that only the components needed to support the targeted technologies need be considered. The guidelines will be general and flexible enough to fit within the respective utilities' corporate standards and policies for IT implementation.

The previously developed Digital Architecture Gap Analysis Report will also be used to provide guidance on determining the relative effort and cost for a given utility to expand its current IT infrastructure to that required for the digital technologies that they desire to implement. This is the determination of the incremental cost over the cost of present capabilities for a target digital work environment. From this information, a general business case can be derived based on the benefits expected from digital technologies, many of which are being documented in a separate pilot project. It is expected that this business case information will be of interest to senior utility leadership in assessing the potential of these technologies to actually lower the cost of operation

A working meeting of the TAG will be held to develop the guidelines. It will reference standard approaches and good practices while, at the same time, will incorporate considerations specific to nuclear plant implementation. The working meeting will be used to develop annotated outlines for each of the major sections of the guidelines document. Following the working meeting, a draft document will be produced for review and comment by the TAG, Utility Working Group, and other industry stakeholders. This input will be used to develop the completed Digital Architecture Implementation Guideline as the final project deliverable.

6. Project Deliverables

The following project deliverables will be produced as a result of the project activities described in this plan.

- (FY 2014 – half year) Project Plan, including the project description, scope, and schedule. (Complete – Published report *Digital Architecture Project Plan, INL/EXT-14-33177*)
- (FY 2015) Complete a Digital Architecture Requirements Report documenting the information technology requirements for advanced digital technology applied as envisioned to be applied to NPP work activities.
- (FY 2015) Complete a Digital Architecture Gap Analysis Report documenting the gap between current typical I&C and IT capabilities in NPPs vs. those documented in the Digital Architecture Requirements Report.
- (FY 2016) Complete a Digital Architecture Conceptual Model, including a methodology for mapping the support requirements for digital technologies into the digital architecture.
- (FY 2017) Complete a Digital Architecture Implementation Guideline, documenting a graded approach in applying the conceptual model to selected digital technologies and in determining the incremental IT requirements based on a current state gap analysis.

7. Project Resources

The project is currently planned as a three and a half year effort with the first half year focused on the development of the project plan (completed). It is possible that the schedule can be accelerated depending on the amount of funding that can be obtained, the availability of additional technical resources, and the pace at which the industry stakeholders would desire to see this work completed.

INL will serve as the project manager and will be responsible for core work activities such as facilitating the TAG, facilitating the TAG working meetings, producing project materials, and producing project deliverables. The TAG will likely meet one or two times a year, including the annual NITSL workshop. INL will provide resources for this effort though the Light Water Reactor Sustainability Program – Instrumentation, Information, and Control Systems Technologies Pathway.

NITSL will sponsor collaboration through its Infrastructure and Application (I&A) Committee, providing opportunity for its member utilities to participate in the effort (including the other NITSL committees). These members will compose the Technical Advisory Group and will participate at their own expense. Individual TAG members will be attend the working meetings and participate in the scheduled conference calls. They will make available to the group any relevant materials from their respective companies consistent with any proprietary information protections. At this time, it is not anticipated that Non-Disclosure Agreements with the participating organizations would be needed in that the project documents, materials and deliverables are intended to be widely disseminated throughout the nuclear industry. Individual members of the TAG might participate in developing some portions of the project materials and deliverables as they are able.

EPRI will participate both as a co-developer and a member of the TAG. EPRI will provide relevant resource material as needed as well as provide access to technology experts on relevant topics of the Digital Architecture. EPRI will also be instrumental in publicizing this within the nuclear industry through their various utility contacts and technical committees.

8. References

1. Dominion Resources, Inc. News Release, October 22, 2013, *Dominion to Close Kewaunee Power Station*
2. Hallbert, B.P., Thomas, K.D. (2014) *Light Water Sustainability Program Advanced Instrumentation, Information, and Control Systems Technologies Technical Program Plan for 2014, INL/EXT- 13-28055, Revision 3*. Idaho Falls: Idaho National Laboratory
3. Nuclear Information Technology Strategic Leadership (NITSL) Web Site https://www.nitsl.org/Shared%20Documents/NITSL%20Overview%20OneSheet.pdf, 2014
4. Electric Power Research Institute (EPRI) Web Site, http://www.epri.com/About-Us/Pages/Our-Business.aspx, 2014
5. Department of Energy (2013) *DOE-NE Light Water Reactor Sustainability Program and EPRI Long Term Operations Program – Joint Research and Development Plan, INL/EXT-12-24562A, Revision 1*. Idaho Falls: Idaho National Laboratory

Appendix A
February 26-27, 2014 LWRS/NITSL/EPRI Joint Meeting Attendance List

Name	Organization	Representing
Bruce Gordon	Arizona Public Service	NITSL – I&A Committee
Ann Orr	Arizona Public Service	NITSL – I&A Committee
Darwin Hollingsworth	Southern Nuclear	NITSL – I&A Committee
Amy Houston	Southern Nuclear	NITSL – CS Committee
Eric Jurotich	Southern Nuclear	NITSL – I&A Committee
Jeff Keith	Duke Energy	NITSL – I&A Committee
Lakshminarayanan Rajagopalan	SCANA	NITSL – I&A Committee
Ed Greco	SCANA	NITSL – I&A Committee
Nathan Faith	Exelon Nuclear	NITSL – CS Committee
Larry Cerier	Exelon Nuclear	NITSL – CS Committee
Craig Crandall	Constellation Energy	NITSL – DCS Committee
Joe Naser	EPRI	EPRI – I&C
Rick Rusaw	EPRI	EPRI – I&C
Bruce Hallbert	INL	LWRS Program – II&C
Ken Thomas	INL	LWRS Program – II&C
Ron Boring	INL	LWRS Program – II&C
Shawn St. Germain	INL	LWRS Program – II&C
Ron Farris	INL	LWRS Program – II&C
Johanna Oxstrand	INL	LWRS Program – II&C
Nancy Lybeck	INL	LWRS Program – II&C
Vivek Agarwal	INL	LWRS Program – II&C

I&A Committee: Infrastructure and Application Committee

CS Committee: Cyber Security Committee

DCS Committee: Digital Control System Committee

Appendix B
July 14, 2014 LWRS/NITSL/EPRI Joint Meeting – Proposal Handout

Idaho National Laboratory – Light Water Reactor Sustainability Program
Proposal for Collaboration on Digital Architecture to Support Integrated Digital Technologies
February 28, 2014

The Light Water Reactor Sustainability (LWRS) Program is a research and development program sponsored by the Department of Energy, which is conducted in close collaboration with industry to provide the technical foundations for licensing and managing the long-term, safe and economical operation of current nuclear power plants. The LWRS Program serves to help the US nuclear industry adopt new technologies and engineering solutions that facilitate the continued safe operation of the plants and extension of the current operating licenses.

Within the LWRS Program, the Advanced Instrumentation, Information, and Control (II&C) Systems Technologies Pathway conducts targeted research and development (R&D) to address aging and reliability concerns with the legacy instrumentation and control and related information systems of the U.S. operating light water reactor (LWR) fleet. This extends to the information and technology applications that support the wide spectrum of plant support activities. The II&C Pathway is conducted by Idaho National Laboratory (INL).

The Program has two over-arching goals: (1) to ensure that legacy analog II&C systems are not life-limiting issues for the LWR fleet, and (2) to implement digital II&C technology in a manner that enables broad innovation and business improvement in the nuclear power plant operating model. These goals are addressed through a series of pilot projects to develop and demonstrate new technologies that can effect transformative change in the operations and support of nuclear plants.

A major premise of the R&D program is that significant business improvement can be achieved through the integration of plant systems, plant processes, and plant workers through the application of digital technology. For example, data from digital II&C in plant systems can be provided directly to work process applications and then, in turn, to plant workers carrying out their work using mobile technologies. This saves time, creates significant work efficiencies, and reduces errors. A major objective of the R&D program is the development of a seamless digital environment for plant operations and support by integrating information from plant systems with plant processes for plant workers through an array of interconnected technologies.

- Plant systems – beyond centralized monitoring and awareness of plant conditions, deliver plant information to digitally based systems that support plant work and directly to workers performing these work activities.

- Plant processes – integrate plant information into digital field work devices, automate many manually performed surveillance tasks, and manage risk through real-time centralized oversight and awareness of field work.

- Plant workers – provide plant workers with immediate, accurate plant information that allows them to conduct work at plant locations using assistive devices that minimize radiation exposure, enhance procedural compliance and accurate work execution, and enable collaborative oversight and support even in remote locations.

Foundational to this integration of digital technologies is a plant digital architecture that can provide the needed connectivity to support the large number and variety of concurrent work activities that are conducted in a nuclear plant, especially during outages. It must span what are today separate domains of the plant I&C systems and the plant work processes without compromising the integrity and security of these systems. It must further extend to the emerging mobile technologies to enable new levels of automation in field work activities.

One of the currently-planned pilot projects for the II&C Pathway is the definition of this supporting digital architecture. The intent of this project is to provide a long-term strategy to achieve this broad integration reflecting best industry practices. At the same time, the strategy must sufficiently flexible such that does not infringe on company-specific standards and product preferences. It further needs to identify current gaps in digital infrastructure technologies and standards that will be needed for the full seamless integration that is envisioned.

The II&C Pathway would prefer to conduct this effort in collaboration with nuclear utilities so that it is fully supportive of the requirements and desired outcomes of these operating companies. Development of a working relationship with the Nuclear Information Technology Strategic Leadership (NITSL) would be a very effective means of achieving this interaction. It is important that the strategy represents a broad consensus within the nuclear industry and NITSL is particularly well-positioned to facilitate this level of industry participation.

The project is currently planned as a three and a half year effort with the first half year focused on the development of the project description, scope and schedule. It is proposed that NITSL solicit its member utilities for interest in participation in a working group under the I&A Committee (or other suitable arrangement) to work with the II&C Pathway. While there would be no set limit on the number of industry participants in the working group, a range of eight to twelve members would be a desirable target.

INL would provide information technology resources to conduct the technical work. The working group could either serve in an advisory role or participate in the actual project work if individual companies are willing to commit resources for this purpose. The project could also incorporate any relevant work by NITSL or the individual companies that could be made available.

The working group would likely meet one or two times a year (one of the meetings in association with the Summer Workshop), with the remaining interactions accomplished by web meetings and electronic document exchanges.

Proposed Milestones and Products:

- (FY 2014 – half year) Project Plan, including the project description, scope, and schedule.
- (FY 2015) Gap analysis between a typical nuclear plant digital architecture (current state) and the requirements to support a seamless digital architecture connecting plant systems, plant processes, and plant workers.

- (FY 2016) Conceptual model for a digital architecture and a methodology for mapping NPP operational and support activities into the digital architecture.
- (FY 2017) Project report on an advanced digital architecture for a nuclear power plant seamless digital environment, with guidance on how to apply the architecture to an NPP's established data network systems. The report could be co-published by NITSL and INL, and/or there could be separate reports produced with somewhat different purposes.

In all, collaboration between NITSL and the LWSRP II&C Pathway could be a major impetus to the adoption of beneficial digital technologies for operating nuclear plants. The effort would serve to collect operating experience and best practices for a robust digital architecture for integrated plant applications. The results of this project would likely have a positive impact on operational performance for the operating nuclear plants and provide a forward path for continuous business improvement.

2014 Scope: This project will pursue a joint plan with the Nuclear Information Technology Strategic Leadership (NITSL) group for the development of a standard digital architecture for deploying II&C Pathway technologies. This has the potential to accelerate the current schedule of this pilot project and obtain substantial nuclear industry involvement and resource commitment through NITSL.

Components of the Digital Architecture Joint Plan

1. Introduction
2. Objective – Provide seamless information flow among plant systems, plant processes, and plant workers in a manner that supports real-time plant work activities.
3. Product – Consensus Guideline for Digital Architecture – co-logo of NITSL and LWRS Program (INL)
4. Development Method
   - 4.1. Gap Analysis on current nuclear plant information architecture implementations and that needed to address objective of the project.
   - 4.2. Conceptual Model and Methodology for mapping NPP operations and support activities into a plant digital architecture
   - 4.3. Description of the NPP Digital Architecture and Guidance on Application (migration from typical current implementations)
5. Description of NITSL-INL collaborative effort
   - 5.1. Nuclear Utility Participation
   - 5.2. Core Technical Team
   - 5.3. Consultants
   - 5.4. Resource Requirements
6. Constraints – Utility Policies and Practices, Technology, Cyber Security, Nuclear Design Criteria, etc.
7. Ongoing Product Support
8. Attachment : Digital Architecture Annotated Outline with Topic Assignments

Appendix C
July 14, 2014 LWRS/NITSL/EPRI Joint Meeting Agenda

Idaho National Laboratory
DOE Light Water Reactor Sustainability Program
Instrumentation, Information, and Control Systems Technologies Research Pathway

Discussion with NITSL on a Nuclear Plant Digital Architecture
July 14, 2014, 8 AM – 12 PM

Agenda

1.	Introduction and Project Background	8:00 AM
2.	Purpose and Objective	8:15 AM
3.	Product	8:45 AM
4.	Development Method	9:15 AM
5.	Project Team	10:15 AM
6.	Project Logistics (Meetings, Conference Calls)	10:45 AM
7.	Reporting	11:15 AM
8.	Other Concerns	11:30 AM
9.	Adjourn	12:00 PM

Note: Breaks will be called as needed.

Appendix D
July 14, 2014 LWRS/NITSL/EPRI Joint Meeting Attendance List

Last Name	First Name	Company
Barr	Charles	PG&E
Buxbaum	Mark	Enercon
Dolansky	Stephen	Rolls-Royce
Forbes	Julia	Altran
Gordon	Bruce	APS
Jordan	James	Invensys
Jurtich	Eric	Southern
Keith	Jeff	Duke
Loose	Brian	Luminant Power
Martin	Ben	Luminant Power
Mitchell	John	Duke
Naser	Joe	EPRI
Rajagopalan	Lakshminarayanan	SCANA
Varga	Dan	Exelon
Boudreaux	Chris	STP
Gibson	Matt	EPRI
Amin	Jay	Luminant Power
Skranning	Gyrd	Halden
Thomas	Ken	INL

Appendix E
July 14, 2014 LWRS/NITSL/EPRI Joint Meeting
Preliminary Topics to be addressed in the Digital Architecture

1. Policies and Principles
2. Standards and Guidelines
3. Application Requirements
    - 3.1. Real-time Collaboration
        - 3.1.1. Video Streaming
        - 3.1.2. Voice
        - 3.1.3. Pictures
        - 3.1.4. Groupware
    - 3.2. Real-time Business Processes
        - 3.2.1. Work Management Activities
        - 3.2.2. Risk Management Activities
        - 3.2.3. Plant Rounds
        - 3.2.4. Operational Activities
        - 3.2.5. Security Activities
        - 3.2.6. Management Oversight and Decision-Making Support
    - 3.3. On-Line Monitoring of Systems and Components
        - 3.3.1. Data Acquisition
        - 3.3.2. Pattern Recognition/Diagnostics/Prognostics (Remaining Useful Life)
    - 3.4. Computerized Operator Support Systems
        - 3.4.1. Plant/System Simulation
        - 3.4.2. Sensor Validation
        - 3.4.3. Fault Diagnosis and Mitigation
    - 3.5. Real-Time Worker Support
        - 3.5.1. Training Videos
        - 3.5.2. Operating Experience
        - 3.5.3. Reference Material
        - 3.5.4. Document Retrieval
        - 3.5.5. Augmented Reality
4. Services and Common Solutions
5. Technology

- 5.1. Platforms/Servers/Computers
- 5.2. Networks/Communications
  - 5.2.1. LANs
  - 5.2.2. WiFi
  - 5.2.3. Process Systems Networks (Field Bus, Profibus, etc.)
  - 5.2.4. Business Process Networks
  - 5.2.5. Mobile Device Networks
  - 5.2.6. Internet connectivity
- 5.3. Data Bases/Historians
- 5.4. User Devices
  - 5.4.1. Desktop
  - 5.4.2. Mobile
- 5.5. Worker Device Location/Orientation
- 5.6. Component Identification/Position Technology
  - 5.6.1. Bar codes
  - 5.6.2. OCR
  - 5.6.3. RFID
  - 5.6.4. Machine Vision
  - 5.6.5. Position Sensors
- 5.7. Cyber Security
  - 5.7.1. Layers
  - 5.7.2. Access/Authentication
  - 5.7.3. Controls
- 5.8. Virtual Organization Support
  - 5.8.1. Video Conferencing
  - 5.8.2. Remote data access

6. Performance
   - 6.1. Bandwidth/Contention
   - 6.2. Latency of Data Update
   - 6.3. Scalability
   - 6.4. Segmentation
   - 6.5. Portability (renderings, XML)
   - 6.6. Connectivity
7. Configuration Management
   - 7.1. Regulatory Requirements

7.2. Corporate Policy

Appendix F

July 14, 2014 LWRS/NITSL/EPRI Joint Meeting – Participant Input

- Need to determine the minimal requirements to make sure of the integrity of information going out to field workers and other people/systems.
- Need to research and propose I&C architectures to support the goals of the information architecture. Common block diagrams of I&C architectures (different equipment probably) will support standardization.
- Systems will be evolving and guidance is needed so that they evolve in a manner that meets the planned goals. The digital architecture must be specified in a manner that does not burn bridges for future improvement.
- Need to be able to foresee what is needed and work towards enabling it.
- The information architecture needs guidance for creating a business case to develop it.
- Need to be able to say that when something is converted to digital, that the information architecture represents the smart way to do it. Information flow is the business model.
- The NPP business model can be changed by improved use of information and its flow paths. Need to optimize operations.
- Need to be aware that how information is presented to people (between people) is critical to making sure they have the same context and same understanding.
- Concern expressed that three years is too long for this project. It is needed sooner.
- How can you know what the architecture needs to look like if you don't know what applications are going to be implemented? Even knowing that, you still need to test the solution to know the best way to implement it to get the desired benefits.
- There is a chicken and egg situation with the architecture and the applications. Needs to be iterative. Want a platform (architecture) that can support a wide variety of applications – including thinks not defined at the time. Expandable platform that will be changed over time. Example – iPhone with apps – new apps keep being added on the platform.
- Suggest milestone deliverables as useful products before the end of the project.
- Architecture not an all or nothing – will grow with it. Need guidance to support putting in pieces which will provide benefits, but also guidance that allows adding pieces with the end vision in mind even if we never get there. Also, even the end vision might change over time due to new technologies.
- Could give guidance for a good foundation, and then add other pieces over time.
- Add early predictive monitoring under Section 3.3.
- Broaden 3.5.1to more than just passive videos because retention may be about 30% for passive but interactive training shows retention of 75-90%).
- Architecture needs to have information connection scheme – needs to have segmentation.
- Group should meet twice a year if possible. Have meetings in a location close to the majority of the participants.
- Need interaction with INPO.
- Need to interface with the NITSL DCS Committee.

Appendix G
Digital Architecture Technical Advisory Group – Initial Membership

Participant	Organization	Representing
Ken Thomas	DOE - INL	DOE - INL
Joe Naser	EPRI	EPRI
Matt Gibson	EPRI	EPRI
Bruce Gordon	Arizona Public Service	NITSL
Jeff Keith	Duke Energy	NITSL
Eric Jurotich	Southern Nuclear	NITSL
Nathan Faith	Exelon Nuclear	NITSL
Janice Schramel	Xcel	NITSL
Ed Greco	SCANA	NITSL
Dan Varga	Exelon – Nine Mile Point	NITSL