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Knowledge Management in Nordic NPPs Summary report of the findings from the workshop

Svein Nilsen
Institute for Energy Technology, Halden, Norway

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Abstract

The title of the reported project is “Nordic Nuclear Safety Research (NKS) Workshop on Knowledge Management in Nordic NPPs”. One important objective of this workshop was to explore if and how knowledge retention activities could be coordinated between the various Nordic utilities.

The main conclusions of the workshop can be summed up as follows: Establishing good knowledge management routines is recognized by many utilities today. However, there seem to be no real consensus on what should be focused on in the present situation. Maybe the most pressing problem is to avoid undesirable consequences of the massive retirement soon to follow. Still, there is no consensus on what those consequences might be, and what should be done to avoid them.

Key words

Knowledge management, workshop, knowledge retention

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The report can be obtained from
NKS Secretariat
NKS-775
P.O. Box 49
DK - 4000 Roskilde, Denmark

Phone +45 4677 4045
Fax +45 4677 4046
www.nks.org
e-mail nks@nks.org

Foreword

This document is the summary report from the NKS funded workshop on 'KM in the Nordic Nuclear Power Plants' (NKS_R_2004_39). The workshop was planned by a consortium consisting of TVO, VTT (Finland), Ringhals (Sweden) and IFE (Norway). This summary report which is defined as the final delivery of the project has been compiled by IFE.

The program of the workshop was structured into three main parts:

1. Presentations of the participants.
2. Structured discussions.
3. Recommendations from the workshop.

This report gives a summary of the reporting and discussions taking place at the workshop and the recommendation forwarded by the people attending.

Halden, December 2004

Svein Nilsen

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Summary

The title of the reported project is “Nordic Nuclear Safety Research (NKS) Workshop on Knowledge Management in Nordic NPPs”. The NKS project number is NKS_R_2004_39.
One important objective of this workshop was to explore if and how knowledge retention activities could be coordinated between the various Nordic utilities. One hoped to be able to conclude on recommendations indicating how experiences could be shared between the various NPP utilities and to see if concerted actions should be carried out, possibly funded by NKS.

As soon as the funding of the workshop was certain, the consortium started to exert influence on people to secure their participation to the workshop. The initial feedback when promoting the workshop was encouraging. However, the eventual participation was less than the consortium hoped for, thus rendering a feedback probably not capturing all viewpoints of the Nordic NPP industry.

The main conclusions of the workshop can be summed up as follows: Establishing good knowledge management routines is recognized by many utilities today. However, there seem to be no real consensus on what should be focused on in the present situation. Maybe the most pressing problem is to avoid undesirable consequences of the massive retirement soon to follow. Still, there is no consensus on what those consequences might be, and what should be done to avoid them.

There is neither any clear signal from the safety authorities on how to approach the problem. This puts the utilities in a limbo on how to deal with the problem. Without clear indications from the safety authorities it is doubtful that the utilities will prioritize KM to the degree that will be needed to deal systematically with the problem.
It is the impression of the author that there is still some way to go before the Nordic NPP industry has decided on priorities and solution strategies for the knowledge management problems of the future.

1. Introduction

For some time, there has been a growing interest in and attentiveness to a field commonly known as Knowledge Management (KM). Eventually the field has also gained some recognition by the NPP community worldwide. Important world wide organizations such as IAEA and NEA have defined activities that address issues relevant to KM. In addition many national research institutes and singular utilities have defined activities of their own.

The reasons for this shift in interest are probably several. However, one of the most important reasons is possibly the concern for knowledge attrition. By and by the competence of the staff will be worn down, sometimes because it is not used but more often because employees either quit or retire. Retirement has become a serious problem in many parts of the world due the general age profile of the NPP staff. Reports say that many places as much as 40% of the staff will retire in less than 5 years. This is a critical problem that needs to be dealt with before it becomes too late.

The deregulation of the electricity market is probably another contributing factor. It has created harsher market conditions, which makes it increasingly harder for the single utility to prevail. KM offer solutions that help companies to acquire, preserve and re-use knowledge more efficiently.

There have been few reports (if any) on concerted KM activities within the Nordic countries. The assumption for the workshop was that it should be purposeful to start a discussion on whether some KM activities of the Nordic countries should be coordinated. A workshop was proposed to NKS and funding was made available by a decision by the NKS board in May 2004. An invitation was sent out in June, and some 30-40 persons were contacted directly. A first response was that many would be willing to participate, however the eventual registration was minimal. Hence, this report is not as balanced as it could have been, given a broader participation.

The program of the workshop was structured into three main parts:

1. Presentations of the participants.
2. Structured discussions.
3. Recommendations from the workshop.

The detailed program together with list of topics for discussion is given in the appendix.

This report gives a summary of the workshop and the recommendation forwarded by the people attending.

2. Knowledge Management – definition and purpose

Knowledge Management is notoriously ill-defined and tends to concern absolutely anything going on within an enterprise. Many competing definitions exist. One of them is:"Knowledge Management enables the creation, distribution, and exploitation of knowledge to create and retain greater value from core business competencies" **[1**]. The reason for this pervasive tendency is obvious. In order for anybody to accomplish a task, knowledge pertaining to that task will be needed. However, starting to talk about Knowledge Management does not imply that there is no prior management of knowledge. The usual reason for bringing it up is that the management of that knowledge is *not satisfactory*. There is a certain discontent with respect to how competence is exploited in performing the various work processes of the organization.

This concern is found within very many domains today. The reasons may be several. One reason is the increased competition. Markets are continuously changing and more and more so. In order to survive in the competition it is crucial that the enterprise is adapting both to the market and the technology used to produce the goods that the market demands.

Increased competition does not only entail increased awareness of external conditions. Increased self-awareness is also required. It is important to know the strong points of the enterprise, to know the knowledge that really matters, the so called 'high value knowledge'. The high-value knowledge of the company is defined as that part of the knowledge that contributes decisively to the revenues of the firm. High-value knowledge is one of the factors that help a company to prevail against its competitors. Surprisingly, this knowledge may not always be easy to identify. In her book "Wellsprings of Knowledge" [2], Dorothy Leonard-Barton describes the 1988 purchase of Grimes by ElProduct, both being manufacturers of electroluminescent lamps. In addition to eliminating a competitor, ElProduct expected to benefit from what seemed to be Grime's expertise in producing high-quality lamps efficiently. Yet the company failed to realize that the critical expertise was the tacit knowledge of the line employees who incidentally did not transfer to the new operation.

Today many solutions aimed at improving knowledge management are being marketed. Knowledge management may thus be used to refer to these recent methods, tools and efforts supposed to *improve* (not implement) knowledge management.

During the first few years of KM the main focus was on the role of technology. Changes to the organization were not considered effective means to improve KM. This view prevailed almost 10 years from the beginning of the 90s to the new millennium. The predominant philosophy during this first period was the assumption that knowledge problems were caused by 'not-enough-of-explicit-knowledge'[3]. Consequently the challenge was to extract, codify, organise, index, and retrieve knowledge, from data, from people, from documents etc Technology/software was available to support those tasks to a certain degree, and appeared as an 'easy' way toward a working solution.

Much of this software had already been around supporting other branches of artificial intelligence field.

Knowledge acquisition techniques are one example of techniques already developed in the pre KM era. This technology was originally intended to capture knowledge from 'experts' and by

using *knowledge engineering* to be included in 'expert systems' solutions. Another KM related topic that received attention in the pre KM era was the *knowledge representation* problem. Knowledge Representation has always been central in the artificial intelligence field. The construction of ontologies was already an important issue early in the artificial intelligence era and received new attention in the KM era being essential to semantic web solutions. The KM era very much coincided with the WEB era and possibilities of synergy were readily identified. This is not surprising since the web is one common approach to deliver 'knowledge' and make that knowledge easily reusable.

Business intelligence, which relates to a specific aspect of the general knowledge problem, has a more recent development. It promoted, during the initial KM generation timeframe, disciplines like *data mining* (and the related knowledge discovery in databases), *OLAP* (On-Line Analytical Processing) and *data warehousing*. Other 'mining' methods heavily influenced by KM are *text mining and web mining*.

Other disciplines like *document management* have also been included in the wider paradigm of knowledge management, since improving quality of documents, and their retrieval, can be seen as a relevant mean to leverage knowledge management.

After the first wave of knowledge management enthusiasm, reports on failures started to seep in, and the suspicions that KM was another consultant's fad started to spread. At the same time, some people started to look for explanation why so many KM initiatives failed.

As part of this process, new viewpoints on knowledge emerged:

- Knowledge is not really the asset, but the people owning the knowledge and able to exploit it are the asset.
- Knowledge is not only explicit, but also implicit and tacit, actually it could happen that the most valuable knowledge is tacit and so people started to suggest that an important part of knowledge could never be codified.
- Knowledge is extremely dynamic, technology often ended in creating repositories difficult to update.
- Instead of managing knowledge it is necessary to look at the knowledge process.

This lead to a big change in perspectives, and today some theoreticians talk about a first generation KM and the second generation.

The shift of focus to the human and organization does not mean that technology has become irrelevant, or that the first technological phase was a big mistake. Experiences collected during the first KM generation era are still useful since it enable a more focused exploitation of the technology during the second generation era (the era that we are currently experiencing).

Consequences of the new knowledge view are a shift of attention which corresponds very well with the MTO paradigm used by the Halden Reactor Project to classify the various branches of their research work. According to the MTO model, the performance of a given utility (inclusive its knowledge management activities) depends on the combination of influential factors belonging to Man, Technology and Organization.

3. Knowledge Management Activities reported on during the workshop.

Below is given a brief summary of the presentations given in the beginning of the workshop. The intention of the presentations was to focus on important facts pertaining to KM, in particular important to the NPP industry. In other words, the presentations were intended to be a starting point for the subsequent discussions.

3.1 A survey of KM activities worldwide with an emphasize on NPPs – S.Nilsen(IFE)

S. Nilsen gave an overview of the Knowledge Management stressing its pervasiveness in many domains. This pervasiveness can be explained by the general observation that in order to take actions or decisions aimed at any given reality, knowledge about that reality must be presumed. Nilsen explained about the various technological and organizational factors that would influence the quality of the knowledge management. In particular the organizational factors and the responsibility of the management were underlined. Nilsen also gave an overview of some NPP activities worldwide. Types of such KM activities include:

- KM to improve safety cultures.
- Guidelines on KM.
- Guidelines on Knowledge Elicitation and Preservation.
- Technological Basis for KM solutions.
- Portal Technology
- Knowledge Retention Activities.
- Supply Chain Re-Engineering Activities.
- Knowledge Dissemination across Enterprise to Local Plants.
- Knowledge Retention to support Decommissioning.

Nilsen also gave an account of the KM activities of the Halden Project which are:

- Using Learning Organization Principles to improve the performance of the Central Control Room Operators. Learning Organization Principles try to introduce holistic thinking to the organization and establish a feedback loop facilitating learning from own (and others) experiences more efficient.
- Using KM tools and methods to implement better operating procedure maintenance.
- Establishing a portal to give more intelligent support to the member organizations when searching for reports and papers produced by the Halden Project.

During the ensuing discussion, the question was raised what could make the management more successful in communicating their strategic ideas downward in the organization. There was a consensus among the participants that the responsibility of the management does not stop with creating a climate affording knowledge exchange across the organization, but also to make the employees understand the strategic vision of the management (supporting knowledge flow downwards in the organization).

A question relating to knowledge quality was also raised. Since much knowledge is dynamic, it is important to implements some kind of 'best before' mechanism that would eventually lead to either a deletion of the fact from the knowledgebase or a piece of previous knowledge to be considered false.

3.2 Knowledge Management in NPPs – O. Ventä(VTT)

O.Venta gave a broad introduction to VTT activities pertaining to KM. VTT has activities both within the Technology branch and the M&O branch, though not all associating with the NPP industry.

In the M&O vein, VTT has contributed research in the mechanisms of the social construction of safety and efficiency in industrial organizations. Main elements of this research are to understand the interaction of the subjective process with the objective organizational performance. The focus is on the manner in which the employees construct their work, make it befitting to the organization and its demands. The influence and dynamics of the organizational culture is important in this respect.

Modern industrial organizations are constantly forced to improve their knowledge management due to competition and people leaving the organization, while at the same time they need to ensure and prove their reliability and safety to the general public. Adapting the organizational culture has been proposed as one mean to tackle these challenges. Old, rigid organizational structures and narrow-mindedness can inhibit change and be detrimental to the effectiveness of organization.

In order to be able to make an objective assessment on the organizational culture, organizational culture is defined in terms of *organizational core tasks* (OCT) [4]. The OCT is composed of four analytical components: the object of the activity, the objective of the activity, constraints and requirements of the activity. The object of the activity (e.g. particular power plant, manufacturing plant or offshore platform) and the environment (e.g. deregulated electricity market) put constraints on the fulfillment of the OCT (e.g. generating electricity safely and economically by light boiling water nuclear reactor to the electricity market at a competitive price). The OCT frames the motive of the activity and the shared constraints and requirements that all the workers have to take into account in all their tasks.

Concerning the representation of knowledge and its exchange, VTT has a strong focus on standardization. This is related to the recent trends in IT. It also related to the trend that NPP activities are increasingly more outsourced.

Present standards considered to be of importance in the future are

- ODBC, JDBC, ADO
- SOAP, WSDL, UDDI
- XML, XSD, RDF
- WWW, WAP, SMS

One potential problem is that these standards are representing rather shallow semantics, and deeper (and probably more domain specific) semantics/ontologies are needed to represent and exchange knowledge more effectively.

Among the NPP related areas, VTT considers the following to be of importance in a working KM solution:

- Knowledge on nuclear process technology
- Knowledge on organization structure
- Knowledge on the operational processes
    - Management
    - Operative use
    - Maintenance, development
    - Procurement, logistics
    - Auxiliary functions
- Identification of fields requiring cooperation between organizational units
    - Configuration management
    - Life time management
    - Performance measurement
    - Expertise and experience management
    - Safety management
    - Fuel management

3.3 Enhancing the transfer of expert know-how at the Finnish NPPs – L.Hyttinen(HUT)

A research group in Helsinki University of Technology BIT Research Centre has a special interest to explore the role and challenges related to the transfer of so-called *tacit* knowledge. They started researching in the NPP context in spring 2004 with a pre-study which has been reported e.g. in [5] and [6].

Tacit knowledge has at least two different definitions. One definition states that tacit knowledge is knowledge that cannot be documented explicitly in a feasible manner. This is the narrow definition. The other definition is that tacit knowledge is all knowledge that has not been documented. This is a more liberal that includes the first definition. Hyttinen primarily focused on knowledge complying with the second definition.
Hyttinen reported on a pre-study made at Finnish NPPs, including 17 interviews and 2 group discussions. The purpose of this pre-study was to investigate:

- The role and importance of tacit knowledge at the NPPs
- Current challenges in transferring tacit knowledge
- Methods currently in use for transferring tacit knowledge at the Finnish NPPs

The pre-study indicates that tacit knowledge is significant to the operation of Finnish NPPs, and that there exists an important and substantial amount of expertise not available in documents.

Based on the data gathered, it seems that major parts of tacit knowledge cannot be shared by verbalizing and disseminating it through knowledge management systems In the organizations studied, experienced workers have attempted to externalize their tacit knowledge, but there were several obstacles to share tacit knowledge in explicit form.

First, when externalizing the tacit knowledge on their own much essential knowledge was left out by the expert, knowledge that was considered self-evident. Normally, experts were unable to assume the position of a novice worker and generally they did not know what kind of knowledge should be conveyed. During face-to-face interaction between novices and experts, psychological and social factors came into play. These factors are left out in a setting where experts have to document knowledge by themselves. Motivation and ability of the mentors to share tacit knowledge were especially influential to the outcome of the knowledge sharing process. The eagerness of the new workers to learn and the enthusiasm and willingness of the experts to share their experience was very much influencing the result. Also the ability of the experts to reflect on and communicate their know-how, and the ability of the learners to pose questions to reduce ambiguities seemed to affect effectiveness of the tacit knowledge sharing.

Moreover, if the working culture of a work unit favored specialization rather than multi-professionalism, new workers were able to utilize newly learned tacit knowledge only in a few tasks. Thus, expertise acquired in other tasks was in danger of becoming obsolete. Even though many methods for sharing tacit knowledge were used in the organizations, tacit knowledge sharing occurred fairly unsystematically. There was no general knowledge about *what actually happened* when an expert and a new worker interacted and *how* tacit knowledge was shared in this relationship. Several research questions pose themselves

- In what ways is tacit knowledge communicated?
- Can knowledge be efficiently shared by asking questions, observing and imitating or telling narratives?
- Can knowledge sharing be modeled as a process and do these ways of communication have different implications in different phases of the process?
- How can the accumulation of expertise of the novice worker be described?
- How will the increase in trust between the expert and the novice influence the knowledge transfer process, its phases and the ways the expert and the novice communicate?

These questions need immediate attention, not the least due to the approaching retirement of knowledgeable staff. It will also take some time to find an appropriate solution to the transfer problem due to the following facts

- Apprenticeship requires resources and time
- Experts may lack abilities in teaching and guiding and may need training and motivation to be able to accomplish the mentoring in a satisfactory manner.
- Documenting tacit knowledge can be impossible/ unpractical and for this reason other solutions like mentoring should also be applied.
- All tacit knowledge is not worth transferring, and it may take time to identify what knowledge should be preserved.

The project will thus be carried on with the purpose to enhance the transfer of tacit knowledge to the new employees before the retirement of the experienced staff. The actions for 2005 and 2006 comprise:

- Pilot and implement methods enhancing the transfer of tacit knowledge in four cases selected by company representatives.
- Analyze experiences related to implementation of the methods and possibly recommending further studies within the field.

The selected cases are:

- Loviisa:
  - occupational instruction in mechanical maintenance
  - control room training period
- Olkiluoto:
  - master-apprentice pairs
  - transfer of expertise from OL1 and OL2 to selected groups in OL3

3.4 The TACO Traceability Model – can it be used for KM? T.Sivertsen.(IFE)

Sivertsen gave an overview of the TACO (Traceability and Communication of Requirements in Digital I&C Systems Development) project. The overall objective of the TACO project is to improve the knowledge on principles and best practices related to requirement traceability and communication. This comprises:

- *The requirements elicitation process*: Best practices and most important criteria for ensuring effective communication leading up to the requirements specification. Sources of ambiguities, misunderstandings, inconsistencies and defects in these requirements, and how they can be eliminated or their impact reduced.
- *Requirements analysis*: Efficient communication between the experts performing the analysis, and the process experts. Demonstration that the requirements analysis correctly reflects the safety analysis of the plant and other relevant information.
- *Traceability of requirements*: Traceability of requirements from the requirements specification to the requirements of the computer system, and through the different design phases.
- *Understandability*: Effective means to make the computer system requirements understandable to all parties, in particular when a high degree of formalization is employed.

It is interesting (but maybe not surprising) to see that exactly the same concerns relate with good knowledge management. There is a knowledge elicitation process preceding the externalization of knowledge that should be handled in an appropriate manner. There is a need to be able to verify the knowledge thus capitalized. Third, not only requirements are dynamic, but most kinds of knowledge are dynamic and the evolution process should be controlled and documented. Finally, all kind of knowledge should be available in a form that helps apprehension. This close correspondence is not surprising, since requirements are just one type of knowledge.
The question thus poses itself: What are the potentials of combining forces between a possible future NKS funded KM project and an extension to the TACO project?

One important result of the TACO project this far is the so-called *TACO shell*. The TACO Shell is a framework for traceability and communication of requirements. The shell can be filled with different *ingredients* to reflect the needs in different application areas. To facilitate its practical use, the shell is provided with *recipes*, for filling it with the different ingredients and utilizing it for its intended appliance By varying the ingredients and recipes, the shell can

be used for the development of different kinds of target systems. The model facilitates traceability by representing requirements changes in terms of a change history tree built up by composition of instances of a number of change types, and by providing analysis on the basis of this representation. The introduction, changes, and relationships between different requirements, design steps, implementations, documentation, etc. are represented in terms of an extended change history tree. By complementing the model with appropriate terminology, data structures and guidelines for use, the model can be adapted to the different needs related to management of changes in computer-based systems, including safety-critical and security-critical systems.

An interesting question is whether the TACO traceability model and the TACO shell can be applied to general knowledge management, and whether it can be used to control the dynamic development of knowledge. For several reasons, the totality of applicable knowledge will be changing as time pass by. New knowledge will emerge, some of it replacing obsolete knowledge. Also erratic knowledge may substantiate and later on there may be a need to retract to previously established knowledge.

3.5 The AKSIO project. Report on work process modeling to solve problems related knowledge management in the oil industry.(IFE)

Recently, staff at the Halden Project became involved in a fairly large research project for the oil industry. The project, called the AKSIO project, aims at uncovering how improved knowledge management may make tail-production profitable to the oil industry. The fact is that oil reserves on the Norwegian Continental Shelf are starting to dry out and unless something is done there will be no commercial oil fields left after 2020. There are many solutions to this problem and one of them is improved knowledge management. This corresponds closely to how the market forces are shaping the NPP industry after the deregulation of the electricity market. The AKSIO project focuses on the planning and implementation of the oil drilling process.

The Oil industry is characterized by decision making involving safety, high costs and potential revenues. Often one need to find a balancing point that measure costs against the possibility to earn money and dangers involved in bringing the oil up to the surface level. It is not always easy to calculate the economical and environmental hazards in a drilling operation since the geological conditions may not always be accurate to the point needed for risk-free drilling. Several kinds of knowledge need to be taken into account to make good decisions. The decisions are thus taken by a multi disciplinary group where effective communication is essential to the quality of the decisions taken.

Moreover, work may be sub-optimized both with respect to revenues/costs and safety. One organizational unit (like the drilling organization) may cut costs and thereby reduce both safety and/or income in the subsequent process (oil production). The reason for this is that people are rewarded based on a suboptimal measurement strategy and will thus perform in a sub-optimized manner. Obviously this is not in the interest of the organization, but is an effect of the management failing to create a work climate that favors cooperation on a sufficiently

wide level. There may also be a difference in time scope of the various desired effects that distort a proper view on the balance between safety/costs/revenues. Obviously, a reasonable level of safety is necessary to stay in business for a longer period of time. However, increased safety also increases the costs, while the revenues are temporarily decreased since the effects of increased safety are only observable over a long period of time.

One aspect that introduces risks is the impossibility of giving an absolutely certain prediction on the pressure from the formation through which the hole will be drilled. There is a pressure from the formation that needs to be counterbalanced by the drilling fluid circulating downwards inside the drilling string and then upwards through the annulus, the spacing between the formation wall and the drilling string. The drilling fluid serves several purposes. One purpose is to exert a given pressure on the formation wall so that it does not collapse. This is done by the pure weight of the drilling fluid, no pumps are involved. Another purpose is to transport the cuttings from the drilling upwards to the oil rig. However, if the weight of the drilling fluid is too high the circulation will stop and drilling fluid will instead seep into the formation. Oppositely, if the drilling fluid becomes too light, the fluids of the formation will seep into the drilling fluid and if too much in unbalance may trigger an uncontrollable blow-out. These are dire consequences that one will have to control based on rather uncertain seismic data.

The planning of a drilling operation is highly complex and a lot of strategic decisions need to be taken by a whole group involving several disciplines. Several types of expertise need to cooperate to make a high-quality drilling plan, such as geologists, geophysicists, petrophysicists, drilling engineers, reservoir geologists etc. For such a large group of people to cooperate, the challenges to proper knowledge management are substantial. Unless due consideration is taken with respect to satisfactory management of safety relevant knowledge, safety may be jeopardized.

Several complex operations are routinely planned and implemented on the Norwegian Continental Shaft. They are all unique since the formation is not identical at different reservoir targets. In this way, the conditions are radically different from NPP industry where the production process follows the same path as long as it is kept within design conditions. In the oil industry, it seems to be an absolute necessity to be constantly worried about safety, or else a disastrous well blow-out may follow. In spite of this, people in the business speak about problems coming from a drilling plan of less quality than it could have been. Factors causing quality defects are:

- Planning teams are dominated by opinionated people that tend to disregard advices or piece of facts that come from not so outstanding people in the team.
- There is an unwillingness/inability to use previous knowledge in the planning of a new well. Part of this problem is that knowledge is not readily available. One spokesperson from Hydro states that 60% of the time is used in looking for relevant information.
- Inconveniences in using IT tools that could have been more useful if more integrated in the work processes.

The AKSIO project aims at looking for ways to deal with the above mentioned problems. A workflow modeling activity has been started to identify the main steps in the planning and implementation operations. In doing this one hopes to have a clear enough understanding of how the various steps in the planning operation depends on each other and what qualities (including safety relevant risks) that associate with the steps. The next move will be for the

AKSIO project team to suggest improvements and further investigate around these improvements to have a better understanding if these solutions would improve the situation or not.

The preliminary experiences from the investigations suggest that the planning is rather unstructured and opportunistic. This is probably partly due to the complexity of the problem one tries to solve. Again, the opinionated people may take the lead and completely disregard potential safety problems that may cause problems during the drilling operation. Re-modeling of the work processes, re-educating people and/or introducing improved IT solutions may alleviate these problems.

Same kind of solutions may also be attempted for the NPP industry. Modeling of work processes may have the effect that activities done in the plant may be better understood, that more appropriate IT tools may be introduced and that crucial knowledge may be more easily identified.

4. Summary of general discussions.

As can be seen from the workshop agenda given in the appendix, the workshop delegates were faced with a set of questions following the general presentations of the workshop. These questions were meant to stimulate the discussions. Thus it was not a requirement that all questions should be used. The questions were classified according to three main classes.

A. How can understanding of the current situation be improved?
B. How can knowledge be preserved?
C. The Nordic Dimension.

Among these classes, the last class was considered the most important as it would be the basis for the recommendations given to the NKS. The following presentation of the discussion may obviously reflect conflicting viewpoints, and the summary must not be read as a consistent set of viewpoints on the role and importance of KM.

A. How can understanding of the current situation be improved?

Is there any reason to believe that we will face problems related to loss of knowledge such as when people go into retirement?

Some people believe that not enough is done to deal with KM problems of today. One weak point is the available documentation that may not be good enough. The language used in the documentation may not be stringent enough. For a large portion of the documents there are obvious potentials to remove ambiguities. However, this will incur high costs and only the most important knowledge can be improved for the activity to be cost effective.
A second point is that documentation is often produced during the development process. Proper quality assurance is thus a key to completeness, consistency etc. Development and documentation should never be a single person activity. Teamwork will improve the quality of both development and documentation.
The issue of outdated design solutions was also touched upon. Archaic design solutions may seem uninteresting for today's staff, but may be very important in a situation of re-engineering.

Not amenable to documentation is purely tacit knowledge. It is uncertain if tacit knowledge is appropriately tended to today in the Nordic NPP industry.

Are there any financial drivers in the quest for better knowledge management (effect of the deregulation in the electricity market)? What is being done to shorten revision periods?

The application of KM will always reach a balancing point, when additional spending will not be cost effective. Still it is believed that we have not reached this point quite yet and that knowledge management does not always mean high-cost knowledge elicitation. In particular, it is still possible to implement organizational measures that would afford better knowledge management. The workshop delegates did not take any position as to whether the future electricity market would change the balancing point of cost-effective KM or if further efficiency improvement of work processes (like revision periods) would be needed some time into the future.

Organizational prerequisites and motivation. What is the role of the senior management? How can knowledgeable persons in the organization be motivated? How can KM be more prioritized?

Senior management need to be good examples. All managers need to indulge in good KM practice in order to expect from sub-ordinates to focus on the same kind of practices.
Another problem with KM is that knowledge assets are not taken into account in financial book keeping. No price tag is put on knowledge assets and it will thus not influence the revenues of the enterprise.
Organization must emphasize social gatherings as an important mean to sustain good communication channels in an organization. Job rotation is another important mean to keep communication channels open.OL1 & 2 are very similar so they use crew rotation as a mean to keep communication channels open. Experiences from Forsmark 1&2 are not that encouraging. Also Ringhals will probably have some problems to achieve the same effects due to differences between the units.
It is important to have high quality work processes as this may be one of the best means to secure better KM. By integration of KM in the daily/regular routines, it will be given a chance to go on in the long run.
Involving safety authorities in the work for better KM is probably very important. Many safety authorities have already engaged in the definition of KM requirements and will probably have a role to play here in order to enforce better KM in the plants. One example on this was mentioned in referring to STUK's work to define requirements to the education and training of operators such as [7] and [8].
Both STUK and SKI presented papers at the recent IAEA conference on KM in Saclay, Paris [9][10].
STUK adopted the systematic approach to training in early 90's, this method is based on IAEA TECDOC 1254 (2001). A very stable work force of STUK eliminated much of the need for training. In 2001 the systematic approach was revitalized to assure adequate in-house competence at STUK. Central to this effort is a method called *competence analysis.* Competence analysis is in common use by the public sector and governmental organizations in Finland. STUK adjusted this method to fit own needs. The model apply four different competence categories: substance related, management skills, common working skills and STUK related working skills. These were further defined by listing various competence fields.

This resulted in more than 80 competence areas related to nuclear safety and 7 of those were common to all kind of experts.
In [10], SKI talks about the need to educate professionals by financing an adequate number of university places and professorates. The main mean to achieve this has been co-operation between the authorities, the Swedish Centre for Nuclear Technology and major Swedish universities. A prediction of the needed number of persons to be recruited has been made and with the present level of education there will be no problems with staffing in the near term future.

What measures can be taken to identify and delineate the knowledge that really matters?

Key competence areas have been proposed by many NPP organizations even though these have not been taken down to a sufficiently detailed level. WENRA have had an activity on this. LEARNSAFE is another project that may have contributed something to the understanding of key competence areas [11]. According to one of the workshop delegates, the LEARNSAFE projects deal with the following key competence areas:

1. Knowledge and competencies that are needed for operating and maintaining the nuclear power plant.
2. Knowledge and competencies that are connected to the own plant, its structure and its behavior in transients and accidents.
3. Knowledge and competencies in nuclear technology in general that includes nuclear science and technology in areas that are not directly connected to a specific plant.
4. Knowledge and competencies that are connected to laws and regulations in the nuclear field.
5. Knowledge and competencies that are connected to behavior and handling of nuclear fuel and waste.
6. Knowledge, competencies and skills that are connected to the management of intellectual resources and including the management of people and organizations.
7. Knowledge and competencies that are connected to the management of knowledge and practices.
8. Knowledge and competencies that are connected to finances and money.
9. Knowledge and competencies that are connected to the management of projects.
10. Knowledge and competencies connected to the management of contacts and relationships to the society.

Other people still believe it will be very complicated to identify significant classes of knowledge. Some may even think that one should not waste resources on this.

How can the quality of documented knowledge be assessed?

Software quality measures may be applied for to assess quality of existing documentation. Still certain things remain unsolved. NPP utilities have a fairly good update procedure for existing documentation. The most important (FSAR, PSA) are routinely updated every third year (in addition to updates whenever anything is changed). The usability of the documents is also important, allowing crew to access pertinent information in a facilitated manner.

How can knowledge management facilitate effective communication between people of different background and expertise?

The TACO project has addressed this issue in their requirement specification communication rumination. In a requirement/design situation it is often needed that end users communicate with designers. This is often a challenging task. To facilitate this communication, the TACO project suggest introduction of different kind of perspectives on the same knowledge. This may imply a translation process that will use a dictionary to translate problems formulations belonging to one perspective into the vocabulary of another perspective. It may be a particular challenge to keep the two views consistent. One example is when constructing operation procedures from other types of technical documentation. This extracts the technical information and the implications so that can be more readily applicable by the operators. Since there is a manual construction, there may be a possibility that the two views on the process may become inconsistent or outdated. More efficient knowledge management would address this maintenance and re-usability problem and it may thus be maintained that KM will indeed facilitate communication among people. Still, lack of communication is often an organizational problem and organizational measures to increase communication may often be the appropriate focus when improving KM. The question was raised if there exists communication problems within utilities today. For instance, communication between field operators and control room crew may in certain non-routine situation be a challenge because they have a partially non-overlapping vocabulary. Communication within the central control room crew is trained in simulator. Still information dissemination may not be extensive enough among shifts and departments.

B. How can knowledge be preserved?

What tools are being used by the industry today to document knowledge? Are there any plans to introduce new tools?

MS Words is an extensively used tool that will be used for many years to come. However, incompatibilities between various Word versions may cause problems in reading old documents. Other tools typically being used are various databases, CAD systems, Intranet. It is a widespread opinion that it is important to have a database of core-competencies and to have a plan on how to preserve that knowledge within the organization associated with that database. Such information is normally elicited by interviewing work leaders. There is definite knowledge about tools to be introduced in Nordic NPPs in the time to come.

Can operator support system be integrated with KM systems to enhance KM solutions?

In principle yes, but there are problems with safety and security that requires operator support systems to exists totally isolated from documentation systems.

What kind of challenges is related to tacit knowledge at the moment?

In reference to Hyttinen's presentation one may say that the most important aspects are:

- The forthcoming retirement of a large proportion of staff, especially certain types of experts.
- Apprenticeship requires resources and time. There is a tendency that sufficient resources are not allocated to management of tacit knowledge.
- Experts possessing the tacit knowledge may lack abilities in teaching and guiding.
- Tacit knowledge is self-evident for the expert and may thus not be identified as something that should be transferred to other people.

- Documenting tacit knowledge can be impossible/ unpractical. Thus mentoring which is costly need to be applied.
- All tacit knowledge is not worth transferring. It is important to identify exactly what should be passed on to other staff members.
- Building a new NPP and managing knowledge of the process. Some of this knowledge may be tacit and there may be no provision for this knowledge to persist into the operation phase.
- Develop training to transfer also tacit knowledge, making this a routine task of all operator/staff training.

How can management of tacit knowledge be integrated into a total knowledge management solution?

Competence (including the one based on tacit knowledge) should be mapped so that competence may easily be located when it is required irrespective whether it is tacit or has already been externalized. There should also be a plan on how to preserve the knowledge. For instance, there is a need to plan for (re-) education to be sure that a sufficient level of competence is always kept within the organization. TAITO (Finnish for 'skill') is a TVO system that implements such yellow page functionality with features for knowledge/skill preservation.

C. The Nordic Dimension.

What about Nordic research cooperation? What topics are the most promising?

The cooperation between Nordic countries seems very relevant. It encourages the sharing of experiences between utilities affording better KM solutions on the individual plants. It is required that any research activity be multi-disciplinary, because knowledge management very much rely on human/organizational/technological elements to work together. Using spin-offs from the TACO project may possibly be combined into a proposal. The relationship between Quality Management and KM is another possible track. Yet another possibility is the assessment of current documentation. In particular evaluation of the plant documentation in the perspective of the whole plant life-cycle could be interesting. Delegates that have worked with identification of competence areas prefer to continue investigation of this particular aspect. Existing competence areas need to be further detailed to be sure that the plant really possess the competences it needs, also in the future.

Establishing guidelines on introducing KM related methods and systems into the utilities.

The workshop delegates were not sure if such guidelines are needed. In all cases, the guidelines must take into account solutions that are available already (even though they are only functional in parts).

Can Nordic portals for sharing experience be erected?

International organizations like WANO and IAEA have already implemented portals offering this kind of functionality. Human networks of information exchange are already in place. Several of these are arranging meetings a number of times a year, so the needs for portals may thus be smaller than otherwise. One such initiative is the ERFATOM organization that connects to the incidents reported by WANO as well as incidents in the Nordic NPPs. The infor-

mation thus acquired pertains to Westinghouse Atom type of plants and in addition to Westinghouse the following NPPs organizations are associated: Forsmark, Ringhals, Barsebäck, OKG, TVO and KSU. KSU is manages the administrative work which among other things is to identify those documents that may be relevant to the Nordic utilities. KSU also adapts their training program to reflect important incidents that have been reported. The information is distributed further on to contact persons for the various associated NPPs. Other examples of such networks are working groups on technical specifications, maybe working under the auspices of some international NPP organization or vendor. Language barriers may cause a problem. Even though the lingua franca is English, the communication between Finnish and Swedish plants may be inhibited because a foreign language needs to be applied.

How can KM thinking be incorporated into the (re-)education of NPP professionals? How can universities and utilities cooperate on this issue?

Plant personnel have various types and levels of education. Thus there is no possibility to introduce Knowledge Management education at the basic stages of their education. Graduate courses on KM may be arranged, but there was a certain reluctance among some of the workshop delegates to believe that people will attend this type of courses. The effects of the courses are also disputable. Still 1-2 weeks courses may have a certain effects if they are well planned and may inspire plant personnel to explore the potentials of Knowledge Management.

The priorities of the individual plants are to a large extent governed by the requirements laid down by the licensing authorities. Any requirement with respect to work processes or documentation (e.g. FSAR/PSA) will be adhered to by the utilities and there is a tendency that any non-mandatory activity will only be attended to if deemed necessary in the short-term perspective. In the de-regulated electricity market the margins of profit are very narrow and the utilities are reluctant to deal in activities which do not save money or increase revenues. Thus, it seems necessary that licensing authorities adjust their requirement to force utilities to take improved KM more seriously.

5. Recommendations of the Workshop.

There was no clear recommendation given by the workshop. Establishing good knowledge management routines is recognized by many utilities. However, there seem to be no real consensus on what should be focused on in the present situation. Maybe the most pressing problem is to avoid undesirable consequences of the massive retirement soon to follow. Still, there is no consensus on what those consequences might be, and what should be done to avoid them.

There is neither any clear signal from the safety authorities on how to approach the problem. This puts the utilities in a limbo on how to deal with the problem. Without clear indications from the safety authorities it is doubtful that the utilities will prioritize KM to the degree that will be needed to deal systematically with the problem. KM requires substantial investments, and utilities are reluctant to initiate any activity without knowing whether it will be required (by safety authorities) or what effect it will have on the financial surplus in the years to come.

Deliberating the good responses received by the organizers when contacting people it seems that wavering from the plant management may be one of the reason that the participation

turned out this low. Plant staff is notoriously weighed down with various tasks, and will have to prioritize according to directives given by the management.

Thus, it seems natural at this stage to proceed with exploratory work, investigating the consequences of massive retirement on plant operation. The recruitment of new NPP professionals seems to be under control within in the Nordic countries, while the situation with respect to knowledge transfer from one generation to the next seem to be much more uncertain. This is especially true with respect to tacit or undocumented knowledge. Taking into account the experiences from the workshop, it seems that under present conditions it will be difficult to have access to the experiences and viewpoints of the utilities unless a certain portion of the work is actually handled at the utilities themselves. Only modest investments from the utilities themselves must be expected in the short term, until the view on knowledge preservation and dissemination has been consolidated and materialized in material requirements from the safety authorities.

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7. Appendix: Workshop Agenda.

Thursday 7th October:

9.00 Welcome.
9.10 Presentations:

- A survey of KM activities worldwide with an emphasize on NPPs – S.Nilsen
- Knowledge Management in NPPs – O. Ventä.
- Enhancing the transfer of expert know-how at the Finnish NPPs – L.Hyttinen
- The TACO Traceability Model – can it be used for KM? T.Sivertsen.
- The AKSIO project. Report on work process modeling to solve problems related knowledge management in the oil industry.

12.00 Lunch.
13.00 Structured discussions.

A. How can understanding the current situation be improved?

- Is there any reason to believe that we will face problems related to loss of knowledge such as when people go into retirement?
- Are there any financial drivers in the quest for better knowledge management (effect of the deregulation in the electricity market)? What is being done to shorten revision periods?
- Organizational prerequisites and motivation. What is the role of the senior management? How can knowledgeable persons in the organization be motivated? How can KM be more prioritized?
- What measures can be taken to identify and delineate the knowledge that really matters?
- How can the quality of documented knowledge be assessed?
- How can knowledge management facilitate effective communication between people of different background and expertise?

B. How can knowledge be preserved?

How can knowledge be encoded/formalized and maintained?

- What tools are being used by the industry today to document knowledge? Are there any plans to introduce new tools?
- How can standard document management be transformed into/used by KM systems?
- Can operator support system be integrated with KM systems to enhance KM solutions?
- How can undocumented knowledge be elicited and documented?
- How can QA and KM be integrated? Are there any problems related to security/safety?
- How can diagrammatic methods, e.g. the diagram types in UML, facilitate knowledge management?
- Is it possible to define concepts like "knowledge patterns", "knowledge modules", "knowledge structures", "distributed knowledge", etc. and utilize this in a systematic approach to knowledge management, in particular when handling large amounts of

knowledge and information? Can such concepts facilitate analysis of the knowledge within an organization to identify incompleteness or inconsistencies?
- Revision of knowledge vs. revision of system requirements: What can knowledge management learn from requirements management, and vice versa? Do we need a methodology for managing revisions of knowledge, and if so, can we do this by technology transfer from the requirements management area? What are the possibilities for technology transfer the other way around?
- How can we eliminate, or reduce the impact of, sources of ambiguities, misunderstandings, inconsistencies and defects in the represented knowledge?
- How can knowledge management be utilized to facilitate changes within an organization? Relations to change management?

What knowledge cannot be formalized (tacit knowledge)?

- What is tacit knowledge?
- What is the role of tacit knowledge at NPPs?
- What kind of challenges is related to tacit knowledge at the moment?
- How is it being currently transferred?
- Are there some efforts going on to enhance the transfer of tacit knowledge at the NPPs?
- How can management of tacit knowledge be integrated into a total knowledge management solution?

C. The Nordic Dimension.

- What about Nordic research cooperation? What topics are the most promising?
- Establishing guidelines on introducing KM related methods and systems into the utilities.
- Portals for sharing experience.
- What about exchange of experiences? Are there any reports on cooperation on KM across Nordic utilities?
- How can KM thinking be incorporated into the (re-)education of NPP professionals? How can universities and utilities cooperate on this issue?

This list of topics to touch on is only tentative and additional topics may be suggested freely by the participants of the workshop.

19.30 Dinner at Halden Klubb.

Friday 8th of October:

9.00 Recommendations from the workshop. What should be in the report to be submitted to NKS? What are the major challenges being faced by Nordic NPP utilities today? What is the potential benefit of concerted actions? Discussion

10.45 Summary of the workshop.
11.00 Lunch

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Abstract

The title of the reported project is “Nordic Nuclear Safety Research (NKS) Workshop on Knowledge Management in Nordic NPPs”. One important objective of this workshop was to explore if and how knowledge retention activities could be coordinated between the various Nordic utilities.

The main conclusions of the workshop can be summed up as follows: Establishing good knowledge management routines is recognized by many utilities today. However, there seem to be no real consensus on what should be focused on in the present situation. Maybe the most pressing problem is to avoid undesirable consequences of the massive retirement soon to follow. Still, there is no consensus on what those consequences might be, and what should be done to avoid them.

Key words Knowledge management, workshop, knowledge retention

Available on request from the NKS Secretariat, P.O.Box 49, DK-4000 Roskilde, Denmark.
Phone (+45) 4677 4045, fax (+45) 4677 4046, e-mail nks@nks.org, www.nks.org