Learning Organizations for Nuclear Safety

Björn Wahlström, Bernhard Wilpert, Sue Cox, Rosario Solá, Carl Rollenhagen

Abstract–Organizational learning (OL) is a crucial component of operational excellence in nuclear power plants. OL relies on performance assessments, change management and continuous improvements. OL has become increasingly important for the nuclear industry with regards to adaptation to changes in the political and economic environment, work force, technology within plants, and organizations of the nuclear utilities. A danger in this adaptation process is that even minor problems may trigger a chain of events where the risk of deteriorated safety and/or diminishing trust in safety standards of the particular nuclear power plant becomes possible. The paper describes a project that considers the demands placed upon the management team of a nuclear power plant in order to create methods and tools to support them. The involvement of nuclear power plants within the project provides a unique possibility for interactions between research and practice. It is hoped that by utilizing such a method the project will be able to benchmark approaches to safety management in different cultures and within stages of change. To ensure the maximum benefit for the participating nuclear power plants, results are being tested and adapted continuously as part of the project.

Index terms–Nuclear power generation, safety, human factors, organizations, learning systems.

I. INTRODUCTION

A project "Learning organizations for nuclear safety (LearnSafe[1])" was started 01.11.2001. LearnSafe is funded by the Nuclear Fission Safety part of the 5th Framework Programme of the European Union and involves a total of 14 partners from five countries and one international organization. The project is scheduled to run for 30 months, with the total projected costs approximately 1,2 M€. The main objective of LearnSafe is to create methods and tools for supporting processes of *organizational learning* at the participating nuclear power plants. The primary objective was selected due to the fact that organizational learning has become increasingly important for the nuclear industry in its adaptation to changes in the political and economic environment, changing regulatory requirements, a changing work force, changing technology within the plants, and the changing organization of nuclear power plants and utilities. The danger during a rapid process of change is that minor problems may trigger a chain of events leading to actual degrading of safety and/or diminishing political and public trust in the safety standards of the particular nuclear power plant, utility or corporation.

The focus of the project is senior managers at nuclear power plants and utilities who are responsible for strategic choice and resource allocation. This focus was selected with the understanding that their decisions, approaches and attitudes have an important influence both on the safety and economy of nuclear power plants. It is intended that LearnSafe will develop methods and tools, which can be used in the management of change, and in ensuring efficient organizational learning. Project results will include recommendations and inventories of good practices.

The project has been set up in two major phases, which cover both theoretical considerations and empirical investigations. The first phase places an emphasis on management of change and the second on the components of organizational learning. Both phases start with the creation of data collection instruments to be used in the empirical part of the work. The second theoretical and empirical phase takes a major step towards developing methods and tools, which can be applied by the nuclear power plants themselves in creating and maintaining efficient processes of organizational learning. One important feature of LearnSafe is a continuous interaction between the researchers and managers at the participating nuclear power plants in addressing issues connected to organization and management, which are important for both safety and efficiency.

II. THE CONSORTIUM

The LearnSafe consortium consists of the following partners:

- Technical Research Centre of Finland, VTT Industrial Systems, Finland,
- Berlin University of Technology – Forschungsstelle Systemsicherheit, Germany,
- Lancaster University, United Kingdom,
- The Research Centre for Energy, Environment and Technology (Ciemat), Spain,
- SwedPower AB, Sweden,
- UNESA, Spain,
- World Association of Nuclear Operators,
- Teollisuuden Voima Oy, Finland,
- Forsmark Kraftgrupp AB, Sweden,
- Kernkraftwerk Grafenrheinfeld, Germany,
- Kernkraftwerk Krümmel, Germany,
- British Nuclear Fuels plc, United Kingdom,

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– Ringhals AB, Sweden.

The consortium is unique in its partnership. The partners represent a broad range of experience in nuclear activities and it is due to this experience that they have joined an international consortium aimed at conducting research in issues connected to organization and management. The research has a great potential for improving safety and efficiency of nuclear power plants. The formation of the consortium also indicates a break with an old tradition of emphasis only on technical aspects of nuclear safety. The partners in the consortium are complementary and they represent a true trans-European and multi-disciplinary approach.

Prior to the LearnSafe project some of the partners had co-operated successfully in the so-called ORFA project [1] which, was also funded by the European Union. Due to the emphasis on nuclear utilities, the partners involved in the ORFA project, that were representing regulatory bodies did not find a position in the present consortium. This does not mean that regulatory bodies are disclosed from access to generic project results, they will on the contrary be invited as discussants to the seminars arranged within the project.

The R&D organizations involved in the project have a living interest in issues of organizations and management for safety in nuclear power. Some of the partners are involved in consulting to the nuclear industry and have in that position good possibilities to support technological implementation of projected results. The participation of universities will also give the possibility to include early results of the project into the curricula for an immediate support of preserving knowledge in the field of safety management of nuclear power. The broad emphasis on safety and efficiency is assumed to provide students with a relevant introduction to business activities relevant for the nuclear industry.

The project is expected to provide improved and innovative tools and methods for the management of changes, which may influence the safety of existing nuclear installations. In the long term the project is expected to have an influence on organizational design at the nuclear power plants in their quest to adapt management innovations from conventional industry to the special needs of the nuclear industry.

III. MANAGEMENT OF CHANGE

The management team of a nuclear power plant is confronted with a wide variety of novel demands, which enforce new methods of dealing with them. These demands are a result of ongoing changes; hence management is challenged to manage change processes efficiently and effectively in order to ensure safe and economic production, as well as competitive survival.

A. Changes in the political and economic environment

Deregulation and the internationalization of the energy market induce everywhere the need to cut production costs in order to maintain the competitive nature of the nuclear industry. The opening of the market for competition between plants and countries has brought the price of electricity to a level where nuclear power plant operating costs are difficult to cover. Shareholder values impose short term planning horizons. Cost saving strategies are directed towards reduction of investments in technological improvements and reduction of personnel. Early retirement schemes are developed and implemented begetting the threat to lose experience and competence. In some countries political changes and increasingly negative attitudes of the population have lead to nuclear exit policies which further push towards limited time horizons of management.

B. The changing work force

The average age of the work force within nuclear power plants is increasing. This is partly a consequence of demographic changes in the work force at large. However, the nuclear industry is faced with specific additional aging characteristics of its employees: Younger qualified persons are becoming increasingly hesitant to seek employment in the nuclear industry. This reflects to a certain degree the change of public opinion and attitudes towards nuclear energy production. But many universities have cut down on training efforts for engineers to gain qualifications to work within the industry. Furthermore, in some countries there is a genuine motivation crisis, which affects experienced personnel working in nuclear power plants. The reasons are sometimes a result of the apparently limited time horizon of the industry due to nuclear exit strategies of governments. Such limited perspectives add to discourage young qualified persons to apply for work within nuclear power plants.

C. The changing technology in plants

New information technology offers opportunities to change not only instrumentation and control systems, but also use integrated information systems in all work processes and activities. These may improve operating procedures, but pose particular challenges for nuclear power plant staff. Staff is often opposed to accept such innovations due to the requisite competence of handling them appropriately. Spare parts for older nuclear power plants are often no longer available from manufacturers, which may lead to ad hoc stop gap operations in order to maintain production. The number of companies offering equipment and services is decreasing. Particular managerial problems emerge in connection with aging of technical components.

D. The changing organization of nuclear power plant and utilities

Merger activities in response to economic challenges imply new authority lines within the organization of utilities and induce new ways of operating which often is not found appropriate by staff, feeding back into a potential motivation crisis. The same can be noted in connection with new business strategies attempting to reduce investments and personnel by outsourcing certain functions, which hitherto were dealt with within the nuclear power plant. The integration within Europe has also lead to the present situation where utility companies, which some years ago were national now, own nuclear electricity generation capacity in several countries.

IV. A RESEARCH FRAME

A framework of organizational factors was established within the ORFA project. This was based on the five interacting systems of *technology*, *individual*, *group*, *organization* and *environment*. The framework can in a restricted sense also be seen as a model of the objects of study, the management process and the organization at the nuclear power plants. The framework was used in the ORFA project to discuss various mechanisms of interactions between the five systems, among them organizational learning. The preliminary framework presented below is a slight extension of the framework presented in the final report of the ORFA project and it will be revised and extended in the first work package of the LearnSafe project. It will also be further refined in subsequent workpackages to better reflect concepts and understanding of the managers involved in the empirical fieldwork of the project. This revised framework will serve as a basis for structuring project results in the final report.

A. Five interacting systems

Technology includes, but is not only restricted to plant design, buildings and degree of automation. An important part of the technology system is connected to the procedures, their structure, content and format as well as the plant documentation system.

Considerations for the *individuals* include motivation, commitment, qualifications and experience. Important are also individual risk perceptions and attitudes. The identity and thinking styles of people have an influence on their behavior in different situations. Individual teamwork skills and social capital are further characteristics to be taken into account.

The *group* is an important intermediate between individuals and the organization. Group size and composition are factors, which influence interaction styles and communication. Group norms are influenced in relationship to other groups, status in the organization and the role and purpose of group.

The *organization* includes management activities such as creating visions, defining goals and creating strategy. It also includes the management of resources, capabilities and practices as well as defining norms and ideals. Other important components are leadership and the creation of a reward and punishment system. It also includes approaches and solutions such as outsourcing of activities and the use of contractors.

The *environment* includes factors beyond management control such as the legal system and the regulatory frame. Important are also relationships with suppliers and customers as well as public and media relations. The educational system, labor markets and trade unions as well as the local and national governments are also important in this connection.

B. Three views of the organization

The five interacting systems can be viewed in different ways. Each view concentrates on certain aspects of the system, which in different situations emerge as the major contributor to observed behavior. In this connection a difference is made between three views, the administrative, the political and the cultural view.

The *administrative view* is typically reflected in organizational charts giving an account of authority and responsibility. It also includes the documentation of regulation, policies, procedures and practices. The administrative view is also reflected in descriptions of work processes and activities. The cycles of goal setting, planning, implementation and evaluation is another example of an administrative view taken on the systems above.

The *political view* is concerned with differing interests, conflicts and negotiation. It is also concerned with the emergence and disruption of confidence and trust among people in groups and organizations. Power structures and power games people play are also included in this view.

The *cultural view* is concerned with how people understand and make sense of their environment. This view includes artifacts such as visible products, behaviors, organizational structures and processes. It includes shared values such as strategies, goals and philosophies as well as basic underlying assumptions such as unconscious, taken-for-granted beliefs, perceptions, thoughts and feelings.

C. Generic dilemmas of management

One of the findings from the ORFA project was that the management of a nuclear power plant involves the task of finding a balance between a large number of, sometimes conflicting, requirements. These can be thought of as generic dilemmas of management, which have to be understood, resolved and integrated into organizational activities. One example is the balance between safety and efficiency, which has to be approached in a way not to let one compromise the other.

Other balances to be found in the day to day operation are for instance a simultaneous focus on traditions and renewal as well as an emphasis on both formal and informal management methods. In a learning organization both self-confidence and willingness to listen should co-exist for the best performance. Efficiency can be achieved only if competition is channeled into co-operation between groups and individuals. Nuclear power plant organizations are by necessity centralized, but decision making should still be distributed to a level were necessary information is available. Procedures and practices should involve discipline, but should also allow for flexibility and innovation. Managers in various positions should maintain an overview, but not loose their focus on important details. Finally there should be a continuous evaluation of both short and long term priorities.

One of the main challenges for the managers is to identify such dilemmas of management and find suitable balances, which can be proceduralized and communicated to the organization in an understandable and acceptable manner. One of the hypotheses in the project is that an efficient identification and management of these balances is one of the root causes of good performance in nuclear power plants.

D. Organizational learning

Several models of organizational learning have been proposed. The models usually separate between individual and organizational learning. The models rely on different representations of a learning cycle of *observation*, *assessment*, *design* and *implementation*. The implementation at the end of

each cycle represents a new *change* in the system. The learning cycle is similar to various cycles proposed for instance as interpretations of the total quality management concept.

An important part of many models of organizational learning is the concept of *double-loop learning*. Double-loop learning implies that not only practices, but also frameworks, methods and tools are changed to improve the performance of the organization. Double-loop learning is supposed to take place both on an individual and an organizational level. Efficient double-loop learning sometimes may imply changes in norms and thinking. On a senior management group level this may involve a redesign of mental models and the creation of new visions to be shared within the organization.

The five systems and the three views above will be combined with the generic management dilemmas to identify couplings between factors which have an application on organizational learning. One important result of the project is an identification of impediments and barriers for organizational learning together with approaches for handling them. In this connection it is also important to note that it is very seldom that a problem can be approached with one solution, but instead several solutions have to be combined to yield the wanted outcome.

V. CHALLENGES IN THE NUCLEAR INDUSTRY

In the practical work of the project the following research question was formulated to guide the work of the first phase of the project:

What are the perceived developing challenges (short-term and long-term) in the management of your nuclear power plant in the context of safety?

The research question has been approached in four groups of people:

- Experts in safety, health and environmental management,
- Utility Top Management,
- Upper Nuclear Power Plant Managers,
- Multifunctional Managers at the nuclear power plants.

The first group was approached with a preliminary list of challenges generated by the LearnSafe team. Experts were then asked to categorize the challenges in terms of importance and time span of influence. The utility top managers have been approached with semi-structured interviews in which the earlier list of challenges was also brought up for a discussion. For the third and fourth group the so-called Metaplan technique [2] has been used with two moderators and a visualization of the advancing map of challenges and their relationships.

So far about half of the intended data collection has been completed. It is expected that the data collection will be completed by the end of July 2002. When the data collection has been completed similarities and differences will be identified to select several for a more in depth study.

VI. CONCLUSIONS

The LearnSafe project is still in its initial phase. Due to the importance of the subject it is the intention to share generic results of the project with the nuclear community within Europe and also outside Europe. For that purpose seminars will be arranged to which discussants will be invited from organizations not directly involved in the project. During the project the possibility of research co-operation with other similar projects in the United States and Japan will be investigated.

The safety of existing nuclear installations is dependent on efficient organizational learning in which the total world experience of more than 6000 reactor-years are utilized. Many international studies and reports have identified the need to broaden the exchange of operational experience, to include issues connected to organization and management. In this way it is possible to approach root-causes of events and incidents which have raised recent safety concerns. It is believed that the LearnSafe project can have an important contribution in this respect.

The project builds on methods and tools used within the nuclear power plants by which the interactions of man, technology and organization are analyzed in maintaining and improving safety and performance. Project results are intended to include the identification and evaluation of safety indicators, the development of methods and tools for organizational self-assessments and the integration of human and organizational factors in safety assessments. Results are also expected to support risk informed decisions among senior managers in their optimization of work practices at the plants from both a safety and economic point of view. In general the project aims to promote the exchange of best practices and strive for more integrated approaches in managing conflicting objectives at the nuclear power plants.

VII. REFERENCES

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[2] www.moderationstechnik.de

VIII. BIOGRAPHIES

Björn Wahlström was born 1944 in Pietarsaari, Finland and was educated at Helsinki University of Technology (MSc 1967, PhD 1971). He has been employed at VTT since 1971 where he was appointed laboratory director and professor in 1985. During 1989-91 he was on a leave of absence working with the International Institute for Applied Systems Analysis in Laxenburg, Austria. Since 1994 he has been a research professor in systems engineering at VTT Automation. He was a member of the reactor safety section of the Finnish advisory committee for nuclear power between 1988 and 2000. He is a past and present member of several working groups of IAEA and OECD/NEA. He has written more than 200 papers in the fields of systems engineering, simulation, control and instrumentation, nuclear power, control room design, human factors, organization and management, risk analysis and technology management.

Bernhard Wilpert was born 1936 in Breslau and educated in the universities of Tübingen, Bonn and Oregon, USA (Diploma in Psychology 1960, PhD 1965). He has been appointed professor in Berlin in

1978. Since 1980 he has been in charge of the Division of Work and Organizational Psychology of the Institute of Psychology (Berlin University of Technology). Since 1990 he directs the Forschungsstelle Systemsicherheit (FSS – Research Center of Systems Safety). 1994-1998 he was President of the International Association of Applied Psychology. In 1989 he received an honorary Doctor's degree of the Rijksuniversiteit Gent (Belgium) for his contributions to international comparative organization research and in 1999 he was appointed as Honorary Professor of Industrial and Organizational Psychology by the Institute of Psychology of the Academia Sinica (Beijing). In 2001 he was elected froreign member of the Royal Netherlands Academy of Science. 1993-1996 he served as member of the German Reactor Safety Commission and in 2000 he was appointed as member of Operations Committee of the German Reactor Safety Commission. Professor Wilpert is scientific advisor of an international research project of Eurocontrol on Cognitive Aspects of Air Traffic control and of the French governmental program "Groupement d'Intérét Scientifique (GIS) "Risques Collectifs et Situations de Crise" (CNRS, INRA, INSERM, IPSN). He published 25 books and close to 200 contributions to learned journals and edited volumes.

Sue Cox is Dean of Lancaster University Management School in the United Kingdom. She has an expertise in safety psychology and systems design. During her career Sue has worked as a consultant to major companies, both nationally within the UK and internationally, including companies within the nuclear sector. She has carried out research and published work in many areas, including management systems, safety culture, behavioral safety, attitudes to safety and occupational stress. Professor Cox is a member of both the UK HSC Nuclear Safety Advisory Committee and the UK Committee on Medical Aspects of Radiation in the Environment. She has been involved in two previous EU projects, 'Health and Safety Management in SMEs and the feasibility of voluntary schemes for health and safety improvement' and 'Measuring the Impact of Accidents and Ill-health' both funded by DG V.

Rosario Solá was educated at the University Complutense of Madrid (D. in Geological Sciences and PhD in Psychology). She has been employed at Ciemat since 1970, where she was working in the Mineral research laboratory until 1975 and in the Nuclear Safety Research department until 1986. During 1986-1992 she was member of the CICYT (Spanish Interministerial Committee for Science and Technology) as a responsible of several international and national research programmes and projects. She has been the head of the Safety of Complex Systems for Energy Generation project since 1992 and the technical responsible of the research project "Development of methods for evaluating and modelling the impact of organizational factors on nuclear power plants safety" sponsored by the Spanish Nuclear Regulatory Body (CSN) and the Spanish Utilities (UNESA). She has written different papers, articles and books regarding risk perception and communication, the influence of organization and management on nuclear power plants safety, the analysis of operating experience and the modelling of human errors of commission in PSAs.

Carl Rollenhagen was born 24 September 1953. He was educated in psychology and human factors at the University of Uppsala, University of Stockholm and University of California, San Diego, USA. He has a PhD from the University of Uppsala. Presently he is dividing his time between a professorship at the Mälardalen University and as a senior specialist and manager of the Human Factors Group at SwedPower, Vattenfall. Dr. Rollenhagen is Swedish representative in ISO standardisation for control rooms. His professional qualifications include studies of nuclear safety from a human factors and organizational perspective, organizational assessments with focus on nuclear safety, root cause analysis, and man-machine studies at nuclear power plants. He has written several conference reports and contributions to IAEA documents. He has written a textbook in Swedish on human factors. He has also been a invited teacher in IAEA workshops on human factors.