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Nuclear Seminar on Nuclear Automation 5-7 April 2004 in Oskarshamn, Sweden

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OKG, Sweden

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Abstract

A general conclusion from several of the presentation is that the I&C platform and the application need their own development and verification and validation processes. A confidence in the platform and the application can then be built on the collection of information both from the design process and from the product. A structuring of the design and verification and validation processes in terms of claims of dependability and evidence to support these claims may help in ensuring a smooth licensing process.

From the seminar some general recommendations can be made. Firstly it seems necessary to develop a better understanding of the best ways for interactions between the utilities and the vendors in agreeing on the scope of the modernisation projects. A long term view in terms of a development plan for the power plants may help the utilities to arrive at an internal agreement on the scope for forthcoming modernisations. Furthermore the licensing process seems to need some clarifications to avoid surprises. The international projects presented at the seminar seem to provide some clarifications in this respect. More generally there are needs for additional methods and tools for the verification and validation process on which research organisations and universities are working.

Key words

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Nordic Seminar on Nuclear Automation

**Oskarshamn, Sweden
5-7 April 2004**

The Nordic Nuclear Safety Research (NKS) welcomes all experts and managers from Nordic countries and beyond to participate in an open discussion between regulators, utilities, vendors and researchers.

The seminar will be arranged in collaboration with the Technical Working Group on Nuclear Power Plant Control and Instrumentation of IAEA (TWG-NPPCI). Presentations at the seminar will cover Projects, Lessons, Safety, Technology, Trends, Processes, Users and Concepts connected to modern I&C systems at nuclear power plants.

There are many challenges in approaching modern I&C systems at the nuclear power plants. Some of them are connected to the following issues:

- Modernisation of automation systems
- Replacement of equipment in automation and electrical systems
- Project (including quality) management
- Harmonisation of requirements on the plant, system and equipment levels,
- I&C solutions for new nuclear power plants.

The seminar will start at 13.00 hours on Monday 5 April and it will end at noon on Wednesday 7 April 2004.

The registration: Name, Title, Company, Address, Telephone, Fax, E-mail shall be sent to: karl-erik.eriksson@okg.sydskraft.se

Please find more details on the seminar in the enclosed flyer.

Yours sincerely,

Karl-Erik Eriksson
OKG AB

Petra Lundström
NKS
c/o Fortum

Björn Wahlström
IAEA / TWG-NPPCI
c/o VTT

April 5

Session 1

Chairman: Nils Olov Jonsson

Project management – experiences so far and future challenges

13:30 – 15:30 Session 1.1-1.4

Present and future challenges for nuclear I&C systems seen from a US perspective

Joseph Naser, EPRI

Realization of modernization projects – The decision making process
Hans Reddersen, Colenco Power Engineering Ltd

Lessons learned from project MOD

Anders Helmersson, OKG AB

Experiences from recent I&C replacement/modernization projects

A Johansson, L Johansson, Ringhals AB

15:30 – 16:00 Coffee break

16:00 – 18:00 Session 1.5-1.8

Experiences from the safety I&C project for the Tianwan plants

Torsten Tech, Framatome ANP

Experiences from the Paks NPP Process Computer Reconstruction

Csaba Major, Paks Nuclear Power Plant Ltd

Modernisation of the I&C at the Olkiluoto NPP

Juha Miikkulainen, TVO Teollisuuden Voima Oy

Involvement in Project O1-MOD and lessons learned

Jan Erik Farbrot, Institutt for Energiteknikk,

OECD Halden Reactor Project

18:00 – 19:30 Visit at OSKARSHAMN 1 Simulator

19:30 – 21:30 Get together

April 6

Session 2

Chairman: Öivind Berg

Plant-level requirements – redundancy, separation, diversity, safety classification, etc.

08:30 – 10:10 Session 2.1-2.4

Finnish Requirements for Modern Automation Systems in Nuclear Power Plants

Juhanni Hyvärinen, STUK, Radiation and Nuclear Safety Authority

European Utility Requirements on I&C

Olle Andersson, Forsmarks Kraftgrupp AB

Experiences and further development from a regulatory perspective

Bo Liwång, SKI – Swedish Nuclear Power Inspectorate

Cost effective modernisation of systems important to safety (CEMSIS)

Jan Tuszynski, Datavoice

10:10 – 10:30 Coffee break

10:30 – 12:30 Session 2.5-2.8

A study on Quantification of Information Flow and Effectiveness of information Aids for Diagnosis Tasks in Nuclear Power Plants

Poong Hyun Seong, KAIST

Requirements on future modernisation projects

Anders Helmersson, OKG AB

Modernisation of I&C systems in the Loviisa NPP

U Lindén, Fortum Heat and Power, M Välisuo, Fortum Nuclear Services

Regulatory Oversight Process for FIN5

Petteri Tiippana, STUK, Radiation and Nuclear Safety Authority

12:30 – 13:30 Lunch

April 6

Session 3

Chairman: Timo Okkonen

Plant-level I&C concepts – experiences so far and future trends

13:30 – 15:30 Session 3.1-3.4

IAEA I&C Activities

Janos Eiler, IAEA

Modernising of control room in OKG: Experiences and future projects

Thomas Gunnarsson, OKG AB

I&C in the near future and in a longer perspective

Anders Johansson, L Johansson, Ringhals AB

Instrumentation and control concepts in Olkiluoto 3

Lars-Erik Häll, TVO Teollisuuden Voima Oy

15:30 – 16:00 Coffee break

16:00 – 18:00 Session 3.5-3.9

Advanced products for efficient and safe operation

Øivind Berg, Institutt for Energiteknikk, OECD Halden Reactor Project

New principles for Human System Interface design

Jon Kvaalem, Institutt for Energiteknikk, OECD Halden Reactor Project

Experience from Human Factors Integrated System V&V in
the O1-MOD project

J E Farbrot, Institutt for Energiteknikk, OECD Halden Reactor Project

Virtual reality for control room design and V&V

J E Farbrot, Institutt for Energiteknikk, OECD Halden Reactor Project

Implementation of Advanced On-Line Monitoring for Equipment
Condition Assessment

Ramesh Shankar, EPRI

19:30 – 22:00 Dinner

April 7

Session 4

Chairman: Anders Helmersson

Software qualification – automation systems and programmable equipment

08:30 – 10:30 Session 4.1-4.4

Qualification of RPS at Oskarshamn 1

Karl-Erik Eriksson, OKG AB

Benchmark exercise on safety evaluation of computer based systems
(BESECBS)

Urho Pulkkinen, VTT Industrial Systems

Software QA issues important to safety of digital I&C systems

Terje Sivertsen, Institutt for Energiteknikk, OECD Halden Reactor Project

Traceability and Communication of Requirements in Digital I&C
Systems Development

Janne Valkonen, TACO team, VTT Industrial Systems

10:30 – 11:00 Coffee break

11:00 – 13:00 Session 4.4-4.8

Risk assessment of computerised systems

*Atoosa P-J Thunem, Institutt for Energiteknikk,
OECD Halden Reactor Project*

CORAS – A platform for Risk Analysis of Security Critical Systems

R Fredriksen, Institutt for Energiteknikk, OECD Halden Reactor Project

ARRAC, Automation & Reactor Safety, Requirements,
Assessment & Concepts

Sixten Norrman, VTT Processes

NKS project Barriers, Control and Management

Morten Lind, DTU

13:00 – 14:00 Lunch – End of seminar

Nordic Seminar on Nuclear Automation, Oskarshamn 5-7.4.2004

The seminar was well attended with participants from 13 countries and one international organisation. The participants came from power utilities, research organisations, universities, regulators, consultants, automation system vendors and international organisations. The presentations covered all aspects of experiences from past projects, ongoing activities and development projects aiming for new methods and tools. The presentations also covered broad aspects of project management and technical details of the I&C systems. The seminar gave the participants condensed experiences from several modernisation projects and their corresponding licensing procedures.

There are many conclusions, which could be made from the presentations. Firstly there seems now to be available concrete experience from several large I&C modernisation projects. This collected experience give clear evidence that the modern digital systems have matured and can be used also in the most demanding applications at the nuclear power plants. In spite of these generally positive statements, there also seems to be several hurdles that have to be reacted on to make forthcoming modernisation projects to flow smoothly and efficiently. One common problem seems for example to be the definition of the scope of the modernisation, because the utilities often expect the vendors to be able to define the scope, but vendors on their hand expect the utilities to do it.

A general conclusion from several of the presentation is that the I&C platform and the application need their own development and verification and validation processes. A confidence in the platform and the application can then be built on the collection of information both from the design process and from the product. A structuring of the design and verification and validation processes in terms of claims of dependability and evidence to support these claims may help in ensuring a smooth licensing process.

From the seminar some general recommendations can be made. Firstly it seems necessary to develop a better understanding of the best ways for interactions between the utilities and the vendors in agreeing on the scope of the modernisation projects. A long term view in terms of a development plan for the power plants may help the utilities to arrive at an internal agreement on the scope for forthcoming modernisations. Furthermore the licensing process seems to need some clarifications to avoid surprises. The international projects presented at the seminar seem to provide some clarifications in this respect. More generally there are needs for additional methods and tools for the verification and validation process on which research organisations and universities are working.

The seminar clearly showed the need for an exchange of experiences with modern digital automation systems at an international level. The joint sponsorship of the Nordic nuclear Safety Research (NKS) and the International Atomic Energy Agency (IAEA) also showed beneficial in the arrangement of the seminar. Several of the participants thought for example that the seminar should be made to a regular forthcoming event.

Session 1: Project Management – Experiences So Far and Future Challenges

There were eight presentations in this session. Four of these presentations concerned modernizations implemented in operating plants, one concerned design of digital systems for plants being built and the three remaining presentations concerned other experiences and conclusions from work in the automation area.

Joseph Naser from EPRI provided insights into the US work on modernization of LWR I&C equipment. The conclusion is that the preparations for managing large modernizations now are in place. The design characteristics are known, the licensing environment has been stabilized and supporting processes and procedures have been put in place. This concerns both the I&C systems and the modernization of the control rooms. Pre-qualified digital platforms are also available. The major hurdle to overcome at this time is the projected high costs of modernization. Given the excellent energy production improvements in the US plants and work on simplifying the modernization processes we may expect to see additional large scale modernization projects also in the USA.

Hans Reddersen of Colenco provided some conclusions from looking into the decision process for I&C modernization projects. His key conclusion was that large I&C modernization projects are complex. They require an integrated approach for design, validation, training, and operation and maintenance. Due to this integrated nature decisions taken need to be well supported and stable in time. Stability means that there need to be active involvement of suppliers, the plant organization and regulators in the process. The process of modernization must also be stable and paying attention to details, in particular in the early design phases.

Anders Helmersson from OKG summarized the modernization of Oskarshamn 1. This was a very complex undertaking including modernization of the safety concept for the plant (i.e. the safety systems), the power supply, I&C and control room part of the plant, and also the turbine. A fourth supplier was involved for new buildings and modifications of existing building structures. There were three major suppliers involved over a time span of almost six years. The major experiences were the amount of work required because of the huge interface between the new I&C and the existing plant. Also the interdependence between the old and the new equipment provided some unexpected additional work. The complex scope and structure of the project also made it difficult to have everything reflected in the contract and in the time schedule. In the end the project was completed and the plant is now operating successfully.

Anders Johansson and Lars Johansson from Ringhals presented experiences from I&C modernizations at the Ringhals site. A step-wise introduction of new technology has been applied at Ringhals. The first step is replacing old equipment with new programmable equipment but unchanged functionality. This has been very successful and has demonstrated the high reliability of the new equipment. The second step includes expanded functionality and much interfaces in the plant. At the same time the dependency on the vendor of the equipment/system increases. Other experiences were that maintenance and operation were affected by the change of technology. This requires a significant amount of training and modifications of routines and instructions.

Torsten Tech from Framatome presented experiences from introduction of digital technology in the two Tianwan plants that are soon taken into operation. Two major achievements are that the qualification / licensing results from one country could be re-used to a great extent in

a new country and that completely digital systems were approved for the plant without any solid state backups.

Mr. Major presented experiences from implementing modern plant process computers at Paks including advanced operator support functions. This was done using commercially available software like Windows NT, a number of compilers and development tools and the SCADA software. Although there were several compatibility problems, the overall conclusion was that the mix of SW was acceptable – availability requirements have been met. The simulator tests were indispensable in arriving at an optimal design.

Juha Miikkulainen of TVO provided information and conclusions from modernization work at TVO for their Olkiluoto plants. A number of limited scale modernization projects were cited. The main conclusions are very much the same as others have made: complexity increases quickly with the size of the change, integration between new and old equipment requires special efforts and new routines are needed for maintenance. The four key items are clear project structure, close cooperation, powerful products and availability of expertise in refitting and commissioning (after the change).

Jan Erik Farbrot from IFE provided some experiences from supporting the Oskarshamn 1 control room modernization. The development of the new control room was supported by virtual reality models. These were important in helping the designers to get feedback from control room crew and human factors experts. The VR technology also made it possible to verify design concepts at an early stage. Mr. Farbrot also noted that there were limitations in the commercial systems that were used and recommended that vendors should cooperate with end users in developing the standard products.

Summary

Session 2: Plant-level requirements – redundancy, separation, diversity, safety, classification, etc. Chair: Øivind Berg

There were eight papers in this session discussing various aspects of plant-level requirements and the presentations were given by representatives from regulatory bodies, utilities and research organisations. They provided a good overview of the experiences, current practices and trends both for modernization projects as well as for the new power plant being constructed in Finland, FIN5.

The first paper given by Juhani Hyvärinen, STUK, was entitled “Finnish Requirements for Modern Automation Systems in Nuclear Power Plants”. The applications are modernisation of Loviisa 1&2 and FIN5/Oukilouto 3, and no real difference is seen from the regulatory point of view whether one consider a modernisation or building a new reactor. One of the major new challenges in the transition to digital systems is to cope with possible common cause failures. He also said that STUK is not only concentrating on the licensing process itself, but is also involved in assessment of the technical products.

The European Utility Requirements (EUR) on I&C were described in a paper by Olle Andersson, FKA. He could not attend the meeting, but the paper was distributed. The EUR objectives are to give a stabilised frame to develop the next generation LWR plants for Europe, to achieve competitiveness, standard designs, cost-effective design features and conditions for fair competition between vendors. Further, it should help to reduce licensing risks, promote safety progress, stabilising regulatory environment and improve the public acceptance.

Bo Liwång, SKI, described the experiences and further development from a regulatory perspective. Their lessons learned are that it is difficult to perform a technical analysis even on a small system with low complexity. Considering also that SKI is a rather small organisation, they focus on the licensing process. A major part is the validation of the platform being applied, and the applicability of the platform when reused.

The EC supported project “Cost effective modernisation of systems important to safety (CEMSIS)” was presented by Jan Tuszynski. It covers programmable instrumentation and control (I&C), e.g. safety systems and safety-related systems. The aim is to obtain a common approach to development and safety justification to maximise safety and minimise cost. The tools are publicly available.

A Study on Quantification of Information Flow and Effectiveness of Information Aids for Diagnosis Tasks in Nuclear Power Plants was presented by Poong Hyun Seong, KAIST, Korea. This R&D work proposes a framework for the design of decision support systems to aid MCR operators’ diagnosis tasks in NPPs. The framework consists of 1) quantitative approach to modelling the information flow of diagnosis tasks, for the task consideration, 2) a strategy-based evaluation of information aids for diagnosis tasks, as a study on human performance model in the design of operator support systems and 3) and a method for the quantitative evaluation of NPP decision support systems.

Anders Helmersson, presented the requirements on future modernisation projects at OKG for O2 and O3 in the period 2004 - 2012. The strategy is to take smaller modernisation steps. The plan to re-use the process and document structure from the previous O1 modernisation, but the detailed analyses can not be re-used. They will start with operation systems and after that continue with the safety systems. They plan for power uprates.

The Modernisation of I&C systems in the Loviisa NPP was described by Martti Välisuo, Fortum Nuclear Services. The scope of renewal is the control room, operational and safety I&C systems, process computer and the training simulator. Corner stones of safety for the new I&C will be to use well proven functions and build in tolerance against common mode failures. Simulations will be used extensively for analyses, MMI development and validation, I&C testing and operator training.

Finally, the regulatory oversight process for FIN5 was given by Petteri Tiippana, STUK. The role of STUK in the licensing process is to set the safety requirements (safety level) and ensure that safety requirements are fulfilled. They will review documents and perform independent analysis and assessment, and make inspections on and off site. Focus and scope will be to keep the oversight of changes during the licensing process. STUK will perform QM throughout the licensing process.

Session 3: Plant-level I&C concepts – experiences so far and future projects

Janos Eiler introduced IAEA's organisation and activities on I&C. IAEA works on exchange of information, generating guidance documentation, organising specialists meetings, as well as running technical cooperation projects and training courses.

Lars-Erik Häll presented TVO's perspective to nuclear power and I&C in near and longer-term future, including the new nuclear plant project. Mr. Häll emphasized the importance of capturing safety requirements and design criteria long before the implementation phase is commenced. The new power plant and its I&C concept, as ordered by TVO, comprises the necessary defense-in-depth and diversity features to make it most tolerant also to common cause failures.

Thomas Gunnarsson focused on OKG experiences and future projects on control room modernization. A thorough design and V&V process is required to come up with an implementation that meets the regulatory requirements and the needs of control room operators. The design work is challenging and calls for a skillful, experienced design team including human factors expertise.

Lars Johansson and Anders Johansson talked about I&C modernization challenges and strategies at Ringhals. Different options are available for implementation: stepwise or one shot. This decision is critical and needs to be carefully analysed taking into account plant specific features and needs. The project planning derives from a wide variety of requirements and needs: information handling is critical. Resources are not only money, but also the time available from key experts in the project.

Öivind Berg presented IFE/Halden's latest ideas on advanced products for efficient and safe plant operation. Similarly to previous presentations, Mr. Berg pointed out the development needs in alarm systems design, and described the R&D work underway in the area. Computerized procedures, on-line monitoring systems, and plant simulation and diagnostics systems offer new methods of excellence for plant economy and safety.

Jon Kvalem (IFE/Halden) presented new principles and innovative approaches for human system interface design. Concepts such as ecological interfaces, task-based displays, and a function-oriented display and alarm design, are under development. The same goes for new human system interaction designs, rich-information displays and large screen applications. This field is propagating fast, aiming at a full utilisation of human-centred, computer-based concepts and tools: new approaches are needed and surfacing.

Jan Erik Farbrot (IFE/Halden) gave two presentations on human factors design and V&V for control room applications, including experiences from the Oskarshamn 1 project and the latest virtual reality tools. The goals and tasks of the different V&V process phases (levels of demonstration) have to be carefully planned, and the findings fed back to the design by a transparent issue resolution process. Right timing is crucial for the process to be most productive, while Virtual Reality technology offers new possibilities for early V&V.

Joseph Naser (EPRI) introduced new ideas on implementing advanced on-line monitoring for equipment condition assessment. The R&D work underway aims at demonstrating technology, developing a cost benefit monitoring methodology, and integrating the monitoring smoothly into the normal business processes.

Key lessons from the session are the following ones: information sharing, modernization strategies and decisions, requirements management, design process, human factors expertise,

and constantly renewed technology. All in all, we need to have both honesty (openness) and humour (tolerance) in the projects we are running. We also need to generate facts (safety documentation) and feelings (user opinions) that support the judgements on safety; i.e., both evidence and confidence. All this requires well-prepared strategic decisions, a transparent design and validation process, as well as professional engineering attitude.

Anders Helmersson, Chair session 4.

It has been three very interesting days and we have heard presentations from Utilities, Authorities and Vendors. The subjects has been about what has been done concerning I&C modernization, future modernizations plans, modernization strategies, requirements, QA-issues, QC-issues, different tools concerning I&C and a lot more. It has been a tremendous interest for the seminar and people from fourteen different countries have participated.

All this have given us a really good picture over the situation concerning modernization of Nuclear Automation.

The fourth and last session was about “Software qualification – automation systems and programmable equipment”. The session concluded the Nordic Seminar on Nuclear Automation with following interesting presentations:

- Qualification of RPS of Oskarshamn 1
- Benchmark exercise on safety evaluation of computer based systems
- Software QA issues important to safety of digital systems
- Traceability and Communication of Requirements in digital I&C Systems development
- Risk assessment of digital systems
- Automation & Reactor safety – Requirements, Assesment & Concepts
- A Platform for Risk Analysis of Security Critical Systems
- NKS project about Barriers, Control and Management

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Abstract	<p>A general conclusion from several of the presentation is that the I&C platform and the application need their own development and verification and validation processes. A confidence in the platform and the application can then be built on the collection of information both from the design process and from the product. A structuring of the design and verification and validation processes in terms of claims of dependability and evidence to support these claims may help in ensuring a smooth licensing process.</p> <p>From the seminar some general recommendations can be made. Firstly it seems necessary to develop a better understanding of the best ways for interactions between the utilities and the vendors in agreeing on the scope of the modernisation projects. A long term view in terms of a development plan for the power plants may help the utilities to arrive at an internal agreement on the scope for forthcoming modernisations. Furthermore the licensing process seems to need some clarifications to avoid surprises. The international projects presented at the seminar seem to provide some clarifications in this respect. More generally there are needs for additional methods and tools for the verification and validation process on which research organisations and universities are working.</p>
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