SKI Report 2007:26

Research

Safety Culture Enhancement Project Final Report

A Field Study on Approaches to Enhancement of Safety Culture

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SKI

SKI PERSPECTIVE

Background

At the International Conference on Safety Culture in Nuclear Installations, organized by IAEA in 2002, one concluding remark was that the regulators should encourage a sincere interest in safety culture among licensees. In line with this SKI wanted to explore a proactive path to encourage the licensees in their safety culture work. SKI also had the ambition to gain more information on the MTO considerations taken and how the safety work is approached from the top management level in the Swedish nuclear power industry. Furthermore, recent incidents within the Swedish nuclear power industry had made it obvious that safety culture issues have a great impact on a wide range of work practices.

SKI´s purpose

This work was aimed at giving an overview of the Swedish nuclear power industry concerning its safety culture enhancement strivings, and at the same time proactively support these strivings. A specific method was used in order to see if this type of method could be effective for achieving the aims.

Results

SKI noted that the project validated the method used and gave a good overview of the quality of licensee safety practices. The project also gave SKI an understanding of the status of senior manager's safety perspectives within the industry. The nine recommendations given in the report constitutes a pathway for licensees as well as the regulator to tread on in the continuous work to enhance safety.

Continued work within the field

SKI will continue its work with the development of the oversight of safety culture and which approaches to choose. SKI can see the need for further research into different assessment methods. Safety leadership is another relevant area which needs further research.

Effects on SKI´s work

This research project has given SKI valuable support to the notion that safety culture is an MTO-area that requires a lot of dialogue, discussions and communicating in order to further the understanding of the concept and how it can be approached.

Project information

SKI project coordinator: Lars Axelsson
Projektnummer: 14.3-200303008

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Summary

This report documents a study commissioned by the Swedish Nuclear Power Inspectorate (SKI) with the objective of enhancing safety culture in the Swedish nuclear power industry. A primary objective of this study was to ensure that the latest thinking on human factors principles was being recognised and applied by nuclear power operators as a means of ensuring optimal safety performance.

The initial phase of the project was conducted as a pilot study, involving the senior management group at one Swedish nuclear power-producing (NPP) site nominated by SKI. The pilot study enabled the project methodology to be validated after which it was repeated at other Swedish nuclear power industry sites, providing a broad-ranging analysis of opportunities across the industry to enhance safety culture.

The introduction to this report (*Section 1*) contains an overview of safety culture, explains the background to the project and sets out the project rationale and objectives.

The methodology used for understanding and analysing the important safety culture issues at each nuclear power site is then described (*Section 2*). This section begins with a summary of the processes used in the information gathering and data analysis stage. The six components of the Management Workshops conducted at each site are then described. These workshops used a series of presentations, interactive events and group exercises to: (a) provide feedback to site managers on the safety culture and safety leadership issues identified at their site, and (b) stimulate further safety thinking and provide 'take-away' information and leadership strategies that could be applied to promote safety culture improvements. Section 2 concludes with an outline of the confidential site reports prepared as one of the project deliverables.

Section 3, project Findings, contains the main observations and output from the project. These include:

- a brief overview of aspects of the local industry operating context that impinge on safety culture;
- a summary of strengths or positive attributes observed within the safety culture of the Swedish nuclear industry;
- a set of identified opportunities for further improvement;
- the aggregated results of the Safety Culture Perceptions Questionnaire conducted with site managers to access their opinions about the adequacy of the local safety culture;
- a framework of safety-related competencies for managers, representing desirable actions for leading and promoting a positive safety culture;
- results of an evaluation survey completed by participants at the conclusion of the Management Workshops to assess the utility of this activity.

Section 4 of the report, Recommendations for Future Action, highlights nine proposed activities that could be undertaken to build on the outcomes from this project, to support the enhancement of safety culture within the Swedish nuclear industry in the longer-term. Specifically, these recommendations propose actions to:

1. Introduce formal processes to ensure the ongoing development of **safety-related competencies** amongst industry managers.
2. Strengthen the resources, contribution, value and profile of **Man Technology Organisation (MTO) expertise** within nuclear industry sites, in order to promote a better understanding of human performance issues, enhance error management and accident prevention capabilities.
3. Identify ways to **embed existing positive safety culture attributes**, in an environment of considerable workforce changes resulting from increasing use of contractors and (expected) retirements amongst an ageing industry employee population.
4. **Standardise** and improve aspects of **incident and accident investigation processes** and analysis methodologies currently used, to improve information sharing and optimise learning.
5. Implement harmonised **MTO / human factors awareness training** programs at appropriate levels for all nuclear industry personnel.
6. Formalise the application of applied teamwork training (as per the principles of **Crew Resource Management training** in aviation) for NPP Control Room Operators, Maintenance workers and other employees working in safety-critical teams.
7. Increase the use of simulation training to enhance **non-technical team** problem-solving and decision-making **skills.**
8. Continue to **defend against complacency** about safety performance.
9. Implement a process to provide regular quantitative **measures of the industry safety culture**, as a guide to future enhancement actions.

It should be noted that this project was designed and undertaken in accordance with an agreed condition that SKI was not to be provided with any specific or identifiable information, positive or negative, about the safety practices or culture of any participating site. Appropriate safeguards were thus established and implemented throughout the project to enable optimal feedback to be provided to each site visited, but to provide only generic observations and findings in reports to SKI.

The conclusion to this report (*Section 5*) confirms that, on the basis of information gathered and observations made during the project, the safety culture within the Swedish nuclear power industry is intrinsically and substantially positive. This is attributable in part to aspects of societal culture, the prevailing leadership style and professionalism of managers, and an inherent respect for safety amongst industry employees. Notwithstanding the predominance of positive safety culture indicators, a number of opportunities to embed and enhance aspects of safety culture were detected, and recommendations about these are provided. These include a reminder about the risk of complacency, a natural but potentially dangerous outcome in industries where safety performance as measured on standard indicators is customarily very good.

Sammanfattning

Denna rapport utgör slutrapporteringen av en studie beställd av Statens kärnkraftinspektion (SKI) med syftet att förbättra säkerhetskulturen inom svensk kärnkraft. Ett primärt syfte med denna studie var att försäkra sig om att det senaste tänkandet kring MTO-principer får sitt erkännande och används av tillståndshavare som ett medel att försäkra sig om ett adekvat säkerhetsarbete.

Första fasen i projektet genomfördes som en pilotstudie och involverade företagsledningen vid ett svenskt kärnkraftverk utsett av SKI. Pilotstudien möjliggjorde en validering av projektmetoden och studien upprepades därefter vid andra kärntekniska anläggningar och gav en övergripande analys av möjligheter att stärka säkerhetskultur inom industrin.

Introduktionen till denna rapport (*Section 1*) innehåller en överblick av säkerhetskultur, förklarar bakgrunden till projektet och förklarar projektets grund och mål.

Den metod som använts för förståelse och analys av viktiga säkerhetskulturaspekter vid varje tillståndshavare beskrivs i det följande avsnittet (*Section 2*). Detta avsnitt inleds med en sammanfattning av processerna som användes vid datainsamlingen och analysen av data. Vidare beskrivs de sex komponenterna av den Management Workshop som genomfördes vid varje tillståndshavare. Dessa workshops innehåll en en mängd presentationer, interactive moment och gruppövningar för att: (a) ge feedback till chefer om frågeställningar och förhållanden inom säkerhetskultur och säkerhetsledarskap som identifierats i organisationen och (b) stimulera fortsatt tänkande kring säkerhet och tillhandahålla ‘take-away’-information och ledarskapsstrategier som kan användas för att stödja förbättringar av säkerhetskulturen. Avsnitt 2 avslutas med en beskrivning av upplägget i de konfidentiella rapporter som enbart delgavs varje medverkande tillståndshavare.

Avsnitt 3 (*Section 3,* Findings) innehåller de huvudsakliga observationerna och resultaten i projektet. Dessa omfattar bland annat:

- en kort översikt av aspekter av den nationella operativa kontexten som påverkar säkerhetskultur;
- en summering av styrkor eller positive attribute som observerats inom den svenska kärnkraftsindustrins säkerhetskultur;
- ett antal identifierade förbättringsområden;
- de sammanlagda resultaten av Safety Culture Perceptions Questionnaire genomförd med chefer för att stämma av deras uppfattningar om deras organisations säkerhetskultur;
- ett antal säkerhetsrelaterade kompetenser för chefer som betecknar önskvärt handlande för att leda och stödja en god säkerhetskultur;
- resulten av en enkätundersökning som deltagarna genomförde efter workshopen för att utvärdera nyttan av detta projektet.

Avsnitt 4 i rapporten (*Section 4* - Recommendations for Future Action) lifter fram nio rekommenderade aktiviteter som kan användas för att långsiktigt stödja ett stärkande av säkerhetskulturen inom svensk kärnkraftindustri. Rekommendationerna är följande:

1. Inför formella processer för att säkra den pågående utvecklingen av **säkerhetsrelaterade kompetenser** bland chefer.
2. Stärk resurserna för, bidraget och värdet av samt profilen på **Man Technology Organisation (MTO)-expertis** inom organisationen för att **främja** en ökad förståelse för mänskliga aspekter av verksamheten och en förstärkning av förmågan att hantera fel och incident/olycksförebyggande åtgärder.
3. Identifiera sätt att **bygga in existerande positiva säkerhetskulturattribut** i den miljö av stora personalförändringar som är resultatet av ett ökande behov av underleverantörer och (förväntade) pensionsavgångar bland den åldrande personalkåren.
4. **Standardisera** och förbättra aspekter av **incident- och olycksutredningsprocesser** and analysmetoder som används idag för att förbättra informationsutbyte och optimera lärande.
5. Implementera harmoniserad **MTO / human factors awareness-träningsprogram** på lämpliga nivåer för all kärnkraftspersonal.
6. Formalisera en form för tillämpad teamworkträning (såsom principerna för **Crew Resource Management training** inom flygindustrin) för kontrollrumsoperatörer, underhållspersonal och andra anställda som arbetar i team med arbetsuppgifter med betydelse för säkerheten.
7. Öka användningen av simuleringsträning för att förbättra **icke-tekniska färdigheter i grupp** såsom **problemlösning** och **beslutsfattande**.
8. Fortsätt att **motverka självgodhet** i säkerhetsarbetet.
9. Implementera en process för kvantitativa **mätningar av säkerhetskultur**, som en vägledning till framtida förbättringsåtgärder.

Det ska noteras att detta projekt lades upp och genomfördes i överensstämmelse med villkoret att SKI inte skulle förses med någon specifik information, oavsett om den var positive eller negativ, om säkerhetsvanor eller kulturen hos någon av de deltagande tillståndshavarna. Lämpliga åtgärder vidtogs därför genom hela projektet för att uppnå en optimal feedback till enskild tillståndshavare och att bara generella observationer och resultat angavs i rapporteringen till SKI.

Rapportens sammanfattning (*Section 5*) bekräftar, på basis av insamlad information och observationer under projektets gång, att den rådande säkerhetskulturen inom svensk kärnkraft i grunden är god. Detta beror delvis på aspekter i samhällskulturen (societal culture), ledarstilen och chefers professionalism samt en inneboende respekt för säkerhetsarbetet hos medarbetarna. Trots indikationerna på en övervägande god säkerhetskultur så observerades ytterligare förbättringspotential och ett antal rekommendationer ges. Dessa inkluderar bland annat en påminnelse om risken för

självgodhet, som är ett vanligt men också potentiellt farligt inslag i industrier där säkerheten normalt anses väldigt hög.

1 Introduction

This document is the Final Report on a Safety Culture Enhancement project conducted for the Swedish Nuclear Power Inspectorate (SKI): "Safety Culture Enhancement: A Field Study on Approaches to Enhancement of Safety Culture". The SKI Department of Man Technology Organisation (MTO) commissioned this research assignment with the objective of enhancing safety culture across the Swedish Nuclear Power Production (NPP) Industry.

SKI's objectives for the project were to ensure that latest thinking on the importance of human factors (known locally as MTO) was being recognised and incorporated into operational practices as a way of enhancing safety performance in the industry. Further information on the rationale for the research assignment and its objectives are available in the relevant SKI Research Assignment documents (Project 23030, dated 2003-12-09; and Project 200303008, dated 2004-09-07).

Phase 1 of the project involved a pilot study to trial the proposed methodology and to confirm that the intended outcomes could be delivered. The pilot study was conducted at one Swedish NPP site in March 2004, and has been reported elsewhere (Hayward & Lowe, in press).[1]

Following the completion of Phase 1, SKI decided to extend the project to include the remaining NPP sites in Sweden (Phase 2).

The objective of Phase 2 of the project was to apply the Safety Culture Enhancement (SCE) methodology to all other relevant elements of the Swedish NPP industry. The methodology was subsequently employed at one other NPP site and one nuclear fuel production facility. Logistical difficulties prevented the methodology from being applied at the remaining NPP site within the necessary timeframe and a decision was thus taken to exclude that facility from the project. A progress report on Phase 2 activities was issued in December 2004 (Hayward & Lowe, 2004).[2]

This SKI Final Project Report describes in full the project rationale, methodology and activities, and summarises industry-wide findings in regard to safety culture and the application of MTO principles. It also makes recommendations with regard to future activities to strengthen safety culture and the application of MTO principles within the Swedish NPP industry.

The Final Project Report will be a publicly available document and does not therefore contain information identifying any participating site. This report is intended to complement other forms of information obtained by SKI on the quality of licensee safety practices and the overall status of safety culture within the Swedish nuclear industry.

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[1] Hayward, B.J., & Lowe, A.R. (in press). *Safety Culture Enhancement Project, Phase 1 Report: A Field Study on Approaches to Enhancement of Safety Culture.* Stockholm: Statens Kärnkraft Inspektion.

[2] Hayward, B.J., & Lowe, A.R. (2004). *Safety Culture Enhancement Project, Phase 2 Progress Report: A Field Study on Approaches to Enhancement of Safety Culture.* Melbourne: Dédale Asia Pacific.

1.1 Overview of Safety Culture

Safety culture is the term used to describe those aspects of an organisation's reliability that depend on *"shared values and norms of behaviour articulated by senior management and translated with high uniformity into effective work practices at the front line"*.[3] This definition emphasises the direct and powerful influence of an organisation's leadership group on the safety attitudes and behaviour of employees.

The term safety culture was initially used by the International Nuclear Safety Advisory Group (INSAG) in 1986 following a review of the Chernobyl nuclear power plant accident.[4] It has come into increasing use over the past 20 years to help explain why some organisations appear to be "safer" than others, even though they may conduct equally hazardous operations.

INSAG subsequently defined safety culture as: *"that assembly of characteristics and attitudes in organisations and individuals which establishes that as an over-riding priority … safety issues receive the attention warranted by their significance."* [5] INSAG also stated that *"safety culture is both attitudinal as well as structural, and relates to both organisations and individuals"*. (International Nuclear Safety Advisory Group, 1991).

A 2002 review of the concept of safety culture [6] noted that various definitions are now used within and across a range of industries. In an attempt to clarify and standardise the term, the review authors offer their own composite definition, as follows:

> *Safety culture*: The enduring value and priority placed on worker and public safety by everyone in every group at every level of an organisation. It refers to the extent to which individuals and groups will commit to personal responsibility for safety; act to preserve, enhance and communicate safety concerns; strive to actively learn, adapt and modify (both individual and organisational) behaviour based on lessons learned from mistakes; and be rewarded in a manner consistent with these values.

The reality is that an organisation's safety health is the product of two key elements: the quality of the systems and processes implemented to deal with risk and safety-related information (the 'Safety Management System' concept, which may or may not be formalised), and the *safety culture*, which includes people's shared values, beliefs and attitudes about safety. These two elements combine to characterise the way that people behave within their organisation, the 'behavioural norms'. The overarching goal is that all personnel recognise that safety is important, that it is everyone's responsibility, and for this to be reflected in everyday behaviour at work.

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3 Gaba, D.M., Singer, S.J., Sinaiko, A.D., Bowen, J.D., & Ciavarelli, A.P. (2003). Differences in safety climate between hospital personnel and naval aviators. *Human Factors, 45*(2), 173-185.

4 International Nuclear Safety Advisory Group. (1986). *Summary report on the Post-Accident Review Meeting on the Chernobyl Accident. Safety Series No. 75-INSAG-1.* Vienna: IAEA.

5 International Nuclear Safety Advisory Group. (1991). *Safety culture. Safety Series No. 75-INSAG-4.* Vienna: IAEA.

6 Zhang, H., Wiegmann, D.A., von Thaden, T.L., Sharma, G., & Mitchell, A.A. (2002). Safety culture: A concept in chaos? In *Proceedings of the 46th Annual Meeting of the Human Factors and Ergonomics Society*. Santa Monica: Human Factors and Ergonomics Society.

Even the best Safety Management System (SMS) will be ineffective if the safety culture is characterised by counterproductive attitudes and behaviour. Conversely, organisations without a sophisticated SMS can achieve high levels of safety and efficiency via the right blend of attitudes and behaviour which happen to form a positive safety culture. Yet safety culture can be elusive. As noted by Reason, "Like a state of grace, a safety culture is something that is striven for but rarely attained." (1997, p. 220).

Just as the focus in safety occurrence investigation has moved from operator error to systemic failure in recent years, the concept of safety culture must consider the critical importance of *management action* regarding safety, based on their collective values, beliefs and behaviour. This point is neatly summarised by Hopkins (2002) who states:

> It is *management* culture rather than the culture of the workforce in general which is most relevant here. If culture is understood as mindset, what is required is a *management* mindset that every major hazard will be identified and controlled and a *management* commitment to make available whatever resources are necessary to ensure that the workplace is safe.[7]

As noted by the International Atomic Energy Agency (IAEA), "safety culture has to be inherent in the thoughts and actions of all the individuals at every level in an organization. The leadership provided by top management is crucial" (1998, p. 3).

Formal management accountability is also implicit in the elements of a safety culture, as defined by Reason (1997)[8] and Hudson (2003)[9]. They suggest an organisation's safety culture is defined by the extent to which it is:

Informed: Managers know what is going on in their organisation and the workforce is willing to report their own errors and near misses.

Wary: The organisation as a whole and its employees individually are on the lookout for unexpected events, and maintain a high degree of vigilance.

Just: The organisation has a 'no blame' approach to errors, but applies appropriate penalties to unacceptable actions (violations).

Flexible: Such organisations reflect changes in demand, continuing to operate effectively in high tempo and unusual circumstances as well as routine conditions.

Learning: Organisations are ready to learn, and have the will to implement reforms when they are required.

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[7] Hopkins, A. (2002). *Safety Culture, Mindfulness and Safe Behaviour: Converging ideas?* National Research Centre for Occupational Health and Safety Regulation, Working Paper 7.

[8] Reason, J. (1997). *Managing the risks of organizational accidents.* Aldershot, UK: Ashgate.

[9] Hudson, P. (2003). Achieving a safety culture for aviation. *Journal of Aviation Management 2003, 27-47.* Singapore: Civil Aviation Authority of Singapore.

Irrespective of the definition used, there is converging opinion that the concept of safety culture appears to embrace the following features:

- Safety culture is defined at group level or higher, is represented in the *shared values* of all members of that group or organisation;
- Safety culture is about good safety attitudes in people but it is also about good safety management established by organisations;
- Good safety culture means giving the highest possible priority to safety;
- Safety culture emphasises the contribution from everyone at every level of an organisation;
- Safety culture is reflected in an organisation's willingness to develop and learn from errors, incidents, and accidents;
- Good safety culture implies a constant assessment of the safety significance of events and issues, in order that they can be given the appropriate level of attention;
- Safety culture represents the ongoing commitment to safety by all people within an organisation;
- Safety culture is relatively enduring, stable and resistant to change.

Helmreich (2004)[10] identifies the steps which he believes all organisations need to take to establish a proactive safety culture. These include:

- Establish trust;
- Adopt a credible, non-punitive policy toward error (not violations);
- Demonstrate commitment to taking action to reduce error-inducing conditions;
- Collect ongoing data that show the nature and types of errors occurring;
- Provide training in threat and error management strategies for crews;
- Provide training in evaluating and reinforcing threat and error management for instructors and evaluators.

Helmreich (2004) elaborates:

> Trust is a critical element of a safety culture, since it is the lubricant that enables free communication. It is gained by demonstrating a non-punitive attitude toward error (but not violations) and showing in practice that safety concerns are addressed. Data collection to support the safety culture must be ongoing and findings must be widely disseminated…. If all of the needed steps are followed and management's credibility is established, a true safety culture will emerge…

[10] Helmreich, R.L. (2004). Culture, threat, and error: Assessing system safety. In *Safety in Aviation: The Management Commitment: Proceedings of a Conference.* London: Royal Aeronautical Society.

Recent occurrences in the Swedish nuclear power industry have highlighted safety culture as a factor that impacts a wide range of work practices, including the way unforeseen events are responded to, how incidents are reported, and how safety-critical information is communicated. This project was undertaken to understand the current status of these safety culture elements, and to suggest appropriate strategies or practical actions to overcome any gaps or deficiencies identified.

Combining the element of management commitment with those proposed by Reason and Hudson generates the six elements of safety culture used in this project, as displayed in Figure 1 below. A more complete description of the attributes associated with each of these elements is contained in Appendix A.

Figure 1
Elements of a Safety Culture

1.2 Project Background

SKI's Department of Man Technology Organization (MTO) is concerned to ensure that human factors or MTO considerations are adequately recognised and addressed as a means of supporting and enhancing safety performance in the Swedish nuclear power industry. Although the nuclear power industry in Sweden has a very good safety record and operates with a high degree of technical reliability, there is growing awareness that, as in other potentially hazardous industries, human and socio-cultural factors are vitally important components of overall system safety, yet these are frequently the least well understood, and the most difficult to control.

SKI is charged with regulating and supervising the safety of Swedish nuclear activities, while all Licensees conducting nuclear activities in Sweden are wholly responsible under Swedish law for the safe operation of their facilities and compliance with all required safeguards and requirements. While not directly responsible for operational safety, one way in which SKI can assist sites to fulfil their safety responsibilities is by promoting and facilitating research and development activities within the industry.

This research project was commissioned to provide a "snapshot" of understanding and practices in regard to safety culture within the Swedish nuclear industry, and to compare these with other industries dependent on high operational reliability. An evaluation of this nature involving the majority of nuclear facilities within Sweden was seen as potentially very valuable in guiding future strategies, both regulatory and voluntary, for improving safety culture.

1.3 Project Objectives

The ultimate objective of this project was to enhance safety culture within the Swedish Nuclear Industry. While the safety culture paradigm is not new to the nuclear industry, and there is considerable existing awareness and guidance material relating to the philosophy, characteristics and importance of a positive safety culture (see International Atomic Energy Agency, 1993, 1998, 2002a, 2002b, 2005; International Nuclear Safety Advisory Group, 1991, 2002), it has been observed that few formal programs or activities are in place to foster the development or maintenance of safety culture.

The specific objectives of this safety culture enhancement project were thus:

1. To understand the safety perspectives of senior managers at designated nuclear power sites, and the nature of their influence on the local safety culture;
2. To provide the senior management group at these sites with feedback on the above and to suggest ways of improving the safety culture in their organisation; and
3. To provide SKI with information from an industry-wide perspective about future requirements and opportunities for safety culture enhancement.

It is emphasised that this project was not designed to constitute a non-technical audit of nuclear facilities. Although a relatively structured and consistent process was followed, the approach adopted did not employ formal audit tools or validated survey instruments.

The priority concern was to provide feedback and ideas on best practice to industry managers in regard to human factors and safety culture that might be useful to them when planning future safety enhancement activities.

2 Methodology

The project involved visits to three nuclear industry sites between March 2004 and September 2005.[11] Each site visit involved three phases:

1. **Data gathering**. This was accomplished through a series of interviews with key individual site managers and by conducting focus groups with operational staff to gather information on local safety practices and safety culture issues. These activities involved four to five days of interviews / focus groups at each site.

2. **Data analysis**. Information from interviews and focus groups was collated and analysed off site, with key findings integrated into presentations to be used at the subsequent Management Workshop.

3. **Management Workshop**. A two-day management workshop was then facilitated by Dédale consultants at each site. These took place the week following the data collection phase.

These major project activities are described in further detail below.

Throughout the project Dédale worked closely with and was supported by SKI MTO personnel to ensure minimal disruption to the activities of the sites involved. Following confirmation of the designated site and timetable for activities, information was provided in writing to site personnel asked to participate in the project, explaining the project objectives, methodology, deliverables and confidentiality guarantees.

2.1 Data Gathering

The data gathering phase involved two main activities. First, semi-structured interviews were conducted with all available members of the senior management group at each site. A total of 46 managers were interviewed across the three sites, representing all operational units and key functional areas. A set of prepared interview topics was used to ascertain managers' views on a range of standard operational safety and MTO issues at the site. Interviews were conducted with considerable flexibility however, allowing each manager to also express any particular perspectives or concerns. Interviews generally lasted for approximately 90 minutes each.

The second data gathering activity involved employee focus groups at each site. Five groups in total were conducted involving some 45 employees including control room operators, engineering and maintenance workers and other production staff. The focus groups provided a worker perspective on similar issues to those addressed in the manager interviews. These included opinions about the prevailing organisational culture as it impacted on safe behaviour, the extent to which errors and incidents are reported and the behaviour of managers in emphasising safety as a priority.

[11] Visits were conducted at two nuclear power producing sites and at one industry supplier. A third NPP site could not make personnel available for the project within the necessary timeframe.

All focus groups and manager interviews at each site were conducted by the same team of two Dédale consultants, providing additional standardisation in the data gathering and analysis phases.

Participants in the data gathering stage were provided in advance with written notification about the objectives of the project and the nature of their requested involvement. This information advised that all interview notes and records were to be kept confidential, to be seen and used only by Dédale, and that observations would only be reported in a way that did not identify any individual. Their understanding about this and agreement with it was confirmed prior to each interview or focus group.

2.2 Data Analysis

Following data collection, Dédale collated the information obtained, taking care to ensure that the source of specific comments or information was not identifiable. Key observations about local safety culture issues and practices were summarised, drawing on a model of best practice in safety culture enhancement derived from previous experience in a range of high-risk industries. This site-specific information was then integrated into workshop material that provided the basis for feedback and discussion in each Management Workshop. Workshop material consisted of PowerPoint presentations, group activities and exercises, and individual worksheets to be completed over the two days.

2.3 Management Workshop

The Management Workshops comprised a two-day program of presentations and facilitated discussions with the senior managers of each site who had been interviewed in the data gathering phase. Each workshop was facilitated by three Dédale consultants, and was designed to achieve multiple objectives, including:

1. To provide site management with a 'snapshot' of topical issues, concerns, beliefs and attitudes related to their safety culture. This was achieved by presenting summarised feedback on the key themes and observations extracted during manager interviews and employee focus groups.
2. To stimulate creative thinking and action by site managers about the importance of continuous enhancement in safety culture. This was achieved by exposing them to current ideas, concepts and models associated with organisational culture and safety, including those from other safety critical industries such as aviation and health care.
3. To provide managers with practical advice that would support future safety promotion activities. This was achieved through facilitated exercises, and resulted in output including the definition of a set of management safety competencies (described in more detail in Section 3.6 below).

To achieve the objectives outlined above, the Management Workshops were designed around six core activities, and involved a blend of information presented by Dédale, facilitated discussions and structured exercises. The six activities are summarised below and described in further detail in Appendix B.

2.3.1 Safety Culture Principles and Observations

Information distilled from senior manager interviews and worker focus groups was presented to participants using the six-element structure of safety culture displayed in Figure 1 above: *Top level commitment; Informed awareness; Just culture; Wary; Flexible* and *Learning*. For each of these safety culture elements, a detailed definition was provided, then local observations and examples of site activities, actions and attitudes related to that aspect of safety culture were presented and discussed. Finally, a range of site-specific "discussion issues" were raised, where it was felt the potential existed for the site to consider aspects of this element further and to review their current strategies for achieving success in this area.

2.3.2 Management Safety Culture Perceptions

A brief "Safety Culture Perceptions" questionnaire was used to compare and stimulate discussion around managers' different impressions about how well their site currently reflected some key aspects of a safety culture. Questionnaires were completed early on Day 1 of the workshop and results progressively reported back and discussed in relation to each safety culture element. A copy of the questionnaire is shown in Appendix C.

2.3.3 Safety Investigation

The extent to which employees report safety occurrences, and the effectiveness of an organisation's processes for tracking, investigating and acting to prevent these, are important aspects of safety culture. It is also known that, for many and varied reasons, few organisations are consistently able to apply 'best practice' systemic investigation processes, and maximise safety learning from incidents and accidents. The site's current incident reporting practices and investigation processes were thus included as a topic for discussion in the workshops.

2.3.4 Management Safety Competencies

Given the importance of an organisation's leadership group in influencing the safety-related attitudes and behaviour of employees, a practical exercise was conducted during the workshop to generate a list of "management safety competencies" – descriptors of the behaviours that managers would display if they were demonstrating a strong and obvious commitment to safety. Time limitations permitted only a draft of these safety leadership competencies to be developed during each workshop. For the purposes of this report however they have been refined and collated into a more comprehensive list (see Findings Section 3.6). With further development and validation, this safety leadership competency model could be employed as a standard against which the performance of individual managers can be compared, evaluated and developed.

2.3.5 Accident Scenario Exercise

The final workshop activity involved an exercise in which the senior managers worked in small groups to develop a hypothetical scenario under which a nuclear accident could feasibly occur at their site. A structured methodology was provided for creating their scenario and reporting each group's findings, based on the Reason Model of organisational accidents (Reason, 1990, 1991, 1997; Reason & Hobbs, 2003).[12]

The outcome of the accident scenario exercise was a structured systemic analysis of each hypothetical event, including identification of the factors that would contribute to the event, and a set of realistic recommendations to address the contributing factors and prevent the occurrence. The recommendations were designed specifically to address organisational deficiencies and reduce the risk that a set of conditions could develop under which a serious safety event of the type identified could occur. This exercise is designed to heighten unease about the potential for a serious event, while identifying factors within the system which could contribute to such an occurrence, and generating realistic corrective actions.

Due to the sensitive nature of these accident analyses and the confidentiality guarantees mentioned above, the outcomes from the accident scenario exercise were not recorded for presentation in this report. It is hoped however that the findings will be adopted by the individual sites and further considered in risk management processes or other safety-related planning and review activities.

It is known that at least one participating site has adopted the process of 'hypothetical accident investigation' and extended it to other employee groups as means of raising awareness of systemic accident potential and anticipating safety improvements.

2.3.6 Open Discussion Sessions

Throughout the workshop, managers were invited to raise questions related to any aspect of safety management or safety culture enhancement, for comment by the Dédale team and general discussion amongst the group. Typically, a broad range of topics was discussed, and supported by reference to relevant research.

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[12] Reason, J. (1990). *Human error*. New York: Cambridge University Press.

Reason, J. (1991). Identifying the latent causes of aircraft accidents before and after the event. *Proceedings of the 22nd ISASI Annual Air Safety Seminar,* Canberra, Australia. Sterling, VA: ISASI.

Reason, J. (1997). *Managing the risks of organizational accidents.* Aldershot, UK: Ashgate.

Reason, J., & Hobbs, A. (2003). *Managing maintenance error: A practical guide.* Aldershot, UK: Ashgate.

2.4 Deliverables

The tangible deliverables from each project site visit included the following reports and materials:

1. PowerPoint presentations, group activities and exercises, and individual worksheets, for use in the two-day feedback workshop to site managers. These materials were developed following the period of interviews and focus groups with site managers and other employees;
2. Output from exercises and discussions conducted throughout the two-day management workshop, provided at the time to participants and in the site visit report;
3. Site Reports, comprising a summary document (in PowerPoint form) and a separate written report including feedback on the information obtained from initial interviews and materials discussed or developed during the workshop, structured by topics representing the elements of a safety culture. These deliverables are explained further in the next section;
4. A progress report to SKI on the methodology and processes used during each site visit, and this Final Project Report.[13]

In addition to the above deliverables, the workshop provided an important opportunity for the senior management group of each site to focus on and exchange opinions about the current status of their safety culture, and to develop and test ideas on how it might be improved. The value of this interaction can be fully realised over time as the ideas developed are converted to action plans and implemented by managers, individually or collectively.

A final important deliverable was obtained through the Accident Scenario Exercise. Although the events generated by each group were hypothetical, they included existing organisational deficiencies and the preventative recommendations generated represent realistic, practical ways to reduce risk associated with these deficiencies and inadequate safety barriers. With further analysis of exercise output, this exercise has proven to be an important source of organisational feedback and learning for managers and operational specialists in other safety critical industries.

[13] To ensure confidentiality about issues raised at each site visit, none of the SKI reports contains any details of information gathered or observations made from interviews or workshop discussions specific to the particular site involved.

2.5 Site Reports

Written reports on each site visit were prepared by Dédale and provided direct to site management for internal use. The site report included specific observations related to the site's safety thinking and practices. In accordance with the confidentiality protocols agreed before commencement of the project, distribution of these reports was limited to the host site, as their record of issues identified in the project data gathering phase and discussed during the workshop. Any further distribution of the report was to be at the discretion of the site. In broad terms, each site report contained:

1. An overview of the project purpose and methodology;
2. A summary of each component of the Management Workshop, including specific information on data gathered at the site, observations made and further detail on the topics discussed. For example, a complete listing of all relevant observations reported in manager interviews and the focus group was provided. Once again confidentially was guaranteed and special care was taken to avoid the attribution of comments or issues raised to any individual or group;
3. Appendices containing a summary of the environmental and contextual factors affecting the site, description of Safety Culture Elements, and local results on the safety culture "Ratings Questionnaire".

In providing feedback on information collected during the data gathering phase, a detailed definition and characteristics were provided for each of the safety culture elements, and examples were presented of ways in which the site was conforming or otherwise with that aspect of safety culture. Important discussion issues were listed, where it was felt the potential existed for the site to consider this factor further and to review their current strategies for achieving success in this area. The information gathered and reported back at each site has been synthesised, in de-identified format, in the Findings section of this report.

To complement the written report, the site was also provided with summaries in PowerPoint format of the material presented over the two days of the workshop. This included, for example, the additional stimuli material used as a basis for facilitated discussion, models of Organisational Culture, and the diagram of safety culture levels, used to give insight into the site's current organisational climate and its progress towards what is regarded as a mature safety culture.

3 Findings

3.1 Introduction

This section summarises the findings of the Safety Culture Enhancement project about the current status of safety culture within the Swedish nuclear power industry. These findings represent the significant observations made by the project consultants in the course of interviews, focus groups and the Management Workshops described above. The issues included in this section are higher level, pervasive ones observed across one or more of the sites visited. As noted earlier, site-specific issues have been reported back to the relevant site management and are not discussed here in accord with project confidentiality agreements.

3.2 Operating Context

The Swedish nuclear power industry is historically and intrinsically well-defended and 'ultra-safe'. It operates on a 'safety plateau' with very few significant safety occurrences. This is particularly critical in a country where the socio-political climate is such that one bad safety event could threaten the future of the industry.

Since deregulation of the industry in 1996 continued profitability has depended on reducing costs and increasing efficiency. Labour requirements for example have been reduced and are now relatively lower than other comparable industries. A strong focus on commercial viability has in the past tended to lessen the concern for safety in some parts of the industry, although this imbalance has now been redressed.

The current workforce includes a predominance of experienced individuals with high technical competence. A significant loss of experience is expected in forthcoming years due to a 'bow wave' of retirements amongst those who joined the industry at its commencement.

Contractors are an integral part of the industry's current cost efficiency and operational cycle, however the number of suitably qualified suppliers is reducing, their specialist experience and expertise is diminishing, and there is increasing competition for their services at critical times annually.

3.3 Safety Culture Observations ~ Strengths

Two general observations can be made about the industry culture before some apparent strengths in specific safety culture characteristics are reported. First, the sites visited employed relatively flat organisational structures and a very open, participative management style, creating the opportunity for effective communication between base level workers up to senior management. This has direct, positive influence on aspects of safety culture such as the reporting of hazards and errors, and an organisation's capacity to learn from these and implement improvements quickly.

Second, the industry's operational philosophy can be characterised as one that has historically relied on 'engineered safety', that is, controls or barriers against serious

events are primarily technological in nature. Protection from hazards, incidents and accidents is provided by designed-in safety systems, proper maintenance practices, clear and comprehensive procedures and good 'housekeeping'. It therefore follows that solutions to problems and corrective actions identified following safety occurrences typically involve modifications to equipment, processes or procedures.

Underlying this philosophy is an implicit assumption that human performance is not really a variable: people are seen as reliable in the way they complete tasks and in following rules. Technological controls are seen as preventing human error from producing a safety occurrence. While this thinking is not entirely incorrect, it limits the value that can be gained from a different understanding of human variability, not as a threat to safety but as another form of barrier against undesired events.

The key elements of a safety culture, as identified in Section 1.1 above (and elaborated on in Appendix A), are clearly apparent throughout the nuclear power industry in Sweden. This section summarises evidence observed for each identified aspect of safety culture.

3.3.1 Commitment to safety

- Safety is a high priority and always "on the agenda" (although this has become the case only more recently at some sites).
- Evidence that safety is an implicit organisational objective underlying daily operation and activities:
  - Integrated Safety Management Systems / Quality systems;
  - Discussion about and attention to safety by management; economic / commercial factors are no longer the overriding goal;
  - Dedicated safety personnel / units / departments at all sites, although some resources appear overly occupied with reactive/bureaucratic tasks;
  - Presence of some nominated MTO representatives at most sites;
  - Safety clearly on the agenda at management meetings, and promoted through safety seminars and presentations, safety culture surveys, seminars, newsletters;
  - Formal safety measures, reviews and audits;
  - Safety training, including (in some cases) information on MTO / human performance issues;
  - Resources are available for key safety issues / activities when required;
  - Use of risk assessment tools, and safety analysis processes (eg., STARK)[14].

[14] STARK: Stop, Think, Act, Reflect, Kommunicate.

3.3.2 Informed Awareness

- A reporting culture is well-established, providing important safety information:
  - Staff report accidents, near misses and hazards, and probably their own errors or mistakes when something needs to be learnt form this;
  - Messengers are encouraged, reporting is made simple (eg., through hazard reporting systems);
  - Action is taken on matters understood to be a threat to safe operations.
- At the industry level it is also apparent that safety data is reported, collected and distributed:
  - Safety staff monitor global safety events and trends: "We get information from all over the world": KSU, industry events, case studies, etc.
- As well as conducting internal audits, safety checks and reviews to improve awareness, the industry is open to external review and feedback, for example through WANO audits.

Other activities that help senior managers understand what is really going on regarding worker safety attitudes and behaviours include: safety culture surveys (as well as more general organisational climate surveys), and managers spending time "out in the field" in first-hand observations, meetings and discussions.

3.3.3 Just Culture

An 'organic' or natural kind of just culture can be observed within the Swedish nuclear industry.[15] This is apparent from the way management reacts to the reporting of errors, near misses, hazards and safety concerns. Information from both management and worker groups consistently confirmed that a non-punitive approach is taken when errors are reported. The emphasis is on learning from the event and worker education rather than attempting to eliminate error through punishment.

The prevalent response from managers to concerns expressed by workers was reported as positive rather than defensive (messengers are not "shot"). It is understood that action is usually taken on matters understood to be a threat to safe operations.

3.3.4 Wary

Constant vigilance and preparedness for rare and unexpected events is difficult to maintain, especially under conditions where the safety record is good, there are relatively few events to investigate and there is a feeling that 'we are safe'. Comments such as "everyone here is aware of nuclear safety as an issue" and "even small events are investigated very thoroughly" are indications of wariness at one level, and this was apparent at the locations visited. There is a different dimension to wariness however,

[15] A distinction is drawn here as the just culture elements observed appear to be related in some degree to Swedish societal conventions rather than a feature restricted to the nuclear industry in Sweden, or necessarily common to the global nuclear power industry.

which was discussed in Management Workshops and is flagged in this report as an opportunity for improvement. This is the notion of wariness as "chronic unease" introduced by Reason (1997). As noted by Professor Reason, "if you are convinced that your organisation has a good safety culture, you are almost certainly mistaken."

3.3.5 Flexible

There was considerable evidence of organisational adaptability and flexibility observed across the sites visited. The key indicators of flexibility included:

- Most of the participant organisations had undergone significant change to their operating environments and structures in recent years, and in most respects had adapted positively to these changes;
- With isolated exceptions, management processes at the sites visited were effective in responding to unplanned events and anomalies;
- Planning and resourcing for non-standard elements of events such as outages, major projects and modernisation activities was efficient;
- Human resources were utilised flexibly to meet new changing requirements.,

3.3.6 Learning

The key elements of organisational learning observed at the participating sites are listed below.

- The foundations of a strong organisational learning capacity were evident from the open, just culture and associated reporting systems.
- Investigation processes following incidents and accidents were directed towards understanding what went wrong and implementing corrective actions.
- WANO audits and exchange visits with other nuclear power sites are clear examples of openness to learning through 'peer review' and feedback.
- The willingness to learn extends to the local workplace level where exchange of ideas and discussion of topical safety events is encouraged, both formally and informally.

3.4 Opportunities for Improvement

The previous section summarises the positive indicators of good safety culture. Naturally, not all of these were evident to the same extent at each of the sites visited. The following issues were identified as opportunities for improvement at one or more of the locations involved in this project.

3.4.1 Management commitment to a safety culture

Although observed commitment to safety can be described as generally strong, there was of course some variability across sites and within each management group. Evidence for this can be seen in the results of the Safety Culture Perceptions Questionnaire (see Section 3.5, Table 1), where individual managers, when describing characteristics of their own organisation, rated employee perceptions of senior management's commitment to safety as relatively low (*Item 1*), indicated that they did not feel well-informed about safety issues (*Item 2*), and felt that a low proportion of recommendations are implemented following an investigation (*Item 9*).

The exercise to develop safety leadership competencies (Section 3.6 below) also revealed that managers demonstrate these behaviours to varying degrees. Information provided in interviews, focus groups and the workshop itself confirmed the potential for commitment to be uniformly higher, in areas such as discussing safety issues, listening to worker concerns, taking action to enforce rules and safety requirements, and removing or controlling identified hazards.

Other organisation-wide surveys conducted by some sites provided further support for the proposition that safety leadership could be improved. This was in a context that some managers could generally lead and communicate about safety more effectively, but also that they could show more visibility, accessibility and responsiveness to the views of the workforce on safety-related matters.

3.4.2 New managers – safety training and competence

The fact that that many managers in the nuclear industry are relatively new to their roles, and that this trend is likely to increase in future years, provides further grounds to formally address the issue of commitment to safety. Commitment is demonstrated through the way managers behave, and elements of this ideal or desirable behaviour have been described in the form of management safety competencies. These competencies do not occur naturally in every newly appointed manager, and are probably not taught in the typical academic courses that qualify people professionally for the industry. There is a need therefore to assess the extent to which new managers possess these competencies, and provide training, coaching or other developmental experiences that enable them to properly fulfil their safety leadership responsibilities.

Some of the newer managers interviewed during the project expressed a degree of concern about their capacity to handle the non-technical aspects of their new role. Often they were assigned new accountabilities for safety, but frequently without being given clear direction or guidance on how they should go about achieving these.

3.4.3 Embedding Just Culture

It has been reported above that *Just Culture* is well-established at the industry sites which participated in this project. This is believed to be at least partly a reflection of wider Swedish societal values that understand human fallibility, and adopt a non-punitive stance toward 'honest mistakes'.

The existence of a Just Culture should never be taken for granted however. There is potential in any organisation or industry for influential people to change positions and for attitudes and practices to evolve, in positive and negative ways. Actions to formally recognise and embed the characteristics of a Just Culture would inoculate the industry against subtle degeneration of these important values. For example, the boundaries of acceptable behaviour can be objectively defined, enabling unacceptable behaviour to be acted on promptly, consistently and firmly.

This would also serve to ensure that individuals who knowingly violate established rules and procedures are held accountable for their actions. Taking appropriate disciplinary action against violators was an area that some managers felt was a potential weakness within the current culture, and establishing clear boundaries in this way can safeguard a very fair and forgiving culture from becoming undesirably lenient.

3.4.4 Reporting Culture

Two issues were identified associated with 'reporting culture', that aspect of safety culture involving the predisposition of workers to admit to errors with the potential for serious consequences, so that action can be taken to prevent this from happening again. The organisation's response to worker admissions of error is the critical determinant as to whether reporting occurs or not.

As already noted above, the national and local cultures are predominantly non-punitive in nature and there is little evident fear of being blamed for owning up to a mistake, even if the consequences may be costly. Aggregated responses to two items on the Safety Culture Perceptions Questionnaire (Table 1) however are of interest. First, on average, managers felt that only about two-thirds of errors and violations were being reported, with a small group of managers suggesting it was less than 20 percent (Item 3, *"What percentage of errors and violations are reported by people (including contractors)?*". Responses to Item 5 were slightly more positive. To the question "*What percentage of people would you say are treated justly when they make an error?*", ratings averaged about 77 percent, but were as low as 42 percent for some managers.

A complication exists for reporting cultures in that one negative management reaction to an instance of admitting an error can destroy trust and inhibit all future disclosures.

A recent industry example of a self-reported error leading to consideration of criminal prosecution against the reporter is a serious threat to the strong reporting culture established within the Swedish nuclear industry. It is clearly in the interests of all industry participants to have this situation resolved by providing legal protection to anyone who reports an event that would otherwise be undetected.

3.4.5 Dealing with violations

A strength of the observed industry safety culture was found to be a high degree of compliance with rules and procedures, based on are recognition that non-conformance is a threat to safety. Managers tend to work on the assumption that good policies and procedures are in place, and that employees will follow them.

There was however some evidence contradicting this assumption. Responses to Item 6 of the Safety Culture Perceptions Questionnaire, "*What percentage of the time do people follow rules, instructions and procedures exactly, ie., not commit a violation*") revealed unease by some managers that workers may be working around procedures in potentially unsafe ways. Discussions in the workshops confirmed that 'routine violations' or short-cuts do exist, that some managers are aware of these, but do not always take action to stop them. This was consistent with information obtained from some focus groups. This situation is not unique to the nuclear power industry. Violations exist as a normal part of most work settings, for reasons such as 'impractical' or poorly understood rules, or pressures to improve efficiency through short-cuts that have worked in the past.

It is important for managers to deal with violations effectively. This means first understanding the nature of the violation and the circumstances that allow or even encourage it. Action can then be taken to change conditions like time pressure or poorly written or explained procedures. Different supervisory interventions are required to deal with the less frequent violations that occur to satisfy personal goals of workers, for example, to save effort or finish a task early.

3.4.6 Learning from safety events

Although all sites reported having appropriate processes in place to investigate safety occurrences, three opportunities to enhance these were identified:

1. Standardised investigation processes seem to be used in some locations, however these do not always employ a sound theoretical methodology that links the stages of data collection, analysis and reporting of findings. Using a recognised investigation model and common terminology streamlines the investigation process, helps less experienced investigators with their task and facilitates the communication of findings and recommendations to management and other parties.

2. The extent to which MTO factors are identified, and therefore addressed, through safety investigations appears to be variable. This is because professionally qualified MTO specialists are not routinely included as members of safety investigation teams.

3. A gap appears to exist at the sites in the process for converting investigation recommendations into completed corrective actions. In responding to the Safety Culture Perceptions Questionnaire item 9, "*Following an incident investigation, what percentage of the recommendations made are fully implemented?*, the average rating was about 60 percent, and some managers rated this as low as 25 or 30 percent.

3.4.7 Communicating safety information

As previously reported, the characteristically flat hierarchical organisational structures and participative management styles observed at the sites visited are conducive to effective information distribution. Notwithstanding this general observation, examples were noted where communication of important safety information may have been impeded because:

- Topics discussed at management meetings were not necessarily seen as important enough to communicate to workers;
- Information was passed part way down the communication chain but then lost;
- Horizontal networks do not always exist to transfer important information across departments, units, or even work groups (this is a form of "silo culture", where information sharing is impeded);
- Some information is not evaluated as important or significant enough to warrant passing it on, or as relevant to a particular group of workers.

In other hazardous industries these so-called 'weak signals' have been found to be critical contributors to the accident chain, usually only apparent when a serious occurrence is systemically investigated.

3.4.8 MTO / Human Factors expertise

It is now almost universally accepted in high-risk industries that an understanding of the limitations of human behaviour, and of local and organisational influences on behaviour, is fundamental to safe operations. This assertion is corroborated for example by the increasing attention given to human factors or MTO issues in systemic accident investigations, and by the reported outcomes from these activities.

The domain of human factors / MTO can contribute to safety not only through retrospective investigation and analysis or events, but by applying the principles and tools of the discipline at many other stages of the production cycle. Given the potential safety and efficiency benefits of MTO input, there would seem to be a disparity between the resources devoted to *technical* improvements of the system and preventing *technical failure,* compared to those allocated to improving human performance and preventing and managing human error.

A review of the extent, structure and use of MTO expertise within nuclear businesses and the industry as a whole would be timely to overcome the following observed shortcomings where they exist:

- Lack of ready management access to full-time professional MTO advice and expertise;
- No one person designated with MTO as primary job responsibility, and/or to act as MTO Manager for the organisation;
- No effective MTO network to determine priorities, coordinate activities and resources, develop competence and implement best MTO practices;

- People with some MTO training / skills are not always available, and may not really be qualified for the intended task;
- Dependence on the availability of external consultants or academics with MTO know-how;
- Insufficient MTO resources to be routinely available for core activities such as safety occurrence investigation, human factors review of procedures, or delivery of human factors/MTO awareness training;
- Limited visibility, role clarity and status for the MTO discipline within the organisation (and the industry as a whole), and therefore lack of awareness about the potential benefits/contributions that can be made.

While the nuclear industry would benefit significantly from the establishment of more positions for qualified MTO specialists, MTO expertise should not reside solely within such specialists. It should be dispersed in the form of complementary knowledge and skills amongst all employees, but most importantly supervisors, managers and safety professionals. There is an opportunity to fully integrate MTO concepts and approaches by developing levels competence appropriate to the needs of each position. This would ensure for example that:

- All employees have awareness about the scope of MTO and some basic practical knowledge, for example about human error and performance limitations;
- Safety professionals are able to apply MTO expertise effectively and draw on specialised advice when necessary; and
- Newly promoted supervisors and managers understand the place of MTO in achieving their safety and efficiency goals.

3.4.9 Team training / Error management training

As explained above, front-line workers will be better equipped to detect and inhibit the development of an incident or accident chain if they have an understanding of human factors principles, including error prevention, trapping and management, individual risk management and the performance-shaping characteristics of workplaces. There is particular utility in emphasising the effectiveness of teamwork as an error management strategy.

Limited training in these areas is currently provided within the Swedish nuclear industry, for example for Control Room Operators. However in some parts of the industry, this training is:

- Not provided to all teams, be they co-located or distributed;
- Not provided in significant depth or regularly reinforced (often amounting to only a few hours annually);
- Not based on standardised training concepts, terminology or methods;
- Not integrated with other technical and safety training; and

- Not ‘branded’ as a specific and important form of non-technical skill training.

There is an opportunity to improve and extend existing forms of team training by adopting the model of integrated Crew Resource Management (CRM) training, as evolved and applied within the aviation industry, and subsequently adapted for application to other hazardous domains, including the offshore oil and gas industry, shipping, healthcare, rail and space exploration. The CRM training model provides and reinforces customised knowledge and skills in practical error-management for workers in co-located or extended teams. The principles of CRM are aligned very much with, and therefore reinforce the underlying philosophy and principles of a safety culture.

3.4.10 Being wary

Wariness is perhaps the most elusive and challenging element of a safety culture. There is a tendency to see safety in terms of quality systems and processes, adjusted and fine-tuned through the feedback loop from investigation of safety events. Being wary involves another form of imaginative thinking, initially described by Reason (1987) and elaborated by Hudson (2003) as requiring a state of *chronic unease,* that is, moving from the view “We haven’t had an accident, aren’t we doing well” to “We haven’t had an accident, what are we overlooking?”

Most industries have the potential to increase their wariness, and the nuclear industry is no exception. This would involve:

- Being prepared to anticipate a range of “worst case scenarios”, rather than assume no such serious events could occur;
- Adjusting the balance between standard, reactive safety processes (audits, reviews, investigations etc.,) and more proactive, creative analysis;
- Being constantly on the lookout for new barriers or controls, including human interventions, to prevent accidents;
- Ensuring that as many people as possible are involved in “constructive worrying”. This is not solely the responsibility of Safety Committees or senior managers: all workers should be sufficiently informed to contribute;
- Giving people time away from day to day activities to envisage problems that have not been thought about or considered before.
- Avoiding complacency: an undue level of confidence based on the belief that a good safety record is a guarantee of no future adverse events. This is not just something individuals experience, but can become a negative feature of the local culture, a form of “Group think”.

3.4.11 Contractor management and culture

The commercial benefits of using contractors can be offset by a negative impact on the safety culture if this issue is not well managed. The main challenge identified through this project is how to instil and maintain in contractors the same positive safety attitudes and behaviours shown by permanent employees. That is, how can a good in-house safety culture be transferred to contractors? Accepting that MTO knowledge is useful, the associated challenge is to ensure that contract workers have at least a minimal level of this training in relevant content areas, even if this is not a regulatory requirement.

3.5 Safety Culture Perceptions Questionnaire

A safety culture, by definition, involves alignment and consistency throughout the organisation in regard to safety attitudes and behaviour. Operational managers in particular, but also other workers, should have relatively homogeneous views about key safety issues. The Safety Culture Perceptions Questionnaire was designed to evaluate the degree of diversity in the opinions of site managers in regard to aspects of their local safety culture, including issues such as the reporting of errors and violations, the extent to which recommendations are implemented following a safety investigation, and whether serious problems or accidents are being anticipated adequately.

Individual ratings were kept confidential but group data were summarised and reported back within the management workshops. It was expected that comparing ratings within the management team would prompt discussion about different perceptions – whether a safety culture really existed or not - and perhaps lead individual managers to re-evaluate their perceptions about what more needs to be done. The questionnaire was developed as an informal survey instrument and was not intended to produce 'scientific' findings of the form derived from other more comprehensive safety culture questionnaires. Nevertheless, ratings at each site showed considerable diversity of opinion, prompting fruitful discussion in each of the workshops.

Questionnaire results were presented in each Management Workshop by showing (a) the minimum rating given by any manager, (b) the average rating given by the whole group, and (c) the maximum rating given. All responses were given as a percentage, for example, "*what percentage of errors and violations are reported by people?*". In all items of the questionnaire a higher rating, ie., closer to 100%, represents a more positive safety culture, or a more informed view about human factors influences on safety.

For this report, results from all sites have been summarised into average ratings: the average minimum, mean and maximum ratings, and are presented in Table 1 below.[16]

Two important observations can be made about the results in Table 1. First, there is considerable diversity within each of the site management groups surveyed between those with a positive view of their own safety culture (maximum ratings from 90% to 100%) and those with less optimistic perceptions (minimum ratings below 50%). Interestingly, this diversity existed within each of the sites visited, where there appear to be some managers with what might be termed unrealistically positive perceptions (eg., "*100% of people are treated justly when they make an error*"), and others with distinctly negative views (only 17% of errors and violations are reported by people).

The second point of interest is that the average ratings also show some variability, pointing to that fact that, according to the combined estimates of some 40 managers at three Swedish nuclear industry sites, some aspects of cultural practice are advantageous for safety (people follow rules, instructions and procedures exactly, ie., do not commit a violation 78% of the time), while other aspects can be improved ("following an incident investigation, 28% of the recommendations made are fully implemented"). Mean ratings from each (unidentified) site are shown in Figure 2.

[16] The number and format of questions used was varied slightly through the course of the project, so averages shown in Table 1 may be based on different numbers of responses.

Table 1
Average of minimum, mean and maximum ratings given to items on the Safety Culture Perceptions Questionnaire by participants at three industry Management Workshops

Safety Culture Perceptions Item	Average of Minimum Ratings	Average of Mean Ratings	Average of Maximum Ratings
1. How do you think employees would rate the senior management's commitment to safety at (this site) at the moment?	46.7	73.5	95.0
2. How well-informed do you feel about what is really happening in regard to safety (eg., how people are behaving, what events are occurring)?	43.3	75.0	93.3
3. What percentage of errors and violations are reported by people (including contractors)?	16.7	66.2	95.0
4. What percentage of incidents and accidents in the nuclear power industry involve human error?	50.0	75.3	99.3
5. What percentage of people would you say are treated justly when they make an error?"	41.7	77.3	100.0
6. What percentage of the time do people follow rules, instructions and procedures exactly (ie., not commit a violation)?	55.0	77.9	96.3
7. How would you rate (this site's) ability to deal with highly demanding, unusual and unexpected events?	46.7	76.8	97.0
8. To what extent does (this site) make changes or improvements when they become aware of a problem	46.7	71.3	95.0
9. Following an incident investigation, what percentage of the recommendations made are fully implemented?	27.5	60.3	82.5
10. Of all possible future serious problems, incidents and accidents that could occur at (this site), what percentage of these have been considered?	18.3	64.9	90.0

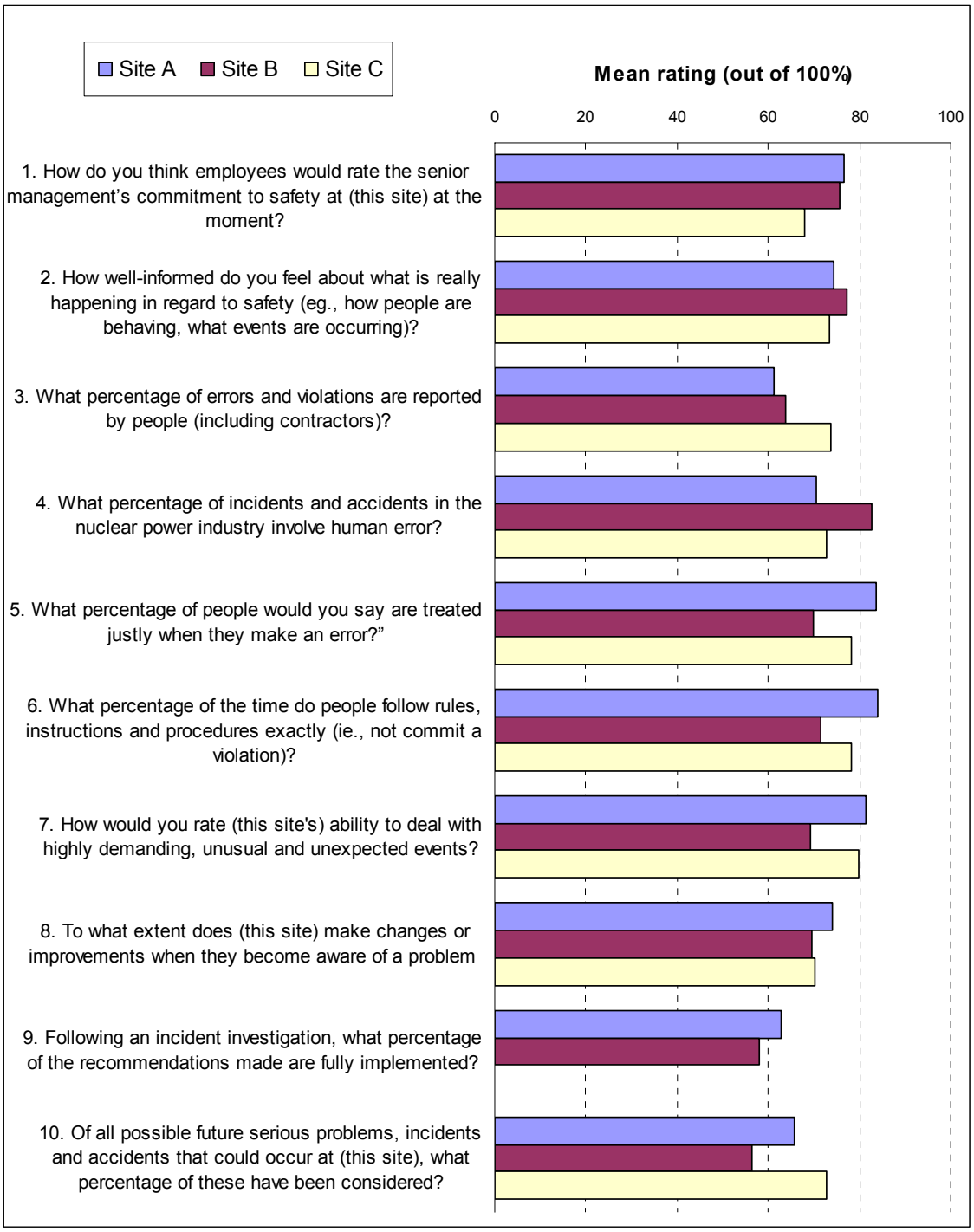

Figure 2
Mean ratings on each item of the Safety Culture Perceptions Questionnaire given by managers at three Swedish nuclear industry sites

3.6 Management Safety Competencies

Competence refers to the combination of skills, abilities and knowledge that enable a person to undertake the tasks involved in a job. Non-technical competencies refer more specifically to the way a person performs their job, that is, the behaviour they can demonstrate that enables them to perform effectively. Competence is thus required to achieve a high level of performance in a particular occupational role, and all organisations, to some degree, seek to ensure that employees possess the necessary competence to do this. Developing required competencies is the focus of performance management systems used by most organisations.

Just as workers in high-risk workplaces require competence to carry out tasks safely (for example, cross-checking others' work, giving clear instructions or providing assistance when someone else is overloaded), managers should also demonstrate behaviours that promote safety.

During each of the Management Workshops an activity was facilitated to gather examples of these management safety leadership competencies, with a view to developing these into a formal competency framework. Competencies are typically written in the form of *behavioural markers*. These are short, precise descriptors of *observable* behaviours, often grouped into higher level categories representing broader performance areas (competency elements). A comprehensive set of behaviours written and organised in this way constitutes a behavioural marker system.

Ideas on desirable safety leadership behaviours were generated by participants in each management workshop and summarised for the site concerned. For the purposes of this report, the ideas from all three sites have been collated and further refined, providing a more complete set of behavioural markers. These are shown in Table 2 below.

While it should be subject to further development, refinement and testing, the safety leadership framework presented here is potentially a useful tool for evaluating the extent to which nuclear industry managers currently posses these competencies, and their need to develop further. Further information on how the management safety competencies can be used is contained in Section 4.1 below, under recommendations for future activities.

Table 2
Safety Leadership Competencies for
Nuclear Power Industry Managers (Draft)

	Competency Element	Example Behaviours
1.	Showing commitment	Demonstrates interest in safety activities/matters
		Shows persistence in addressing safety issues and deficiencies
		Displays enthusiasm regarding safety checks and activities
2.	Promoting safety	Communicates safety / Safety Culture messages
		Highlights past investments in safety
		Promotes safety as a top priority
3.	Clarifying safety goals	Explains organisational goals and vision regarding safety
		Expresses clear expectations about safe behaviour
		Sets and communicates clear safety goals
4.	Being actively involved	Is systematically visible
		Is seen around by staff, regularly interacts with people
		Coaches and leads staff via dialogue
5.	Setting an example	Follows safety rules, sets a positive example
		Leads by example in acting safely
		Ensures that own behaviour is consistent with words
6.	Listening to concerns	Listens to, acknowledges and values employee inputs/opinions
		Encourages staff to be open and express any concerns about safety
		Listens to input from employees regarding safety issues
7.	Implementing improvements	Acts to correct safety deficiencies, unsafe behaviours and circumstances
		Communicates lessons from safety events
		Identifies, records and rectifies safety hazards
		Shows concern/acts to fix safety problems, and reports back on results
8.	Acting justly	Communicates understanding that humans are fallible and will make errors
		Treats people consistently and fairly – follows a "just culture" policy
9.	Seeking to understand	Asks “how is safety?” (enquires about safety "health")
		Enquires about the reasons for “inappropriate” behaviour
		Asks why incidents happened
10.	Shaping behaviour	Reacts appropriately when good/bad safety behaviour is observed
		Challenges people about inappropriate actions/behaviour
		Corrects inappropriate actions/behaviour promptly
		Recognises positive safety behaviours, eg., reporting of events
11.	Being wary	Seeks information on future risks
		Displays a questioning attitude about the way we do things here
		Follows up to ensure safety responsibilities are being carried out
		Demonstrates a desire to learn from safety events

3.7 Workshop Feedback Questionnaire

At the conclusion of each workshop a brief questionnaire was distributed to evaluate participant perceptions of the workshop's format, content and utility. Ratings were requested in four sections, covering overall opinions of the workshop, content and methods, specific topics, and the quality of workshop facilitation. All items required a rating between '1' (low) and '5' (high).

Across the three sites visited a total of 30 completed questionnaires were returned and analysed. A few questionnaires contained missing data, relating to sections of the workshop that the respondents had not attended or about which they elected not to provide an opinion. Results shown below are based on completed ratings only.

Figure 3 below shows the average ratings on questionnaire items covering participants' overall opinions of the workshop, from '1', *Disagree strongly*, to '5' *Agree strongly*.

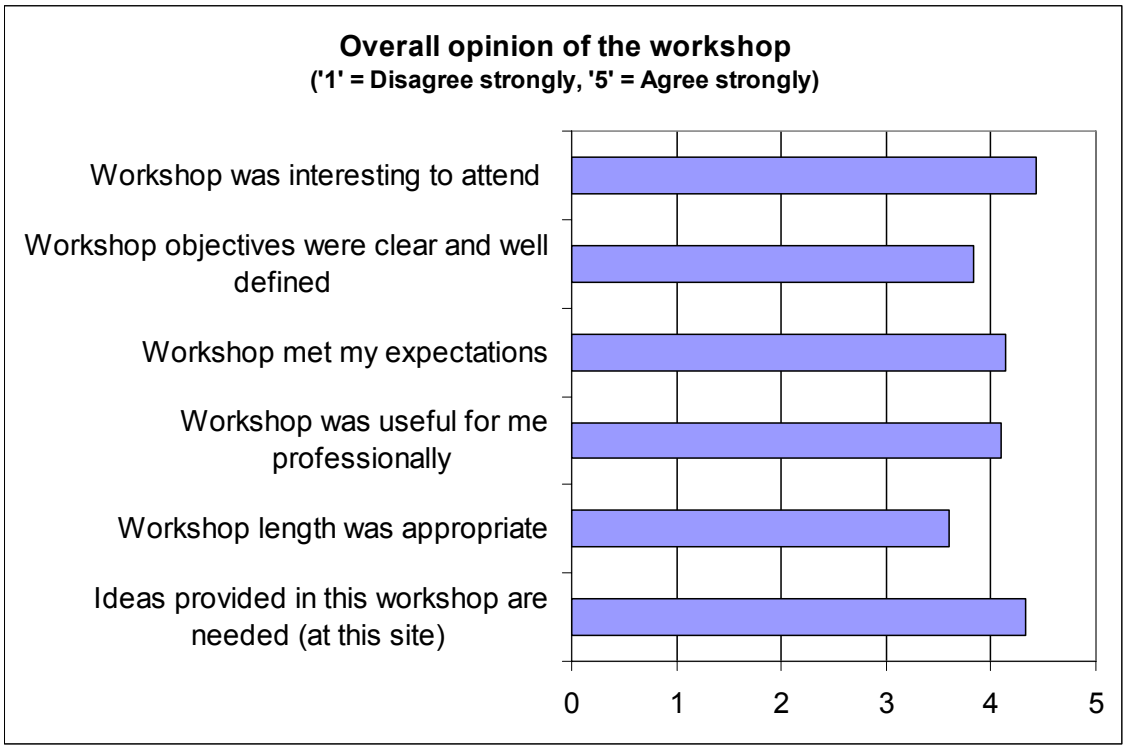

Figure 3
Workshop participant average ratings
of overall opinion of the workshop

Average ratings on the workshop overall ranged from 3.6 to 4.4. Highest ratings were given to items about the workshop being *interesting to attend* (4.4), and that the *ideas provided in the workshop are needed at this site* (4.3). Slightly lower ratings were given to items about the *workshop objectives being clear and well defined* (3.8), and on the *length of the workshop being appropriate* (3.6).

The second part of the questionnaire covered the overall content and methods used in the workshop. Figure 4 shows average responses to these items, once again rated from '1', *Disagree strongly*, to '5' *Agree strongly*.

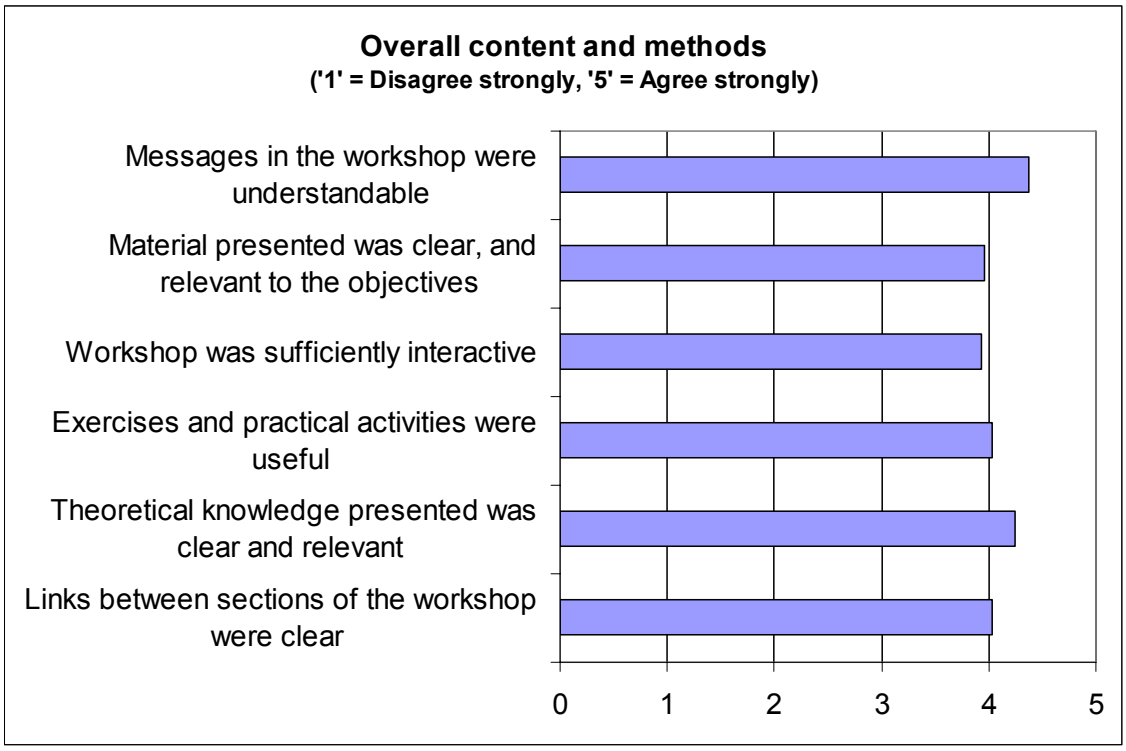

Figure 4
Workshop participant average ratings of overall content and methods in the workshop

Participant average ratings of the overall content and methods used in the workshop were highest on the item "*messages in the workshop were understandable"* (average rating 4.4) and on the item "theoretical knowledge presented was clear and relevant" (average 4.2). Most of the remaining items were rated around '4' on the five-point scale.

The third section of the Feedback Questionnaire contained seven items relating to specific topics covered in the workshop. Figure 5 shows average participant ratings of the value of these specific topics, from '1', *Not valuable at all*, to '5' *Extremely valuable*.

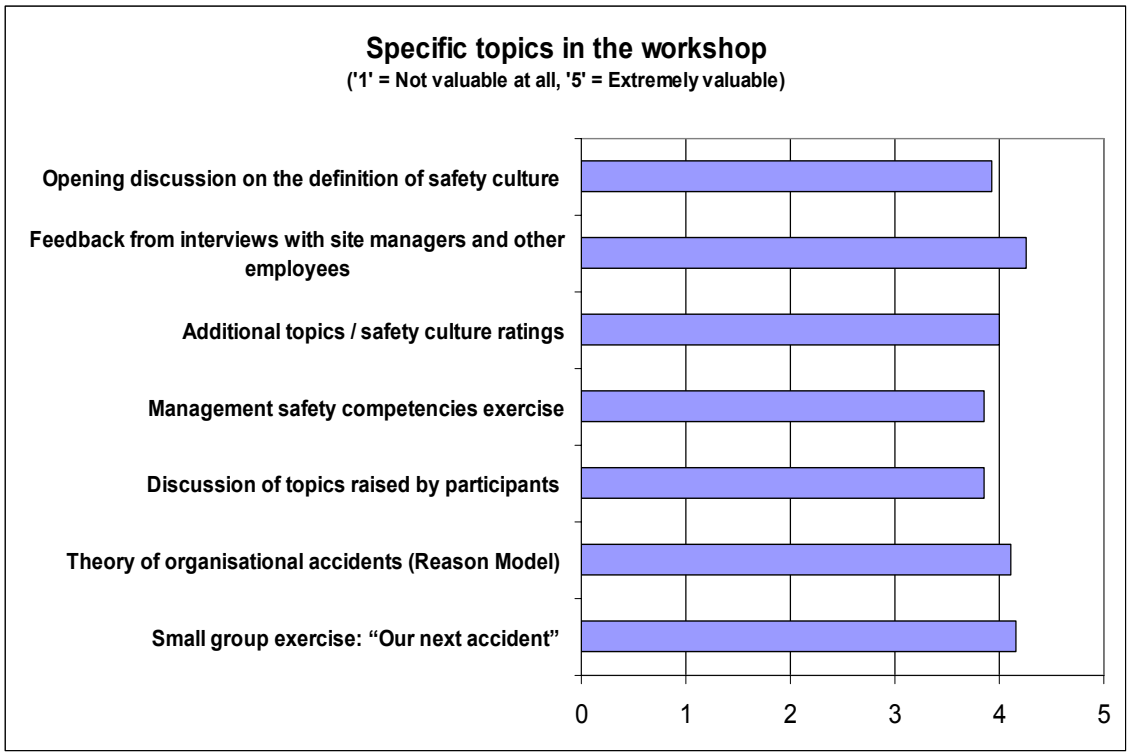

Figure 5
Average participant ratings of specific topics in the workshop

Specific workshop topics were generally rated as "Quite valuable" (a rating of '4') or above by participants, with all topics rated at least of "some value" (a minimum rating of '3'). Average ratings were highest for the sessions that provided feedback from interviews and focus groups (average rating 4.3), and for the small group exercise on "our next accident", average rating 4.2). Explanation of the Reason Model was also valued by participants (average rating 4.1).

Topics rated as slightly less valuable to participants included the definition of safety culture (3.9) and the exercise to develop management safety competencies (also 3.9). While these ratings were still quite high, it is not surprising that some participants would already be familiar with several of these concepts, and accordingly rate them of slightly less personal value.

The final section of the questionnaire included four questions relating to the facilitation of the workshop. Data from the responses to those questions is presented in Figure 6 below, with ratings from '1', *Disagree strongly*, to '5' *Agree strongly*.

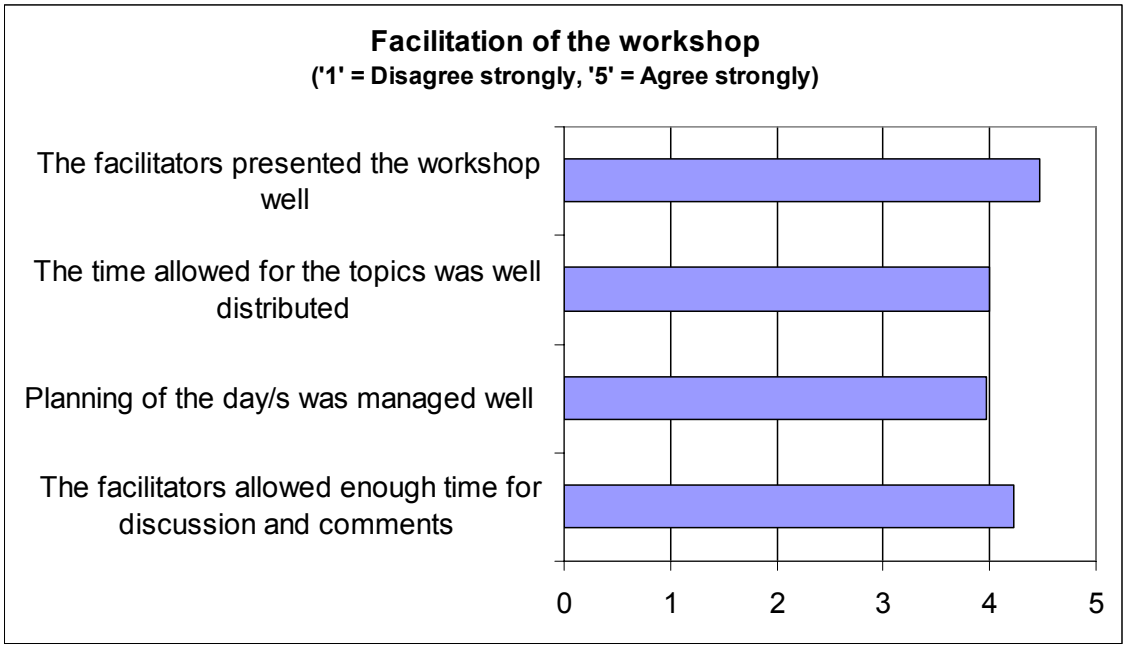

Figure 6
Average participant ratings of facilitation of the workshop

Average ratings for these four items were quite high, ranging from a low of 4.0 (*"Planning of the day/s was managed well"* and *"The time allowed for the topics was well distributed*), to a high of 4.5 (*"The facilitators presented the workshop well"*). Over ninety percent of all responses to these four items were in the *Agree* or *Agree strongly* categories.

In summary, responses from 30 feedback questionnaires completed on the workshop were generally supportive of the workshop concept, the content and methods of delivery and the way it was facilitated. The distribution of ratings on particular topics suggests that some were naturally found to be more valuable than others. It should be noted that feedback from the earlier workshops was taken into account in the way later workshops were prepared and conducted.

4 Recommendations for Future Activities

This section outlines nine recommendations for activities within the Swedish nuclear power industry that would support the further enhancement of safety culture. The recommendations emerged from analysis of information collected in interviews, focus groups and through the management workshop discussions. Given the sound base of existing industry safety systems and practices, these recommendations should be seen as opportunities for improvement rather than immediate critical needs. It should also be noted that although these recommendations are considered significant enough to warrant timely consideration, they may not apply equally to every site involved in the project.

4.1 Enhancing Safety Leadership

Recommendation 1: *Introduce formal processes to ensure the ongoing development of safety-related competencies amongst industry managers.*

This recommendation stems from observations that:

- Effective leadership in regard to safety and appropriate management behaviour are key determinants of safety culture;
- The industry is characterised by a willingness to promote relatively junior managers into senior roles on the basis of sound technical competence, but without formal understanding of how to manage people and influence safe behaviour in the workplace;
- The management actions associated with good leadership and a commitment to safety can be defined through a set of distinct, observable behaviours or competencies, which should be recognised and practiced by all managers.

The exercise undertaken in each of the Management Workshops to draft some basic management safety competencies could be extended and further refined through additional consultation. This would enable a unique Safety Leadership Competency model to be developed for the industry, for the guidance of all site managers. Such a model provides an industry standard which would help align the behaviour of all managers, but more importantly provide a benchmark for developing the competence of newly promoted or less experienced managers.

Typically manager competence is developed through a process of (a) establishing awareness about desired behaviours, (b) providing structured practice in these, and (c) continually reinforcing the expected actions on the job, through peer feedback and senior manager oversight. Competency models can also be employed more formally as part of the performance evaluation system, where individual managers are assessed by their supervisor on their "soft" or non-technical skills, in this case, those relating to safety leadership. In some organisations, a '360 degree feedback' process is used where quantitative feedback on each manager's performance is also provided by their manager, peers and team members.

4.2 Utilising MTO expertise

Recommendation 2: *Strengthen the resources, contribution, value and profile of Man Technology Organisation (MTO) expertise within nuclear industry sites, in order to promote a better understanding of human performance issues, and enhance error management and accident prevention capabilities*.

This recommendation is based on observations that:

- Between 80% and 100% of accidents and incidents in complex socio-technical systems involve human error or other human factors associated with the interaction between people, their work processes and environment and the organisational culture;
- Professional MTO expertise provides a recognised barrier against such events;
- The industry investment in preventing accidents due to technical failure is disproportionate to the investment in preventing human failure through more widespread understanding of MTO principles;
- The role, contribution and profile of MTO expertise across the industry is variable, and therefore not providing optimal value in efficiency improvement and accident / incident prevention.

The range of activities to which MTO specialists can potentially contribute is understood to some degree, but clearer definition of these at an industry level may be of benefit in promoting greater use of MTO expertise. It is also important to define the qualifications and expertise levels required for specialist human factors / MTO positions, and for those requiring lower levels of MTO training. SKI may have a role in providing guidance to the industry on minimum requirements for, and the potential applications of MTO expertise.

4.3 Embedding Positive Safety Culture

Recommendation 3: *Identify ways to permanently embed existing positive safety culture attributes.*

The recommendation derives from the following observations about the industry context and workforce:

- There is increasing use of contractors to undertake and/or support core operational maintenance activities. The safety culture strengths evident amongst permanent employees at individual sites may not be as prevalent or steadfast amongst contracting companies;
- A large proportion of the industry workforce is likely to retire in the next few years, creating an increasing need for recruitment outside the industry. Apart from the obvious potential to create a significant reduction of industry technical knowledge and experience, this also represents a threat to the stability of the existing safety culture, for example in altering attitudes towards error reporting and just treatment of error.

Some potential strategies for embedding existing positive elements of safety culture include:

- Policy statements recognising the specific positive attributes of the existing culture and reinforcing their status independent of management changes. For example, a policy outlining accepted "just culture" principles would provide a permanent reference for future action;
- Training, guidance material and other promotional information on safety culture, as part of the induction process for new employees and to ensure understanding by contractors about the expected standards of behaviour;
- Reinforcement of safety culture principles, behaviour and language at safety meetings, forums, training sessions and operational debriefings. This might involve going beyond general statements about "safety being important" to a deeper level or more specific discussion, for example, about "how well we learnt from an incident", or how a dissenting voice was appreciated and rewarded for speaking up.

This recommendation is regarded as particularly important in the current environment of considerable workforce changes resulting from increasing use of contractors and forecast retirements amongst an ageing employee population.

4.4 Standardised Investigation Methodology

Recommendation 4: *Standardise and improve aspects of the incident and accident investigation processes and analysis methodologies currently used within the industry, to improve information sharing and optimise learning.*

This recommendation acknowledges that an opportunity exists to improve the overall quality and effectiveness of current accident and investigation processes. It is based on observations that:

- The ability of an organisation to learn from its experiences is not only a feature of safety culture, but a critical determinant of its operational viability;
- Reliable processes for investigating accidents and incidents, identifying systemic and human contributing factors and then implementing corrective actions promptly are essential, but rarely achieved in practice;
- A standard methodology for investigating accidents and incidents will improve reliability, learning and information exchange.

It is suggested that SKI may have a role in researching and designating a "best practice" model that would encourage a common methodology for investigating, analysing, reporting and exchanging information on safety occurrences. Such a model should include the following features:

- Adherence to a 'no blame' investigation philosophy;
- A systemic approach, ie., analysis of human involvement, barriers, and contextual conditions as well as organisational and broader system factors;
- A distinct focus on human factors/MTO issues, including human error and performance limitations;
- A reliable, structured process for gathering and sorting evidence and for analysing contributing factors;
- A logical means of developing recommendations for corrective actions designed to reduce risk and prevent recurrence;
- A common "language" for communicating lessons learnt from occurrences to all relevant parties.

A number of such processes currently exist and one based on the "Reason Model" (Reason, 1990, 1991, 1997) was employed successfully for the Accident Scenario Exercise conducted in the project site Management Workshops, as described in Section 2.3 above. This technique has recently been customised and enhanced for use as a systemic safety occurrence analysis methodology in the Air Traffic Control domain (EUROCONTROL, 2005).

4.5 Human Factors Awareness Training

Recommendation 5: *Implement harmonised MTO / human factors awareness training programs at appropriate levels for all nuclear industry personnel.*

This recommendation is based on an acceptance that:

- Virtually all accidents involve human factors, either in the workplace where task demands interact imperfectly with human limitations, or at the higher decision levels of the organisation where safety priorities continually conflict with other operational or commercial goals;
- Human factors contributions can also be found in the design, construction, procurement, installation and maintenance of equipment;
- Accident prevention is thus dependent on the everyday decisions and actions of employees;
- Awareness and understanding about the human factors that are associated with safety occurrences is thus a fundamental knowledge requirement for all employees.

While it is recognised that some human factors / MTO training is already provided within the industry, this is not universal or standardised. There would be benefits from establishing an industry-wide educational framework for nuclear power industry workers in this area. Not least of these is the cost-effectiveness of central design, development and perhaps even delivery of such training.

An industry-wide framework would:

- Ensure minimum knowledge and skill standards at entry level to the industry;
- Establish appropriate additional skill and knowledge standards for progression to higher or specialist roles, and for managers; and
- Over time, contribute to accident prevention and general operational efficiency improvements.

4.6 Team Resource Management Training

Recommendation 6: *Formalise the application of applied teamwork training (as per principles of Crew Resource Management training in aviation) for Control Room Operators, maintenance workers and other employees working in safety-critical teams.*

In the aviation industry Crew Resource Management (CRM) training has become the accepted model for delivering team-based safety training. In contrast to predominantly knowledge-based human factors courses, CRM training uses an experiential, adult learning approach to provide operational personnel with the understanding and skills required to manage themselves and all available resources more safely and effectively.

The CRM model was initially developed for airline flight crew in the early 1980s and evolved considerably before being adapted for other aviation roles. CRM principles have been applied successfully within a range of other safety critical industries (health care, offshore oil and gas, maritime, rail and space flight) to enhance the performance of individuals and teams in both routine and emergency situations.

Although this project did not involve a direct analysis of current "team training" in the Swedish nuclear industry, it appears that processes similar to those used in CRM are being used at some locations, for example with Control Room Operators. It is suggested that this training could be:

- Integrated within the wider umbrella of human factors/MTO training, and promoted as part of a "universal operating philosophy" based on identifying and using all available resources to achieve safe outcomes;
- Supported by industry-wide competencies for team performance, including common evaluation rating forms;
- Extended to other work groups where effective team performance is critical to safety.

CRM principles have been demonstrated to be particularly effective in aviation maintenance and it is believed that a similar application could be of considerable benefit to NPP maintenance operations.[17]

For further detail on the evolution of crew resource management training, its role in error management and its influence on safety culture practices, see Helmreich and Merritt (1998, 2000) and Helmreich, Merritt and Wilhelm (1999). Droog (2004) provides a useful overview of the status of contemporary CRM training and its regulation in Europe, including guidance for training syllabi and content. Salas and colleagues (Salas, Wilson, Burke & Wightman, 2006a, 2006b) provide comment on CRM effectiveness and guidance on training development and implementation.

[17] For further discussion of Maintenance Resource Management (MRM) training principles and effectiveness, see Federal Aviation Administration, 2000; Patankar & Taylor, 2004; Taylor, 2000; Taylor & Christensen, 1998; Taylor & Patankar, 2000.

4.7 Non-technical Team Simulation Training

Recommendation 7: *Increase the use of simulation training to enhance non-technical team problem solving and decision making skills.*

Discussions with operations managers and Control Room personnel revealed that Control Room simulators are currently used to develop skills in basic operational tasks (eg., reactor shut-down and start-up), and to a lesser extent to train operators in managing abnormal events. It is suggested that the use of simulation in the Swedish nuclear power industry could be extended and standardised to improve the way team decision making and problem solving skills are developed.

The simulation training approach used to consolidate effective team skills in aviation, referred to as LOFT (Line Oriented Flight Training)[18], integrates Crew Resource Management principles into what were once technically-focussed simulator training sessions. LOFT training is characterised by the use of 'full mission' scenarios that require effective teamwork, problem solving and decision making in a dynamic, real-time environment. Team behaviour is evaluated using the same behavioural markers required to perform successfully in actual operations, and comprehensive, structured feedback is provided.

The LOFT model may be one that the nuclear industry could draw on to make better use of existing simulation training events. The elements necessary to conduct effective LOFT-style training include sets of realistic operational scenarios, structured evaluation documents and instructors expert in evaluating and debriefing non-technical skills. The effectiveness of team performance will remain the critical factor in managing abnormal and degraded situations in nuclear power control rooms, and every opportunity to improve this should be taken.

Because full LOFT exercises require the use of hi-fidelity simulators, an alternative approach to this type of training has been used in some industries to develop non-technical CRM and team work skills. This involves the use of low-cost, low-fidelity "desktop" simulation training exercises, and the Swedish nuclear industry may also be able to benefit significantly from these.

Desk-top simulation exercises are typically conducted in a normal conference room and would involve a group of reactor managers, control room operators, maintenance workers, related support staff and other specialists confronted with a realistic nuclear event scenario.

Exercises last for up to a day, following a problem or series of problems from start to resolution. Scenarios evolve over the course of the exercise, and there is typically no obvious clear-cut solution. Skills in group problem solving, cooperation and communication are tested, observed and evaluated by the exercise instructors. In the tradition of LOFT, learning outcomes primarily involve the *process* of problem solving in an extended team setting, rather than focussing on results or getting the "right" answer. Exercises are comprehensively de-briefed from the perspective of non-technical skills, focusing on behaviour observed throughout the simulation.

[18] Further detail on the principles of LOFT training is provided at Appendix E.

Specifically, the exercises would target a range of non-technical skills and work processes when faced with the stress of a dynamic critical problem solving scenario, including:

- Problem identification and analysis skills;
- Leadership and support behaviour;
- Group communication processes;
- Team work under pressure;
- Complex decision making;
- Assertiveness.

Whether full LOFT exercises or desk-top simulations are employed, resources for non-technical scenario development and administration could be centralised, providing benefits in training standardisation as well as economic advantages.

4.8 Defending Against Complacency

Recommendation 8: *Continue to protect against the greatest threat facing 'ultra-safe' industries, that of becoming complacent about good safety performance and reducing the attention given to accident prevention.*

Investigations into serious accidents in apparently very safe operations have highlighted complacency about past success as a significant weakness of safety culture.[19] Constance Perin (cited by Reason, 1997), refers to this as the "unrocked boat" phenomenon. As elaborated by Reason:

> It is easy to forget to be afraid of things that rarely happen, particularly in the face of productive imperatives like growth, profit and market share. As a result, investment in more effective protection falls off and the care and maintenance necessary to preserve the integrity of existing defences declines,
>
> Not only that, productive growth is regarded as commercially essential in most organisations… increasing production without the corresponding provision of new or extended defences will also erode available safety margins. The consequence of both processes … is a much increased risk of a catastrophic and sometimes terminal accident.

The counter to this pervasive organisational attitude is a high degree of wariness. As described in Appendix A, wariness requires "constructive unease", defined as:

- a sufficient level of worry to prompt constant assessment of the safety significance of events and issues;
- a commitment to anticipate things that could go wrong; and
- a willingness to recall past failures rather than be blinded by recent success.

Bad accidents or serious incidents raise concern and temporarily promote wariness. Where an organisation has been fortunate enough to avoid such events for a long period, artificial events must be used to initiate "complacency disruption" and refocus attention on safety.

The Management Workshops conducted in this project all involved a "potential accident scenario" exercise, designed to stimulate thinking about how a serious event could occur locally. This activity can be repeated with other groups of employees, not only to arouse "constructive unease", but also to extract useful safety lessons from "subject matter experts" without the costs of having a real accident.

It is understood that this technique has been taken up by at least one of the sites participating in this project and it is recommended that other sites consider its potential value in helping defend against complacency.

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[19] For example the Challenger Space Shuttle accident (see Vaughan, 1996); the Columbia Space Shuttle accident (see Columbia Accident Investigation Board, 2001). See also Perrow, 1994.

4.9 Measuring Safety Culture

Recommendation 9: *Implement a process to provide regular quantitative measures of the industry safety culture, as a guide to future enhancement actions.*

Regular, reliable measurement is the basis of all continuous improvement. This project provided a one-off qualitative analysis of safety culture for the Swedish nuclear power industry. There are additional benefits to be gained from hard quantitative data however, and suitable tools already exist through which safety culture attributes can be reliably measured and compared across sites and over time.

It is proposed that the Swedish nuclear power industry institute a collaborative project to regularly measure and benchmark safety culture and climate amongst key industry participants.

The following broad project outline is suggested:

- Select and /or customise a valid and reliable questionnaire measure of safety culture / climate;
- Administer the questionnaire annually at power producing sites who agree to participate in the project;
- Analyse and establish the first round of data as a baseline measure;
- Provide feedback to each site on their own results compared to the "industry norm", but without sharing any information on the results from other individual sites; [20]
- With the permission of participating sites, provide aggregate data to the regulator, to highlight areas of particular concern within the industry;
- Repeat the survey annually, providing trend information and early detection of changes in safety culture attitudes or behaviour.

The information produced as a result of this proposed project will be particularly useful through the period of change confronting the industry at this time, for example as older employees retire from the workforce, to monitor whether new generation employees hold similar attitudes and expectations.

[20] This would require analysis of data by an independent body, to ensure each site's data were only distributed to them, with aggregate data provided to the Regulator.

5 Conclusion

5.1 Summary of the Project

This project commissioned by SKI demonstrated the benefit of activities designed to further enhance safety culture within the Swedish nuclear power industry. Although many features associated with a positive safety culture are already evident in the industry, the project showed the value of clarifying and reinforcing understanding at senior site management level about what this means in practice.

The initial data gathering phase of the project provided access to the targeted groups of senior managers through individual interviews. Opinions were expressed openly and frankly, confirming a strong level of support for the project objectives. A worthwhile feature of the project methodology was that groups of (non-management) employees were also consulted at each site, providing a healthy balance of opinions and perspectives on safety issues. This enabled 'grass-roots' employee opinions about safety to be contrasted with prevailing management views.

The workshops conducted with senior site managers had the objective of sharing independently obtained information within the management group, extending their understanding of safety culture, and leaving them with practical objectives, ideas and tools for achieving further safety culture improvement. The workshop included the following custom-designed elements:

1. Input provided by Dédale throughout the two-day workshop on safety concepts and models, drawing on experience from other industries, relevant research and contemporary thinking in safety culture and human factors.
2. Feedback from the data gathering phase, provided using a structure based on the elements of a safety culture. This gave workshop participants a 'scorecard' of what was currently being done well, and identified opportunities for improving support of safety culture principles.
3. A facilitated discussion about the limitations of current safety occurrence investigation processes, and the necessity to ensure that investigations are comprehensive, adopt a systemic view of causation rather than focus on individual error, and produce recommendations that are realistic, specific and clearly related to investigation findings.
4. An exercise to compare manager views and attitudes on some key issues in safety culture, demonstrating the importance of a 'common understanding' within an organisation's Senior Management group about what is needed to maintain safety.
5. Presentation and discussion of ideas drawn from best practice in other industries, including aviation, an industry where the importance of addressing human factors considerations as a means of enhancing safety performance is now well recognised.

6. A final practical exercise to develop a scenario through which a serious safety event could occur at the site, identify the factors and conditions that could contribute to the incident, and make preventative recommendations.

Feedback on the workshops was collected both informally and formally. This indicated that the process was generally viewed as interesting and professionally beneficial to participants, and that the ideas presented were seen as valuable for site management.

5.2 Future Activities

One objective of this project was to stimulate action by senior managers of nuclear facilities to review and enhance their safety practices and culture. The second objective was to prepare an industry Safety Culture Report for SKI, describing the current status of the industry safety culture, its strengths and opportunities for improvement. This was achieved by drawing together observations and findings across three nuclear sites, without breeching confidentiality undertakings made to the participating organisations. This report provides SKI with a comprehensive qualitative picture of safety practices across the majority of the Swedish nuclear industry, with a particular emphasis on the application of MTO principles in support of safety objectives.

The nine recommendations made above include opportunities for action at site level and by the industry collectively. There is also an opportunity for SKI to be involved in these enhancement activities in a number of different ways. One level of involvement would be to monitor the extent to which these ideas are taken up by industry players. An example here would be the recommendations on formalising and extending the use of MTO resources. At a different level, SKI might be more directly involved, for example by helping establish strategic objectives or guidelines on projects of common benefit for the industry. Recommended action to implement increased human factors awareness training, customised Team Resource Management training, and additional non-technical simulation training programs would for example benefit greatly from SKI leadership towards a coordinated, industry-wide approach.

The following activities are recommended as future actions to enhance industry safety culture. It is suggested that they will have maximum chance of making a difference if they are:

(a) formally added to the industry safety management agenda;

(b) reviewed and evaluated for feasibility and cost-benefit; and

(c) established and resourced as either local or industry-based projects.

The recommended actions resulting from this project are to:

1. Introduce formal processes to ensure the ongoing development of safety-related competencies amongst industry managers.
2. Strengthen the resources, contribution, value and profile of Man Technology Organisation (MTO) expertise within nuclear industry sites, in order to promote a better understanding of human performance issues, and enhance error management and accident prevention capabilities.
3. Identify ways to embed the positive safety culture attributes that presently exist.
4. Standardise and improve aspects of the incident and accident investigation processes and analysis methodologies currently used within the industry, to improve information sharing and optimise learning.
5. Implement harmonised MTO / human factors awareness training programs at appropriate levels for all nuclear industry personnel.
6. Formalise the application of applied teamwork training (as per principles of Crew Resource Management training in aviation) for Control Room Operators, Maintenance workers and other employees working in safety-critical teams.
7. Increase the use of simulation training to enhance non-technical team problem-solving and decision-making skills.
8. Continue to protect against the complacency that may arise following an historically good safety performance.
9. Implement a process to provide regular quantitative measures of the industry safety culture, as a guide to future enhancement actions.

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Appendix A ~
Elements of a Safety Culture

1. Top level commitment involves:

- Senior Management drives the focus on safety as the top operating priority at all levels of the organisation
- Management recognises and communicates that safety is essential for commercial success
- Strong safety emphasis is systematised and endures regardless of commercial pressures / changes to Senior Management team
- Management ensures that resources are available for safety critical activities
- MTO resources recognised as essential to safety.

2. Informed awareness involves:

- Fostering a reporting culture
  - workers are willing to admit to their errors and near misses, without fear of punishment
- Ability to identify 'at risk' situations/ behaviours
  - obtaining, analysing and disseminating data on critical events and near misses
- Knowing what is really going on regarding worker safety attitudes and behaviours
  - understanding reported data and also knowing what else might be going on
- Knowing where the boundary of safe operation is without having to get close to it
  - difficult in 'ultra-safe' industries

3. Just culture involves:

- High level of trust
  - Workers trust management to respond fairly to errors and near misses
- Just, non-punitive reactions
  - There is a clear distinction between acceptable and unacceptable behaviours
  - Messengers are encouraged, not 'shot'
  - Culpable acts ~ intentional unnecessary violations ~ are dealt with fairly but firmly
    i. 'foresight test'
    ii. 'substitution test'

4. Being Wary involves:

- Constant assessment
  - What is the safety significance of events and issues?
  - Giving them the appropriate level of attention.
- Vigilance and anticipation
  - accepting that failures, errors and unexpected events occur, and actively anticipating them
  - from the organisation as a whole and individuals
  - unexpected events - "what if" scenarios
- Not being complacent about successes
  - Focus on past failures, reminders of fallibility

5. Being Flexible involves:

- Adaptability
  - managing new or complex situations with minimal disruption to operations
  - effectively handling high demand situations and increased activity periods, as well as routine modes of operation
- Delegated decision making
  - Allowing workers (particularly first level supervisors) to make important decisions without depending on management guidance
- Resilience
  - Remaining in control when something out of the ordinary happens; being prepared and composed in emergencies

6. Learning involves:

- Good communications between all levels of the workforce
  - feedback systems to provide information and ideas for continuous improvement
  - valuing the expertise and contribution of front-line staff
- Seeking information
  - Learning from errors, incidents, and accidents
  - Valuing real reform rather than denying the problem
- Commitment to action
  - The will to implement reforms when they are required
  - Eliminating error-inducing conditions and organisational weaknesses (latent conditions)

Appendix B ~
Management Workshop Activities

Safety Culture Perceptions and Principles

The process used in the workshop involved a mix of presented information, facilitated discussions and structured exercises. The information presented initially throughout Day 1 of the workshop was a summary of the observations distilled from senior manager interviews and the focus group. This included manager perceptions about the external and internal environmental factors that impinge on site activities. Feedback allowed individual managers to compare and contrast their own perceptions about safety culture with those of their colleagues, as a first step towards mutual understanding and alignment of objectives.

Observations from senior management interviews and the focus group were summarised using the six-element structure of safety culture: *Top level commitment; Informed awareness; Just culture; Wary; Flexible* and *Learning*. For each of these safety culture elements, a detailed definition was provided, and examples presented of site activities, actions and attitudes related to that aspect of safety culture. Finally, discussion items were listed, where it was felt the potential existed for the site to consider this factor further and to review their current strategies for achieving success in this area. In some cases, a number of additional topics indirectly related to the safety culture element were also noted.

To complement these 'internal perceptions', Dédale provided input throughout the two-day workshop on a number of safety concepts and models. These were drawn from the experience of other industries, relevant research and accepted thinking in safety culture and human factors. The objective of this process was to extend and challenge the existing perspective of the management group in regard to how safety is defined and understood outside the nuclear power industry.

In addition to the safety culture elements defined by Reason and Hudson described above, several other perspectives of organisational and safety culture were presented and discussed during the workshop. One of these was Westrum's (1993, 1995) juxtaposition of the characteristic reactions of organisations when dealing with anomalies including safety occurrences; from the outright defensive ("Pathological"), through the classically bureaucratic, to the elusively enlightened ("Generative"), as depicted in Figure B1 below.

Figure B1
Westrum's Model of Organisational Culture

A related model, adapted from Westrum's original work by Hudson (2002) and depicting identifiable levels in the evolution of an organisation's safety culture was also discussed (see Figure B2 below). It is noted that these perspectives have parallels with the three stages of safety culture development recognised and discussed by the International Atomic Energy Agency (1998).[21]

[21] International Atomic Energy Agency. (2002). Developing safety culture in nuclear activities: Practical suggestions to assist progress. *Safety Reports Series No. 11*. Vienna: IAEA.

Figure B2
Evolving Levels of Organisational Safety Culture

Comparison of Management Attitudes

A key objective of the workshop was to provide a forum for senior managers to openly discuss any differing views on safety and its enhancement. The workshop forum was also used as an opportunity to formally evaluate, compare and discuss individual manager's impressions about the extent to which the site currently approaches some key issues that support a safety culture. Attitudes were assessed using a brief written questionnaire, which was distributed and completed early on Day 1 of the workshop. Results were progressively reported back and discussed in conjunction with other discussions around each safety culture element. A copy of the questionnaire is shown in Appendix C.

The purpose of this activity was to provide feedback on how each manager's views compared to the group view, as a basis for building a greater degree of common understanding between managers. Such alignment of managers' understanding is consistent with definitions of safety culture that emphasise the importance of a shared leadership view about what is important to the maintenance of safety. Group responses to each survey question were also designed to assist participants in identifying organisational opportunities to improve local safety practices and culture, and to develop specific improvement strategies and initial action plans for these.

Safety Investigation Issues

An effective process for investigating safety occurrences (accidents and incidents) is critical to an organisation's capacity to learn about its safety deficiencies. Current investigation processes and practices at the site were included as a topic for discussion in the workshop.

An open question was posed about the effectiveness of the current investigation process - whether managers held any concerns about the way:

- incidents are reported?
- the level of the occurrence is determined?
- the investigation is conducted?
- findings are reported?
- recommendations are made and communicated?
- recommendations are put into effect?

Some of the typical concerns organisations have about investigation processes were discussed, including:

- Different reporting forms and requirements
- Different investigation methods
- Different reporting styles and standards
- A focus on individual error:
  - "didn't follow the procedure…"
  - "further training required…"
  - "not suited to working in that position…"
- Systemic causes seldom identified
- Difficulty sharing the lessons learnt from occurrences
- Hard to ensure recommendations are acted on
- Investigations tend to focus on technology or use of technology:
  - little emphasis on understanding human contributions
  - little emphasis on enhancing human performance

It was noted that improvement in other industries is found to have resulted from:

- A common methodology for the investigation and reporting of all safety occurrences and near misses
- An understanding of the human factors that underlie adverse events
- A means for consistently identifying systemic causes of occurrences
- A logical means of developing corrective actions designed to reduce risk and prevent recurrence
- A common "language" for communicating lessons learnt from occurrences to all relevant parties.

Management Safety Competencies

Many definitions of safety culture emphasise the important influence an organisation's leadership group can have on the safety-related attitudes and behaviour of employees. As noted above, safety culture has been defined as those aspects of an organisation's reliability that depend on "shared values and norms of behaviour articulated by senior management and translated with high uniformity into effective work practices at the front line".[22]

Such definitions clearly imply that senior management need to form certain common beliefs about what is desirable within the organisation, and be able to take action themselves that ensures this preferred situation is "translated into effective work practices". The knowledge, skills and behaviours that underlie a person's performance at work are referred to as competencies. These can be defined in terms of observable behaviours that can be identified, taught and evaluated. Just as managers are required to display competencies relating to specific areas of their job performance (eg., budgeting, marketing, people management), competencies can be defined to specify what a manager should do to promote a safety culture within their business.

A practical exercise was conducted during the workshop to generate an initial model of "management safety competencies" – descriptors of the behaviour that managers would display if they were demonstrating a clear commitment to safety. Time limitations prevented the development of a comprehensive competency framework, however some initial content was produced.

It is proposed that should this project be extended to additional nuclear power sites in Sweden, this exercise could be replicated, and further data collected. This would enable a unique Safety Competency model to be developed for the industry, and distributed for reference by all site managers, present and future. Such models are often employed as part of the performance evaluation system, as a basis for determining the degree to which individual managers are judged by the CEO (or, under a 360 degree feedback approach, judged by each other, their reporting staff etc), as displaying the behaviours necessary to improve the safety culture.

[22] Gaba, D.M., Singer, S.J., Sinaiko, A.D., Bowen, J.D., & Ciavarelli, A.P. (2003). Differences in safety climate between hospital personnel and naval aviators. *Human Factors, 45*(2), 173-185.

Accident Scenario Exercise

On the second day of the workshop a significant exercise was conducted, in which the senior managers worked in two groups to develop a hypothetical scenario under which a nuclear accident could feasibly occur at the site. A structured methodology was provided for the reporting of their findings, based on an accident investigation process derived from the Reason Model of organisational accidents (Reason, 1990, 1991, 1997; Reason & Hobbs, 2003).[23] The exercise encouraged participants to draw specifically on their understanding of the contribution of human error and conditions generated by latent system failures to generate the hypothetical accident scenarios.

The outcome of the exercise was a structured systemic analysis of the hypothetical event, and a set of realistic recommendations to prevent it from happening. The recommendations were designed specifically to address organisational deficiencies and reduce the risk that a set of conditions could develop under which a serious safety event of the type identified could occur. The exercise provides participants with insight into how safety can be jeopardised, and enables preventative action to be taken before the loss is actually incurred. The methodology used also provided the management group with a practical tool for investigating and analysing the conditions which promote accidents and incidents.

The ground rules for the workshop included a guarantee of confidentiality regarding all issues discussed over the two days. Consequently, the output from discussions and exercises was provided to participants in a written summary report to the site, but will not be reported elsewhere.

[23] Reason, J. (1990). *Human error*. New York: Cambridge University Press.

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Reason, J., & Hobbs, A. (2003). *Managing maintenance error: A practical guide.* Aldershot, UK: Ashgate.

Open Discussion Session

Towards the conclusion of the two-day workshop, managers were invited to raise questions related to any aspect of safety culture enhancement. The topics listed were significant and broad-ranging ones. Due to time limitations, some topics could not be addressed in full by the workshop facilitators. Issues addressed included:

- A planned local Safety Culture program
- Other industry experience
- Work and fatigue at night ("during the dog hours")
- Mistakes associated with experienced workers
- Education in safety culture improvement
- Being wary – learning/proactivity
- Defining just treatment (as part of Just Culture)
- Prerequisites for a Safety Culture

This activity allowed the workshop participants to explore issues of particular interest or concern, drawing on the experience of the three facilitators. Where possible, responses were supported by additional material accessed by the facilitators and presented in PowerPoint format. This material was subsequently included within documents provided to the site.

Appendix C ~
Safety Culture Perceptions Questionnaire

SKI Safety Culture Enhancement Project

Management Workshop

Ratings Questionnaire

Instructions: Please complete this questionnaire by writing a number from 0 to 100 on the right hand side of the page after each question. Give the answer that indicates your own personal opinion, as you see things at the moment – not an answer that indicates how things *could be* or *should be*. Do not think about your answer for too long. A rough estimation is all that is required. There will be time later to talk more about what each question means. Your answers are confidential and will not be shown to anyone else. Scores for the whole group will be calculated as a basis for discussion.

Question	**Your rating** (No. from zero to 100)
Example: How much of the time is the food bad at work canteens?	*48*
1. How do you think employees would rate senior management's commitment to safety at the moment? (0 = 'not at all committed'; 100 = 'totally committed")	
2. What percentage of people would you say are treated justly when they make an error?"	
3. How well-informed do you feel about what is really happening in regard to safety at this site (eg., how people are behaving, what events are occurring)? (0 = 'not at all informed', 100 = 'totally informed')	
4. Of all possible future serious problems, incidents and accidents that could occur here, what percentage of these have been considered?	
5. How would you rate this site's ability to deal with highly demanding, unusual and unexpected events? (0 = "not at all"; 100 = "prepared for anything")	
6. To what extent does this site make changes or improvements when they become aware of a problem (0 = "never"; 100 = "on every possible occasion")	
7. Following an incident investigation, what percentage of the recommendations made are fully implemented?	
8. What percentage of incidents and accidents in the nuclear power industry involve human error?	
9. What percentage of the time do people follow rules, instructions and procedures exactly (ie., not commit a violation)?	
10. What percentage of all errors and violations are reported by workers (including contractors)?	

Thank you

Appendix D ~
Workshop Feedback Questionnaire

This questionnaire has been designed to evaluate your opinions about the local Safety Culture Workshop you attended on (*workshop dates*), and to provide feedback from which the workshop process and content can be improved if conducted again.

Please indicate your feelings about each statement below by marking one of the boxes from 1 ("Disagree strongly") to 5 ("Agree strongly").

1	2	3	4	5
Disagree strongly	**Disagree**	**No opinion**	**Agree**	**Agree strongly**

1 – Overall opinion of the workshop:

	1	2	3	4	5
The workshop was **interesting** to attend ……	☐	☐	☐	☐	☐
The workshop **objectives** were clear and well defined ……	☐	☐	☐	☐	☐
The workshop met my **expectations**……..	☐	☐	☐	☐	☐
This workshop was **useful** *for me professionally* ……..……..	☐	☐	☐	☐	☐
The workshop **length** *was appropriate*……..……	☐	☐	☐	☐	☐
The **ideas provided** *in this workshop are needed in this organisation* .	☐	☐	☐	☐	☐

Comments:

……

……

……..……

2 – Overall content and methods:

	1	2	3	4	5
Messages in the workshop were **understandable** ……	☐	☐	☐	☐	☐
The **material** *presented was clear, and relevant to the objectives* ……	☐	☐	☐	☐	☐
The workshop was sufficiently **interactive.**……..	☐	☐	☐	☐	☐
The exercises and practical activities were useful ……..	☐	☐	☐	☐	☐
The **theoretical** *knowledge presented was clear and relevant* ……...	☐	☐	☐	☐	☐
The **links** *between sections of the workshop were clear* ……..……	☐	☐	☐	☐	☐

Comments:

……

……

……..……

3 – Specific topics in the workshop

Please rate each part of the workshop according to how valuable you think it was, using the ratings set out below:

1	2	3	4	5
Not valuable at all	**Minimal value**	**Some value**	**Quite valuable**	**Extremely valuable**

	1	2	3	4	5
• Opening discussion on the definition of safety culture ……	☐	☐	☐	☐	☐
• Feedback from interviews with managers and other employees (Day 1 topics, Commitment, Just, Wary, etc) …….	☐	☐	☐	☐	☐
• Summary of ratings made by workshop participants on safety culture issues ('0 to 100 scores') ……	☐	☐	☐	☐	☐
• Management safety competencies exercise (Day 2) ……	☐	☐	☐	☐	☐
• Discussion of topics raised by participants (Day 2) …….	☐	☐	☐	☐	☐
• Theory of organisational accidents (Reason Model) ……...	☐	☐	☐	☐	☐
• Small group exercise: "Our next accident" ……..……..…….	☐	☐	☐	☐	☐

Comments:

……

……

4 – Facilitation of the workshop:

1	2	3	4	5
Disagree strongly	**Disagree**	**No opinion**	**Agree**	**Agree strongly**

	1	2	3	4	5
The **facilitators** *presented the workshop well* ……..….	☐	☐	☐	☐	☐
The **time** *allowed for the topics was well distributed* ……...	☐	☐	☐	☐	☐
Planning *of the day/s was managed well* ……..	☐	☐	☐	☐	☐
The facilitators allowed enough time for **discussion and comments** .	☐	☐	☐	☐	☐

5 – Comments & Suggestions:

What did you like most about the workshop?

……..……

……..……

What are your suggestions to improve the workshop?

……..……

……..……

Thank you for your contribution

Appendix E ~
Line Oriented Flight Training

Line Oriented Flight Training (LOFT; see Butler, 1993; Lauber & Foushee, 1981) is a non-jeopardy flight crew team performance training exercise, usually conducted in high-fidelity flight simulators, that provides the opportunity for both practice and feedback of CRM (Crew Resource Management) behaviours.

Participants are presented with full mission flight scenarios requiring effective crew coordination in order to ensure successful performance. These exercises provide participants with the opportunity to practice CRM skills and receive feedback on their performance. They have been highly rated by both pilots and instructors (Butler, 1991; Wilhelm, 1991) and have been demonstrated to improve crew performance across a range of non-technical behavioural dimensions (Clothier, 1991).

The use of videotaped feedback from LOFT sessions is particularly effective in that it provides participants with a unique insight into their personal strengths and weaknesses, and allows scenarios to be debriefed with reference to specific individual and team behavioural patterns and work styles. Debriefs are conducted by skilled facilitators trained in the use of role-specific behavioural markers, which exercise participants are also familiar with. Crew-led debriefs are often encouraged.

Where sophisticated simulation facilities are not available, role-playing exercises requiring a similar level of group coordination and problem solving can be effectively used for non-technical skill rehearsal and feedback. These techniques provide the opportunity for valuable practice and reinforcement of CRM skills and behaviours.

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