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U.S. NRC AND ALTRAN SOLUTIONS ENGINEERING TRAINING FOR DIGITAL SYSTEMS

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ABSTRACT

Chairman Klein of the U.S. Nuclear Regulatory Commission (NRC) has addressed public stakeholders by stating; "A Key concern for regulators is understanding how new technologies in digital information and control and human-machine interface will be integrated with the most important priority: safety." This paper presents an overview of the NRC Engineering Training Program for Licensing Digital Instrumentation & Control Systems, conducted by NRC from 2004 to present at NRC Headquarters and Regional training facilities. NRC developed an outline of required subject matter addressing lessons learned, licensing roadmap, environmental qualification and life-cycle management for digital instrumentation systems applicable to operating plant upgrades and to new nuclear plants applying for design certification and combined operating license. Due to the fast changing nature of this subject matter, initial and continuing training is ongoing to address newer and updated subjects such as cyber security and newer instrumentation applications such as Field Programmable Gate Array (FPGA) integrated circuits. Lessons learned in the course development and presentation including comments for improvement will be included as well as NRC goals and objectives for the present and future in this area.

Key Words: Digital I&C Regulatory Training

1 INTRODUCTION

In the early years of this decade, the NRC Office of Nuclear Reactor Regulation (NRR), prior to the formation of a new office for new reactor licensing, the Office of New Reactors

(NRO), recognized a need to train new and existing staff on the changing requirements in utilizing digital systems in nuclear plants to protect the public health and safety. In combination with NRC Research, and recognizing the activities ongoing within the industry to move toward the application of digital systems on a wide scale, NRR prepared a specification for a one week (40 contract hours) engineering training program, coordinated with the NRC Engineering Training Program in Chattanooga, TN, to address this need. This program was awarded to Altran Solutions, based on their experience in teaching industry and academia courses, and a significant development program for the training materials followed with reviews by the responsible NRR staff to complete the package of three elements, following the Institute of Nuclear Power Operations (INPO) training curriculum development process and NRC training requirements; lesson plans, classroom visuals, and student handouts for each module. The NRC Engineering Training Program for Licensing Digital Instrumentation and Control Systems was presented for the first time in 2004 at the Region 1 office in King of Prussia, PA, with attendance by staff from NRR, the Office of Nuclear regulatory Research (RES) and also inspectors from NRC Regional Offices. Evaluations were conducted of the student feedback and plans were made to establish this as a permanent NRC training program. However, the follow-on training classes were delayed while NRC determined resource and training needs, based on priorities associated with the number of industry submittals in this area. In 2006, NRR re-evaluated this process and issued a follow-on contract for multiple training classes per year and a three year contract to Altran Solutions. Two classes were offered in 2007 and 2008 and one in early 2009 to staff in NRR, NRO, RES, and Regional inspectors from all Regional Offices. Introductions to each class were provided by some of the NRC Commissioners as well as NRC management.

Comments were solicited and received for each of the classes held; and incorporated into the following classes, when they were within the scope of the training contract. Examples were higher focus and time allowed for the demonstration of the Programmable Logic Controller (PLC), the addition of new subjects on FPGA, and cyber security, based on newer regulatory guidance, and the addition of review time, where possible, for subjects of significant discussion and dialogue with input from senior NRC staff attending each course. Additional comments addressed the need for more specialized training on specific areas of focus including PLC programming, FPGA's, Environmental Qualification, commercial grade dedication and cyber security. These subjects may be addressed in upcoming NRC training, based on user needs and available funding.

1.1 Scope

The original scope of the class focused on both current technology in I&C as well as new technology being implemented in the existing fleet in 2004. Instruction elements addressed existing technologies such as relays, analog circuit design and application and lessons learned in digital upgrades to date. Following the EPRI course format and style, NRC specific interests were presented referencing the NRC or industry documents, guidelines, etc that provide the basis for NRC review and approval. The original course split the focus between NRR review and Regional inspector review responsibilities, based on whether the upgrade was implemented under 10 CFR 50.59 or with a License Amendment Request (LAR). The licensing basis and regulatory framework established in the NRC Standard Review Plan (SRP) NUREG-0800 Chapter 7 (1997 version) (Reference 1), provided the basis as a regulatory roadmap. Reference to industry documents such as the EPRI Guideline for Licensing Digital Upgrades, EPRI TR-

102348 (Reference 2), and the associated NRC Generic Letter 95-02 (Reference 3) provided the guideline on how digital upgrades are prepared and submitted and the different types of digital upgrades. Reference to the National Academy of Engineering Report in 1997 (Reference 4) and consensus standards from the Institute of Electrical and Electronic Engineers (IEEE), the Instrument Society of America (ISA), the International Electrotechnical Commission (IEC) and Quality Assurance requirements were presented to detail the industry requirements and associated NRC endorsement in NUREG, or Regulatory Guide, where applicable.

To prepare for the first class in 2007, updates were made in the training materials to address additional guidance provided by NRC or industry including the update to the 10 CFR 50.59 rule, the revision to EPRI TR-102348 to Revision 1 (Reference 2) and the associated NRC Regulatory Issue Summary (RIS) 2002-22 (Reference 5), and for the 2008 course, updates were prepared to address the updated SRP Chapter 7 (Reference 1 - 2007 version) as well as the work of the NRC Task Working Groups (TWGs 1-6) and associated NRC Interim Staff Guidance documents. Additional sections were added to address new reactor guidance such as Regulatory Guide 1.206 (Reference 6) for both Design Certification (DC) and Combined License (COL) applicants. Updated material on issues such as cyber security, Field Programmable Gate Arrays (FPGA's) and gamma thermometers were also provided with descriptions on their use in safety applications subject to review by NRC. A Table of the latest course outline presented in 2009 is included as Table 1. Senior NRC staff experts participated as subject matter experts to supplement instructors in specific areas undergoing change or upgrade to the regulatory basis to provide the latest materials to students, as developed by NRC resources. In 2007 and 2008, the NRC Regulatory Roadmap for Digital Safety Systems was updated to reflect the latest guidance from NRC and industry references and is included as Figure 1.

In the courses offered in 2007 thru 2009, a half-day special session including an NRC approved microprocessor demonstration was included, which proved to be a great success and well received by newly hired NRC staff. The Invensys Tricon training platform and associated instructor provided hands-on hardware and software training including qualification experience to date and examples of applications installed in nuclear plants in the U.S. and around the world.

Table I. Digital I&C Engineering Training Course Outline

	MONDAY 02/09/2009 Introduction & History	**TUESDAY 02/10/2008 Microprocessor Components**	**WEDNESDAY 02/11/2008 Regulatory Concerns**	**THURSDAY 02/12/2008 Qualification & Life Cycle**	**FRIDAY 02/13/2008 Life Cycle**
8:00 to 8:30	1.0 Introduction and 1.1 Overview (ELQ)	2 Digital I&C Architecture 2.1 Digital Delta, Revisited (JWH -cont.)	3.3 The 10 CFR 50.59 Rule and EPRI TR-102348/NEI 01-01 (ELQ)	4.4 Commercial-Off-the-Shelf Equipment (ELQ)	5.3.3 Preliminary Hazards Analysis (JWH)
8:30 to 9:00		2.2 Analog Technology (JWH)	3.4 BTP-14 Software V&V (ELQ)	4.5 Case History-Qual of Invensys Tricon (ELQ)	5.3.4 Software Requirements Spec (JWH)

	MONDAY 02/09/2009 Introduction & History	TUESDAY 02/10/2008 Microprocessor Components	WEDNESDAY 02/11/2008 Regulatory Concerns	THURSDAY 02/12/2008 Qualification & Life Cycle	FRIDAY 02/13/2008 Life Cycle
9:00 to 9:30			3.5 BTP-19: Defense-in-Depth & Diversity 3.5.1 NUREG/CR-6303 Evaluation Method 3.5.2 NRC D3 Task Working Group Activities (ELQ)	4.6 Qual of ABB Common Q 4.7 Qual of Siemens TXS (ELQ)	5.4 Design Process 5..4.1 Risk Assessment (JWH)
9:30 to 10:00		2.3 Digital Technology (JWH)	3.6 Regulatory Guidance 3.6.1 Reg Guide Overview (ELQ)	4.8 Cyber Security Guidelines (New - ELQ)	5.4.3 Software Design Description (JWH)
10:00 to 10:15	**BREAK**	**BREAK**	**BREAK**	**BREAK**	**BREAK**
10:15 to 10:45	1.2 Lessons Learned (ELQ)	2.3 Digital Technology, cont. (JWH)	3.6 Regulatory Guidance 3.6.1 Reg Guide Overview (ELQ)	5 SW Life Cycle 5.1 Introduction 5.2 Concept Process 5.2.1 Project Definition (ELQ)	5.5 Implementation and System Performance Issues (JWH)
10:45 to 11:15			4 Qualification 4.1 Qualification Overview and 4.2 Qualification Requirements (ELQ)	5.2.2 Software Safety and Risk Concepts (ELQ)	5.6 IEEE Std 1012 Testing Activities (JWH)
11:15 to 11:45	1.3.1 Digital I&C Upgrade Process 1.3.2 Digital Modification Process (ELQ)		4.3 Qualification Testing and Analysis (ELQ)	5.2.3 Software Safety Plan (ELQ)	5.7 Software Training Plan & Implementation (JWH)
11:45 to 12:30	**LUNCH**	**LUNCH**	**LUNCH**	**LUNCH**	5.8 Operations and Maintenance Support (JWH)
12:30 to 1:00	1.4 Applications (JWH)	2.4 Digital Controller Components (JWH)	3.7 Tricon Training (New - Triconex)	5.2.4 Defense-in-Depth and Diversity (ELQ)	**1230 pm Dismissal**
1:00 to 1:30				5.2.5 Software Risk (ELQ)	
1:30 to 2:00				5.2.6 Software Fault Prevention (ELQ)	

	MONDAY 02/09/2009 Introduction & History	TUESDAY 02/10/2008 Microprocessor Components	WEDNESDAY 02/11/2008 Regulatory Concerns	THURSDAY 02/12/2008 Qualification & Life Cycle	FRIDAY 02/13/2008 Life Cycle
2:00 to 2:30	1.5 New Plant Licensing (ELQ)	2.5 Digital Communications (JWH)		5.2.7 QA Requirements (ELQ)	
2:30 to 3:00		2.6 PLC Programming (JWH)		5.2.8 Verification & Validation and Review (ELQ)	
3:00 to 3:15	BREAK	BREAK	BREAK	BREAK	
3:15 to 3:45	2 Digital I&C Architecture 2.1 Digital Delta (JWH)	2.6 PLC Programming (JWH)	3.8 Triconex Training (Cont.)	5.3 Requirements Process 5.3.1 Requirements Characteristics (JWH)	
3:45 to 4:15		3 Reg Concerns 3.1 Reg Roadmap (ELQ)			
4:15 to 4:45	Review (All)	3.2 NUREG-0800: Standard Review Plan (ELQ)		5.3.2 Safety Requirements (JWH)	

2 CONCLUSIONS

As NRC staff expanded greatly and split into two regulatory arms to match ever increasing industry needs for review of LAR's and new reactor applications for DC and COL's, this course provided the overview and details of the NRC regulatory roadmap on I&C issues. The role of the instructor was to foster knowledge transfer and engage a balanced level of understanding necessary to introduce new staff to the programmatic approach for licensing in this area. The ability to access senior NRC staff for specialized training area focus was very beneficial to the students in knowing the precedent in prior NRC approvals and lessons learned in the entire hardware/software lifecycle process.

3 REFERENCES

1. NUREG-0800, "Standard Review Plan," Chapter 7, Revision 4, 1997 and Revision 5, March, 2007.
2. EPRI Report TR-102348, "Guideline on Licensing Digital Upgrades," Rev 0 and Rev 1.

3. NRC Generic Letter 95-02: Use of NUMARC/EPRI Report TR-102348, "Guideline on Licensing Digital Upgrades," in Determining the Acceptability of Performing Analog-to-Digital Replacements under 10 CFR 50.59, dated April 25, 1995).
4. National Academy of Engineering, "Digital Instrumentation and Control Systems in Nuclear Power Plants," issued 1997.
5. NRC Regulatory Issue Summary 2002-22: Use of EPRI/NEI Joint Task Force Report, "Guideline on Licensing Digital Upgrades: EPRI TR-102348, Revision 1, NEI01-01: a Revision of EPRI TR-102348 to Reflect Changes to the 10 CFR 50.59 Rule," issued November 25, 2002.
6. Regulatory. Guide 1.206, Combined License Applications for Nuclear Power Plants (LWR Edition), dated June, 07.