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Conducting organizational safety reviews – requirements, methods and experience

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Abstract

Organizational safety reviews are part of the safety management process of power plants. They are typically performed after major reorganizations, significant incidents or according to specified review programs. Organizational reviews can also be a part of a benchmarking between organizations that aims to improve work practices. Thus, they are important instruments in proactive safety management and safety culture. Most methods that have been used for organizational reviews are based more on practical considerations than a sound scientific theory of how various organizational or technical issues influence safety. Review practices and methods also vary considerably. The objective of this research is to promote understanding on approaches used in organizational safety reviews as well as to initiate discussion on criteria and methods of organizational assessment. The research identified a set of issues that need to be taken into account when planning and conducting organizational safety reviews. Examples of the issues are definition of appropriate criteria for evaluation, the expertise needed in the assessment and the organizational motivation for conducting the assessment. The study indicates that organizational safety assessments involve plenty of issues and situations where choices have to be made regarding what is considered valid information and a balance has to be struck between focus on various organizational phenomena. It is very important that these choices are based on a sound theoretical framework and that these choices can later be evaluated together with the assessment findings. The research concludes that at its best, the organizational safety reviews can be utilised as a source of information concerning the changing vulnerabilities and the actual safety performance of the organization. In order to do this, certain basic organizational phenomena and assessment issues have to be acknowledged and considered. The research concludes with recommendations on issues that should be considered and taken into account as far as is practically applicable in any assessment where organizational safety issues are considered. Finally, further research needs in the area of organizational factors and organizational safety assessment are outlined.

Key words

Safety reviews, safety culture, organizational factors, safety management

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OrRe 2006-2007 Final Report

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Background

1.1 Organizational safety reviews

Organizational safety reviews are part of the safety management process of power plants. Safety management is usually understood to include all those activities that seek to identify, assess and control risks that are associated with all activities to guarantee the safety of the plant. Reviews of human activities and their support perceived in an organizational context are important in the safety management process. These reviews usually include both self-assessments and external reviews. The concepts of “continuous improvement” and “learning organization” are often emphasised in such reviews.

Safety management relies on a systematic feedback of organizational performance in which collection and analysis of experience is an important part. At the nuclear sites this is usually broken down in two activities; one of which is related to the quality tradition with techniques for conducting audits and the other to analysing incident and near misses using root cause analysis and other means. These activities have at nuclear sites been important ingredients for present practices of organizational reviews.

Organizational safety reviews are typically performed after major reorganizations, significant incidents or according to specified review programs. Organizational reviews can also be a part of a benchmarking between organizations that aims to improve work practices. Present methods for organizational reviews usually identify a set of issues to be assessed and some norms to be used in their assessment. Often the norms are not explicitly defined or they are defined only in qualitative terms.

1.2 Focus and aims of the study

Organizational reviews are important instruments in the continuous quest for improved performance. In the nuclear field there has been an increasing regulatory interest in organizational performance, because incidents and accidents often point to organizational deficiencies as one of the major precursors.

An organizational review is always based on an underlying model, whether the model is implicit in the assessor’s mind or made explicit in the review. All reviews are driven by questions. These questions, in turn, always reflect assumptions inherent in i.e. the methods, individual assessors, and cultural conventions. These assumptions include appropriate methods of data collection and analysis, opinions on review criteria to be used, and models of safe organization.

Most methods that have been used for organizational reviews are based more on practical considerations than a sound scientific theory of how various issues influences safety. The implication is that features and criteria of the used methods and tools are implicit and that they therefore are hard to evaluate and validate in a critical review of the process or the results produced. Review practices and methods also vary considerably.

It is the authors’ personal observation that the absence of well-established techniques for organizational reviews has caused discussions and controversies on different levels. It would therefore be important to collect the experiences from organizational reviews carried out so far and to reflect upon them in a theoretical model of organizational performance. It would also be important to set criteria for the definition of the scope and content of organizational reviews. More generally it would also be necessary to create guidance for people conducting and participating in organizational reviews. In addition it is expected that the application of new regulation in Finland and Sweden will need scientific support to define reasonable and efficient

practices. A common observation from audits and peer reviews is that problems seem to be recurring and do not easily lead into changes in applied practices.

Organizational safety review is a broad concept, and no clear definition exists of what a safety review is. In this report, by organizational safety reviews we mean something that;

- is planned in advance and is executed in at least a partly predetermined manner
- focus more on organizational and social than purely technological safety issues in the given organization
- focus on those structures and practices of the organization having relevance to the functioning and safety of the organization
- is arranged as a project and is conducted in a specified time

A related concept to organizational safety reviews is assessment of organizational performance. Assessment of organizational performance is an even broader concept than organizational reviews. A considerable body of literature exists concerning assessment of organizational performance in general, but they lack an explicit safety focus. We will exclude from this study those activities that focus on organizational performance in general and concentrate on organizational reviews having a safety focus.

The objective of this research is to promote understanding on approaches used in organizational safety reviews as well as to initiate discussion on criteria and methods of organizational assessment. Since this area is relatively new, it is consequently difficult and premature to give specific recommendations for conducting organizational reviews. It is our opinion that more experiences have to be collected before detailed recommendations can be made. However, we do give general recommendations concerning the critical issues to be taken into account when planning and conducting organizational safety reviews.

There is also an issue of the cultural specificity of the methods for organizational reviews. There is a considerable body of evidence that values and beliefs concerning organizational issues and performance vary among cultures (House et al., 2004). Thus, lessons learned from one culture are not necessarily applicable to another culture. This remark applies to organizational as well as national cultures.

Despite the incoherence of the field of organizational assessments, there is an emerging body of literature in this area that gives indications about specific topics and areas that need attention and clarification. This study aims to increase regulators' and utility owners' awareness about organizational safety reviews and clarify the emerging issues that need to be taken into account when conducting them.

As a starting point, we have identified the following issues connected to organizational safety reviews that need clarifying:

- The traditional auditing strategy is often focused on formal and structural issues rather than performance. However, a formal safety management system with all documents in place does not necessarily reflect how this system is utilised.
- The use of culture assessments and the body of literature associated with these culture assessment practices are often used in parallel with traditional auditing. How these two strategies can be used together is not well developed.
- Integration of findings from various methods and assessments. For example, event investigation techniques are usually performed as part of the safety management strategy. How these findings are integrated with other processes of organizational assessments needs to be clarified.

We will return to these at issues the end of this report.

1.3 Outline of the report

In this final report, reviews and assessments conducted regularly at the Nordic nuclear power plants are briefly outlined in Section 2. Then, in Section 3, experiences from selected reviews are presented. Based on the selected reviews, international literature and authors' personal experience with organizational reviews, problem domains as potential solutions concerning organizational assessment are identified in Section 4. Finally, in Section 5 general recommendations are given for conducting organizational assessments and for integration of information from different assessments.

2 Description of current reviews conducted at the nuclear power plants

The power companies conduct numerous reviews, both external and internal (self-assessments) as a part of continuous development of their activities and management of safety. The following list gives examples of organizational safety review activities in the Nordic nuclear power plants:

- Periodic safety reviews
- ASAR/PSR projects (as operated safety analysis review / periodic safety review) are carried out approximately every 10 years as required by SKI
- comprehensive safety reviews are required in connection to licence renewals, or approximately every 10 years in Finland
- Peer reviews as requested either by the national authorities or by the nuclear power plants
- OSART reviews (Operational Safety Review Team, IAEA), all sites in Finland and Sweden have gone through at least one OSART review
- WANO peer reviews, all sites in Finland and Sweden have gone through at least one WANO peer review in their operating history
- Safety culture self assessment, using e.g. the ASCOT guidelines as produced by IAEA (1996)
- SCART assessments (Safety Culture Assessment Review Team), a new service offered by IAEA (2007)
- Regulatory audits and inspections, being part of the normal regulatory oversight in Finland and Sweden
- Safety evaluations of organizational changes having safety significance as required by SKI in Sweden
- Internal auditing according to an agreed quality assurance program (a regulatory requirement both in Finland and Sweden)
- Yearly internal safety climate assessment, which have been in use for several years at the Swedish plants
- Working climate surveys, which usually are carried out yearly in Finland and Sweden
- Internal or external safety culture audits, when seen necessary for some specific reason
- Event investigations and in depth analyses of LERs considering also organizational issues
- Research projects with various foci and research problems

Next we will describe in more detail selected assessment methods.

2.1 Periodic safety reviews

Periodic safety reviews is an instrument for safety management. The instrument was developed by IAEA already in the year 1994 (50-SG-O12) and present guidance is from the year 2003 (NS-G-2.10, IAEA, 2003b). Periodic safety reviews should typically be conducted with a ten year interval. The periodic safety reviews have a broad scope, which also include components of an organizational review.

In Finland the periodic safety reviews were typically carried out in connection with the license renewal, but when longer operational licences have been awarded they have been conditioned to a periodic safety review as required in YVL 1.1¹. In Sweden the periodic safety reviews were developed in the late 1980s and were given the acronym ASAR (as operated safety analysis review). In Sweden the ASAR reviews have over the years been more focused on an assessment of organizational features and safety culture. SKI revises the ASAR reviews to be in line with the IAEA guidance.

2.2 Peer reviews in NPPs

Peer reviews are carried out by persons who have personal experience concerning the work processes and tasks that are to be reviewed. The objectives of the peer reviews are to identify possible strengths and weaknesses in order to enable the reviewed nuclear power plants to make their own improvements in the areas identified and to distribute good practices within the nuclear community. The most commonly known peer reviews in the nuclear field are the IAEA's OSART (Operational Safety Review Team) and the WANO peer reviews.

In the OSART reviews the operation of the plant and the performance of the plant's management and staff rather than the adequacy of a plant's design are reviewed (IAEA 1994b). In 1982, the IAEA added the Operational Safety Review Team (OSART) programme to its services. Under this programme, international teams of experts conduct three-week in-depth reviews of operational safety performance at individual nuclear power plants. These reviews are conducted at the request of the government of the host country.

The WANO peer reviews have been conducted since 1991 and today all plants in the world have gone through at least one peer review. The WANO peer reviews are based on collection of actual observations in selected areas at the host plant and comparing them with what can be considered as the best standards within the industry. A WANO peer review is typically followed up with a second smaller review in a one to two years period. The reports from the WANO peer reviews are confidential between the host plant and WANO.

Peer reviews are typically not relying on explicit models of organization or of human performance. Instead the team members are assumed to bring their own tacit models to the review. This is both strength and a weakness in the peer review process. The strength is that performance is assessed without a priori models, but the absence of an explicit model of performance makes it difficult to define what should be considered as an observation.

2.3 Reviews in the normal regulatory oversight process

Quality audits and periodic safety reviews have been included in the regulatory requirements in most countries already for many years. The Nuclear Installations Inspectorate in the UK (NII) was the forerunner in requiring organizational reviews at the nuclear power plants after major reorganizations, i.e. the so called License Condition 36. The reason for introducing this new requirement was that NII became concerned about the effects of deregulation of the electricity market and the mergers and acquisitions of the power companies after the deregulation. Similar concerns over the effects of deregulation on nuclear power plant safety have been raised by NRC in the USA (see e.g. Bier et al., 2001).

¹ YVL refers to the Finnish regulatory guide on nuclear safety issued by STUK (see http://www.stuk.fi/julkaisut_maaraykset/viranomaisohjeet/en_GB/yvl/)

Normal inspections that focus on human and organizational aspects are sometimes referred to as MTO² inspections in Sweden. SKI has explored various activities associated with the MTO concept such as event analysis, man-machine interfaces, HRA and safety culture. A lesson from these inspections is that the concept of MTO is interpreted rather differently among plant personnel. Since MTO is a broad concept, there have been suggestions that instead of talking about MTO in a general sense one should specify what kind of activities are focused on in the MTO inspections. In Sweden the requirement for organizational reviews focusing on potential risks associated with reorganizations are now documented in the Swedish regulatory requirements (SKIFS 2004:1)³.

In Finland the approach has been that normal inspections also should identify any human factors (HF) issues. However, in contrast to Sweden, which has employed HF specialists at the regulatory body, STUK has not until recently. The development of framework for evaluating human and organizational factors e.g. fatigue, resourcing, safety effects of organizational changes and management of contractors is in progress. The guide YVL 1.4, which deals with quality assurance and safety management of nuclear power plants is presently in the process of being updated. The guide YVL 1.1 includes requirements for the use of expertise acquired in organizational studies in periodic safety reviews.

2.4 Other organizational assessments

2.4.1 IAEA SCART reviews

IAEA's Safety Culture Assessment Review Team (SCART) is a service that is in its initial development at IAEA (see IAEA, 2007). The missions are independent and conducted by a team of safety culture experts from several countries, excluding the host country. The SCART review process follows the recently published IAEA safety standards. The overall aim is to provide advice and assistance to Member States to enhance safety culture at the nuclear facilities.

SCART missions are not an audit; rather they are a joint search by SCART team members and designated nuclear facility personnel (counterparts) to identify strengths and opportunities for improvement of safety culture. SCART missions are centred on human performance – including the performance of the nuclear facility management and staff – rather than the adequacy of the design of a nuclear facility. Factors affecting nuclear facility management and the performance of personnel, such as organizational structure, management goals, and personnel qualification are reviewed.

SCART assessments are based on the five characteristics of safety culture identified by IAEA: safety is a clearly recognized value, leadership for safety is clear, safety is integrated into all activities, safety is learning driven, and accountability for safety is clear. In the assessment, a numerical value is assigned for each of the characteristics on the basis on the evaluation criteria.

2.4.2 Internal surveys

Safety climate surveys

The Swedish plants carry out an annual safety climate review. The instrument being used was originally developed by Carl Rollenhagen at Vattenfall Power Consultant. It consists of a questionnaire that is distributed to all personnel over the intranet. The respondents are asked to

² MTO comes from the words människa, teknik, organization (“man, technology, organization”)

³ SKIFS refers to the Swedish regulatory code on nuclear safety issued by SKI

answer questions on scales and on free text in response to questions such as “what threats for safety can you see”. The safety climate review is described in more detail in the next Section of this report.

Working climate surveys

All the power companies in both Sweden and Finland conduct yearly working climate surveys. They are usually focused more on the employee wellbeing and general working climate than safety culture. Occupational safety issues and issues concerning work place ergonomics are also often included in the surveys. The results are usually compared to previous year’s results or to some industry average.

2.4.3 Event investigations

The event investigation reports usually contain several aspects with direct bearing on organizational and human factors. In fact, the process and tools of event investigation have been very important in order to introduce a broader perspective on safety, a perspective that includes human and organizational factors. The tool most often used in Sweden is referred to as “MTO-event investigation / analysis” and was originally brought to Sweden by KSU in the end of the 1980’s and it is based on the HPES-method. However, considerably changes have been made in the MTO event analysis tool as a consequence of experiences gathered. The current tool is more systemic than the previous and directs attention to safety management issues at a higher level. One experience of using the tool is that proper training in human factors and organizational issues related to safety should be given to people using the tool.

In Finland formal event investigation tools are not utilised to a similar extent and human and organizational issues are not as much in focus. An exception to this has been the investigation into the problems of quality and contractor management at the Olkiluoto 3 construction site, where a large focus of the investigation was on organizational issues and safety culture (STUK, 2006).

As a result of the events taken place in Forsmark 1 in 2006, various organizational assessments including safety culture assessments have been made. For example, a specific internal safety culture report has been made concentrating on previous events and previous assessments. Further evaluations will be made in 2008. Also an organizational review of the maintenance organization is in progress as well as an OSART mission.

2.4.4 Safety evaluations of safety significant organizational changes

SKI requires that power companies conduct a safety evaluation of any organizational change that has safety significance. The methods used for analysis of organizational changes vary among the Swedish plants. The interpretation of the regulatory requirements and the expectations of SKI on the content of the safety evaluation are rather open at the time and the plants have collected experience using different methods in order to fulfil the requirements. SKI has recently been carrying out a follow up on how organizational changes have been treated at the plants. This will be described in more detail in the next Section.

2.4.5 Research projects

VTT has conducted organizational assessments of maintenance units at both Finnish NPPs (Reiman & Oedewald, 2006; Reiman et al., 2005a) and in the Power Plant Engineering at TVO. Contextual Assessment of Organizational culture methodology (Reiman and Oedewald, 2007a; Reiman, 2007) has been applied in the assessment projects. The aim of the assessments has been to evaluate the main features of the case organization’s working culture against the demands of its “core task”; i.e. the tasks that comprise the essence of the mission the

organization is supposed to carry out. These are described in more detail in the Section 3.10 of this report.

SKI has also published recently several research reports in Swedish or English which have bearings on organizational issues (they can be freely downloaded from www.ski.se):

- 2007:27 Kompetensöverföring på svenska kärnkraftverk i samband med pensionsavgångar.
- 2007:16 Hantering av händelser, nära misstag
- 2006:22 Verksamhetsstyrning med processbaserade ledningssystem och säkerhetsfokus
- 2006:21 Processtyrning – kritiska säkerhetsfrågor med inriktning på riskhantering
- 2006:03 Framtagning av bedömningsfaktorer/modell för utvärdering av driftklarhetsverifiering (DKV) inför uppstart efter revisionsavställning
- 2005:63 Safety-Related Contractor Activities at Nuclear Power Plants - New Challenges for Regulatory Oversight
- 2005:53 Ekonomistyrning och säkerhet
- 2005:49 Blandarhändelsen - Ur ett moralteoretiskt perspektiv
- 2005:04 Assuring Competency in Nuclear Power Plants: Regulatory Policy and Practice

Research on organizational issues is currently taking place at Mälardalens Högskola focusing on safety evaluations of organizational change. This dissertation project contains several case studies on organizational changes together with theoretical discussion of these issues. The aim is to increase awareness of organizational issues and clarify concepts and methods that are used for organizational assessment. Research in this area has been ongoing in Sweden for some years, see for example Rollenhagen and Kahlbom (2001), described in more detail in the next Section.

Two EU sponsored projects have been conducted with a focus on organizational issues: ORFA and LearnSafe. Both projects identified a whole set of organizational issues including models and methods. LearnSafe project will be presented in more detail in Section 3.9 of this report.

A joint book on safety management in Nordic countries has been published as part of the NKS program (Svenson et al., 2006). In the book, the authors present empirical and theoretical papers on safety management dealing with e.g. nuclear, offshore, and aviation domains.

On an international level, OECD/NEA has recently published reports dealing with organizational issues (OECD, 1999, 2004), as has IAEA (2006).

3 Examples of selected strategies and collected experience

The following three sections report on selected strategies and collected experience from organizational assessment activities. The examples have been selected to convey additional insights into organizational reviews to be able to pinpoint the challenges.

3.1 The ASAR projects in Sweden

The structure and content of the ASAR reports has changed over the years – initially the demands for safety assessment were primarily interpreted basically as an assessment of technical issues in deterministic and probabilistic terms. Organizational issues were mostly handled as descriptions of organizational processes and structures – very little analysis and evaluation was included in these earlier reports. Successively, the content of the ASAR projects have been changed and most profoundly so for the organizational part of the assessments. The strategies employed for performing ASAR reports, and especially the organizational assessment part, have varied considerably according to interviews with the nuclear regulator SKI. Little

guideline supporting the organizational assessments has been provided by the regulator which, at least partly, offers an explanation for the great variety of strategies employed in the organizational assessments. Lately new directives from SKI have been issued to support the organizational assessments, but at the time of the writing of this document little empirical experience from their use exists.

One example of organizational assessments can be found in the ASAR project conducted for Forsmark 3 in the years 1995-96. This particular study was selected in this connection, because it represents one of the most comprehensive reviews done in the ASAR tradition of the Swedish NPP's. More recent ASAR/PSRs can be found for Ringhals 1 and Forsmark 3.

The Forsmark 3 organizational assessment in 1995-1996

The underlying philosophy supporting the F3 ASAR project in 1995-1996 was to assess the plant from "different perspectives" and to integrate the findings. These various perspectives (implemented as subprojects) all contain information about organizational state of affairs even if they at first sight might be perceived as foremost technical issues. The ASAR project (as a whole) was divided into the following subprojects:

1. Technical safety assessment – an update of safety analysis reports (PSA, deterministic analysis etc).
2. Comparison with modern technical standards and norms – the construction of the plant was assessed with modern norms as a benchmark.
3. Meta analysis of events – a set of important events was selected and the organizations response to these events was evaluated.
4. Safety issues observed in the environment – safety issues that have been raised in US and Europe during the last 10 years were summarized and the F3 response on these issues was evaluated.
5. Ageing issues –issues related to the plant's aging were raised and evaluated.
6. Analysis of organization and activities – this subproject was divided into one part conducted internally in terms of self-assessments and another part conducted as an external organizational assessment.

As can be seen from the list above, information relevant for answering questions about organizational structures, processes and performance could be derived from several of the subprojects. Project number 6 was the co-ordinating force that brought organizational aspects of all subprojects together in order to obtain overall conclusions and recommendations.

The successive (and recursive) integration of information relevant for the organizational part of the ASAR report can in brief be described as in Figure 1 below.

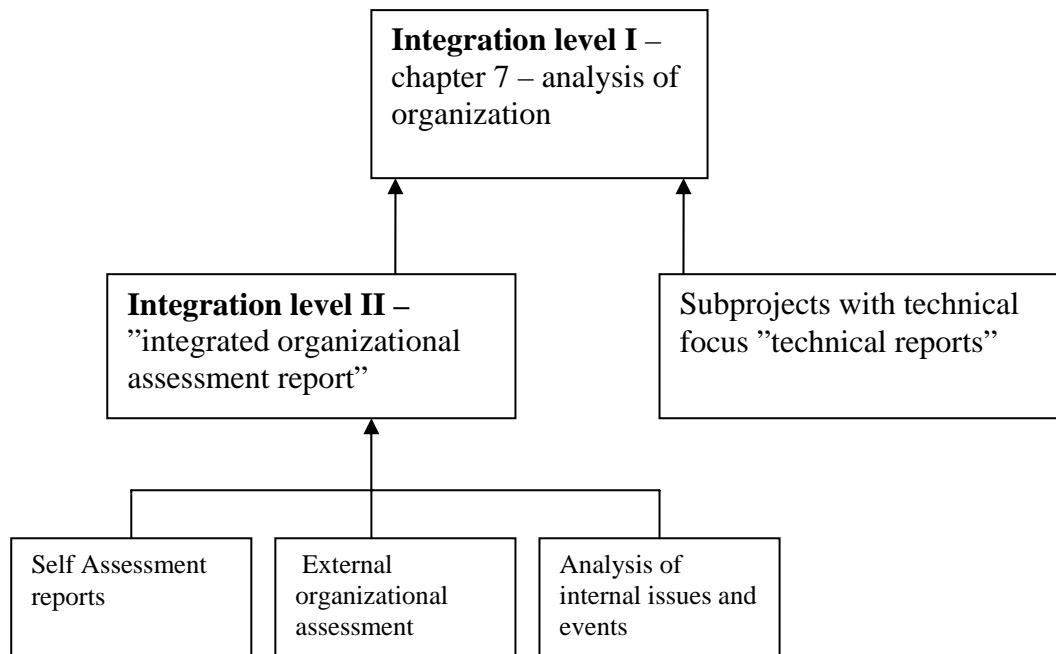


Figure 1. Integration of information relevant for the organizational part of the ASAR report

Self-assessment reports

As can be seen from the figure above one of the several information sources for the organizational part were self-assessment reports. These reports were focused on selected units such as operation, maintenance, technical support, etc. The main strategy for the self-assessments was as follows:

- Information meetings were held to inform the units about the ASAR project in general and the self-assessment in particular.
- A guideline was given to the units which contained a general script to follow in the assessments, for example, a check list of issues that should be elaborated on (such as a brief history of the unit, its organization, resources in terms of manning and time, technical documentation and procedures, training, meeting practices, information exchanges, etc.). In particular, it was stressed that the self-assessment should be an evaluation exercise and not just a description.
- During the progress of the self-assessments, continuous communication among the ASAR project representative and the units took place in order to support the process and clarify ambiguous issues.
- Seminars were held at the end of the self-assessment process as feed-back of results and to collect suggestions about recommendations.

External organizational assessment

An external organizational assessment was also conducted. The assessment was carried out as follows:

- A selected review of research focused on the interface organization/safety and the concept of safety culture. The review became the base for an assessment model used in the analysis.
- Interviews and studies of documentation
- Measurement of safety climate (a questionnaire was produced).
- Information sources provided in other subprojects of ASAR were utilized

The external assessment took a wider scope than the other subprojects. Also units outside Forsmark which had close connection to Forsmark, were discussed and evaluated. For example, organizational units dealing with safety within Vattenfall's central safety support units were included in the analysis.

The approach used in the above mentioned ASAR project had, for example, the benefit of engaging many parts of the organisation since different functions were asked to conduct self-assessments. This process, in itself, provides the employees with the opportunity to reflect on the organisational context of their work. The ASAR project also had strength in that the same work processes were studied from different angles and with different methods (self-assessments, questionnaires, independent review, studies of events etc), which made triangulation of the findings possible. On the other hand the methods used were time consuming. A lesson learned from this project is that organisational assessments of the type used have to be planned well in advance since the assessment will involve many people from the organisation.

3.2 Creation of a description of safety culture and safety management in the periodic safety review of Loviisa NPP

The previous operating license of Loviisa NPP expired at the end of 2007. In connection to the licence renewal process a periodic safety review has been conducted as required by the regulatory guide YVL 1.1. According to the guide YVL 1.1, the renewal of the operating license always involves a periodic safety review of the facility.⁴

The guide YVL 1.1 requires that the licensee develops a description of the licensee's safety culture and safety management as a part of the periodic safety review. According to the guide YVL 1.1, the report on the safety culture shall include a description of the used assessment methods, conclusions from the current status and effects within the operating license period, and the measures aimed to upgrade the safety culture. In assessing and upgrading the safety culture, it is required that expertise both in organizational studies and in practical nuclear safety shall be used⁵. The guide YVL 1.1 also requires that the licensee adheres to the recommendations of the IAEA (2003b) guide on periodic safety reviews to a sufficient degree.

The description of the licensee's safety culture and safety management included for example the following issues⁶:

Description of the management system including description of the organizational structure and the organizational changes, strategy, process development, description of the administrative procedures concerning management, and a description of the co-operation between the Loviisa NPP and FNS (Fortum Nuclear Services).

Description of safety culture including background information on the preparation of the document and a characterisation of the safety culture according to the five characteristics of safety culture (by IAEA): how safety is a clearly recognized value in the company, how safety management is visible in the activities of the company, how the accountabilities for safety are perceived, known and defined, and how safety is integrated into different activities.

⁴ But if the operating license is applied (and granted) for more than ten years (as is the case with Loviisa NPP in its renewal application), YVL 1.1 requires that the licensee carry out a periodic safety review of the facility and request its approval from STUK within about ten years of receiving the operating license or of conducting the previous periodic safety review.

⁵ The Finnish and English wording of the YVL 1.1 can be given slightly different interpretations.

⁶ Based on interview with Teuvo Tinell in the autumn 2006.

Furthermore, the results of safety culture evaluations and development initiatives carried out during the operating period were presented.

The development initiatives connected to the organization and its functioning, such as supervisor and leadership training programs, supervisor-subordinate development discussions, work climate surveys, occupational safety development, and maintenance development programs, were also presented.

Evaluation of the present state of safety culture

Evaluation of the present state (2005-2006) of safety culture was made as a licensee self-assessment. The three person group responsible for conducting the assessment consisted of the retired manager of the Loviisa NPP technical group and the assistant manager of the plant, the retired office manager of the nuclear safety group of Fortum Nuclear Services, and an independent safety auditor at the licensee organization. Assessment was carried out by utilizing the knowledge of the group about the organizational practices and by utilizing appropriate documentation. The views of the personnel were gathered with interviews and discussion at the power plant and FNS. Altogether 34 persons were interviewed from various organizational groups and levels. The IAEA ASCOT-guidelines (1996) were utilised in the interviews. Also additional questions concerning the relation between Loviisa power plant and FNS were asked. The interviewees utilised their experience of the plant by offering concrete examples.

The YVL 1.1 guide (issued 10.2.2006 and in force as of 1 August 2006) was issued during the preparation of the license renewal application. The guide was applied for the first time in the license renewal process and there exist different views on the application of the guide. For example, the requirement of "description" implies that it is sufficient to describe the measures taken and the procedures in place, and not make a deeper assessment of them. Furthermore, the guide YVL 1.1 requires that expertise in organizational studies shall be used in the process. However, what is meant by "expertise in organizational studies" is not clarified in the guide. The evaluation group interpreted this in a manner that they had the necessary competence in organizational issues to carry out the description, whereas STUK's standpoint was that formal behavioural scientific expertise would be needed.

3.3 Experiences from some organizational change projects at the Swedish industry

Before an organizational change that could have a safety impact can be implemented, safety evaluation of the proposed change must be made. If this evaluation does not find any hinder to the proposed change a subsequent independent safety review is performed by the operator's safety department.

One approach that was used when conducting these safety evaluations was to use personnel with a lot of experience in organizational issues related to safety. In some cases these people were fairly independent of (i.e. not part of, nor affected by) the organizational change processes. In these cases they gathered information by conducting interviews with key-personnel and by reading relevant documents describing the change. From this input conclusions were drawn regarding the proposed change. In some other cases, the safety evaluation was done by personnel who were highly involved in the change process. No explicit transparent methodology was used in the above situations.

In some situations the above approach has been somewhat clarified with respect to the used method. The use of focus groups which discuss the impact of the proposed change on a number of relevant domains is one example of a more transparent method. This strategy, which is further described below, has been used in the change projects regarding the SKB takeover of CLAB.

Overall description of a safety evaluation using focus groups

Initially an analysis group is selected consisting of two persons impartial to the change process. After the formation of the analysis group, the group collects information to develop a description of the proposed organizational change. This is done in order to provide a context for the subsequent analysis. This context description should include both an overall description of the organizational structure and a more detailed description of how the change will affect different groups with regard to, for example, the work content.

On an overall level there are three questions that should be addressed in the analysis:

1. Will the organizational change, given that it is implemented as intended and that the co-workers have a positive attitude to the change, lead to an acceptable safety level?
2. Is there a clear and well communicated strategy for how the change process will be conducted including all the relevant conditions for success?
3. Is there a plan for the implementation of the organizational change and methods that are able to cope with threats that may jeopardize the success of the organizational change during and after the implementation?

In order to ensure that the analysis will have sufficient scope (breadth and depth) the analysis group use domains/guide questions. These domains/guide questions are complemented by the analysis group and also by the focus group. The domains/guide questions should then be consulted during the subsequent information collection, specifically regarding the first question above. The domains/guide questions are influenced by the guide questions described in Rollenhagen and Kahlbom (2001), see Section 3.8 of this report.

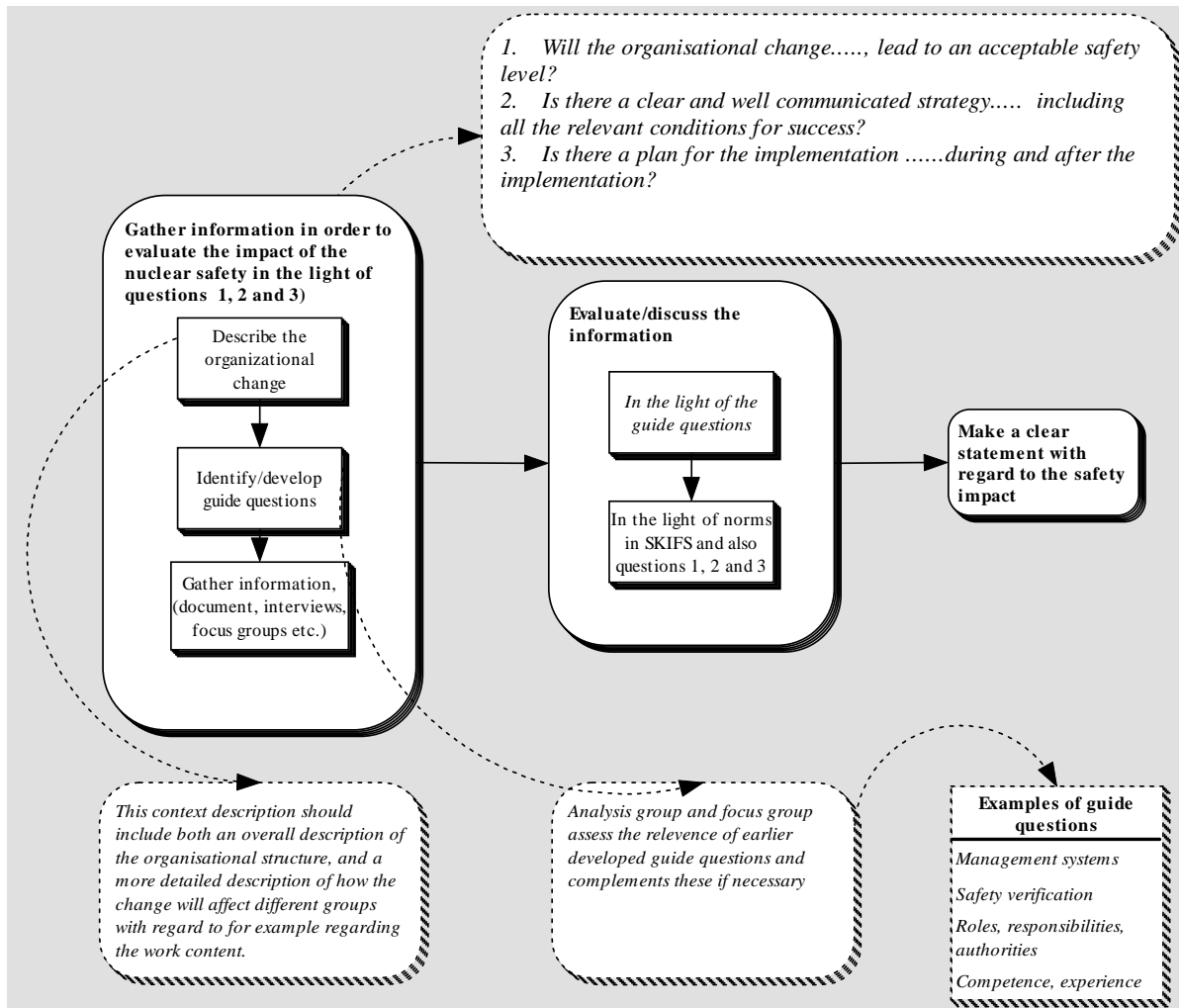


Figure 2: Overall description of the method used when performing the safety evaluation of the SKB takeover of CLAB

The subsequent evaluative judgment of the change process (the question two above) is mostly based on information about the personnel’s attitude toward the change and the plans developed for the change. Evaluation of the implementation phase is based on information derived from the third question above.

The evaluation of the questions above is performed by means of focus groups, individual interviews and studies of documents.

The collected information is evaluated against norms found in SKIFS (2004:1). Based on the results for the evaluation a clear statement regarding the organizational change proposal should be issued. A necessary requirement for such an evaluation is that the change is described in sufficient detail, describing such things as for example roles and responsibilities in the proposed new organization.

All the approaches described in this Section are fairly subjective. However, the use of the method described last does provide a quite transparent document with regard to how the analysis group has come to the conclusion related to the safety impact of the proposed organizational change. One benefit of the method is that it provides both a wide scope and also depth for selected areas. The method provides a transparent process, which may be important for an external observer – one can follow how the process is conducted, and why some areas are seen as more and some as less important regarding safety implications. The process of

providing “system groups” is of value by providing different perspectives on various areas. A drawback of the method is that it is experienced by some as complicated and time consuming since it provides a rather detailed evaluation.

3.4 SKI's evaluations of the nuclear utilities' routines/procedures for organizational change

SKI performed three inspections in the period October 2005 to October 2006 which addressed the nuclear utilities' systems for assessing organizational changes particularly as seen from a safety perspective. The purpose of these inspections was to make sure that:

- The utilities had necessary support from the management systems with regard to routines/procedures in order to plan, carry through, and follow up organizational changes in a systematic and documented way, also including safety reviews.
- Experiences from the organizational changes were dealt with and that conclusions were drawn with regards to further development of the routines/procedures.

The reviews started with SKI informing the plants about the reviews and their purpose. SKI also requested necessary documentation. The documentation was reviewed with a focus on how the plants managed organizational changes including how safety assessment was performed. Visits were performed at the plants and interviews conducted. The collected material formed the base for a regulatory evaluation of to what extent the NPPs fulfilled the regulatory requirements according to SKIFS. By large the regulatory body concluded that the utilities had made use of their former experiences with organizational changes and that progress had been made regarding strategies and supporting documentation for managing organizational changes. The regulators did not in any case report deviations from the regulations. However, SKI identified several areas for improvement although these were judged as being of minor safety significance only. Among the areas mentioned as candidates for further progress was a need for clarification of the following:

- A need to clarify that in the auditing process of management, organizational assessment should be included as a topic.
- A clearer statement in the instructions for assessment of organizational changes regarding how experience feedback should be collected and used also during the organizational change.
- In the instructions for assessment of organizational changes there should be more attention to how suggestions from risk evaluations should be implemented in the line organization.
- There should be more emphasis in the instructions about how assessments were handled after the changes.
- SKI also suggested that both strengths and weaknesses should be included in the descriptions about the current organization (before the changes were initiated).
- The regulator also recommended a stronger focus on experiences collected from organizational changes that were pursued outside the organization.

The above remarks were in some cases only observed in relation to the content of the instructions and not always in the real change processes. Thus, there were some deviations in the formal procedures, but the corresponding activities were sometimes in practice conducted anyway.

3.5 Annual safety climate reviews in Sweden

The Swedish plants carry out an annual safety climate review. The instrument being used was originally developed by Carl Rollenhagen at Vattenfall Power Consultant. It consists of a questionnaire that is distributed to all personnel over the intranet. The respondents are asked to

answer questions on scales and on free text in response to questions such as “what threats for safety can you see”. The responses are anonymous.

In 2006 the questionnaire was updated in a specific project with collaborators from all nuclear sites in Sweden and with support from the psychological department at Stockholm University. New questions were added as a result of a review of safety climate inventories and nuclear safety items were discriminated from occupational safety items. Data from Oskarshamn, Ringhals and Forsmark NPPs has been collected with the updated questionnaire and factor analysed.

The analysis of data suggests a factor structure⁷ that is surprisingly robust for all of the individual plants and which consists of the following dimensions;

Factor 1: Safety management

This factor is assumed to give the core of the safety climate. The underlying questions include; management commitment, problem identification, problem solving, rule following, conflict management, conservative decision making, open discussion about safety.

Factor 2: Knowledge about safety issues

Factor 3: Resources (time and personnel)

Factor 4: Management competence/management of change

Factor 5: Conditions in the immediate working group

Factor 6: Occupational safety

The above factors are clearly shown in the material from all of the plants. The factors appear in a slightly different order except from the first factor that explains the majority of the variance at each individual plant (about 35-40%). An interesting finding in the material is that there were only minor differences among the individual plants but significant variation between different professional groups regardless of the plant. This finding indicates that in the future one should put more focus on describing how different professional subcultures perceive safety climate.

The plants have various procedures for handling the results of the questionnaire. For example, some plants use it as part of their general indicator system. Recently there has been an attempt to review how data is handled and also to make use of other questionnaire data in the interpretation of results. Also, the free text section of the questionnaire has been reviewed regarding the presentation format.

The questionnaire has been analysed by means of factor analysis and produced a robust structure. Safety assessment of safety climate by means of questionnaires is a good way to follow trends in various states of affairs of assumed relevance for safety; such as how personnel experience the quality of instructions, responsibilities, time and personal resources, management attention to safety etc. Questionnaires are relatively easy to administer by means of intranet and feedback to the employees can be rather fast.

Measurement of safety related attitudes and perceptions are, however, difficult to evaluate regarding validity since external criteria for reactor safety aspects may be difficult to obtain. Various response biases - such as socially desirable responding - are also present in questionnaires and it is therefore important to use questionnaires in combination with other types of assessments.

⁷ Factor analysis is a statistical method for reducing the data set to underlying dimensions (factors) in which the individual items share a strong correlation with each other

3.6 Development of an inspection programme for organizational issues at STUK

STUK has been developing its program of inspections concerning the functioning of organizations. Previously, STUK has had biannual inspections concerning safety culture and safety management. However, a need for more integrated consideration of organizational issues has been identified at STUK. There has subsequently been a consideration of integrating organizational issues into all regulatory activities carried out by STUK. This should be accompanied by increased resources in experts in organizational issues. The proposed framework is described in Figure 3.

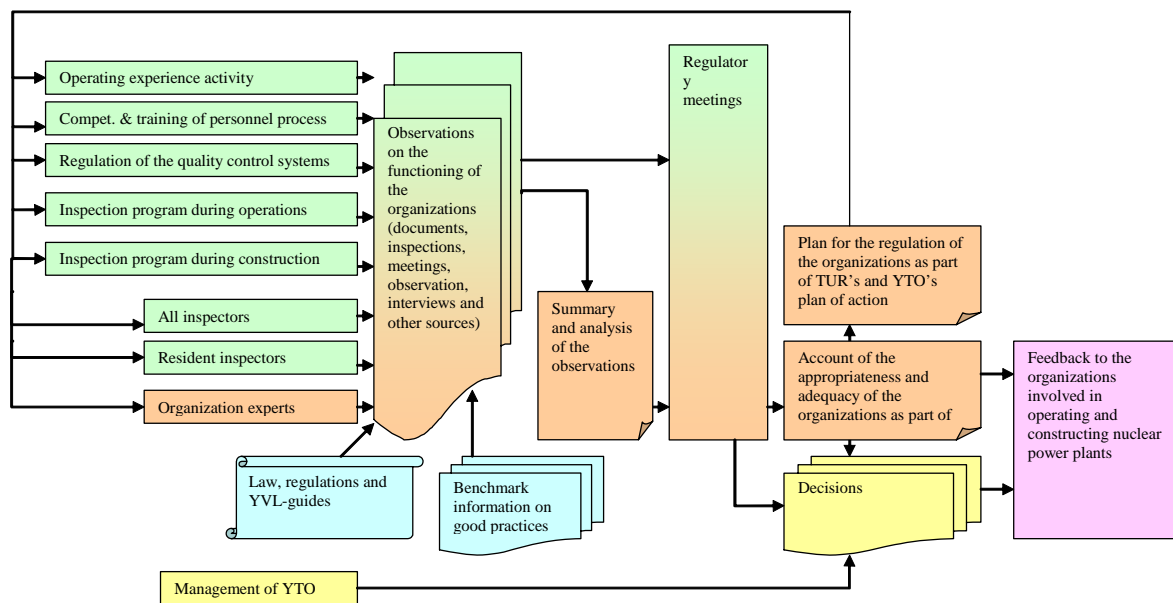


Figure 3. The planned process of regulating organizations at STUK's Office of Nuclear Reactor Regulation, YTO (by Nina Koivula, personal correspondence)

According to the framework, all inspectors gather observations of the functioning of the organizations, not only the experts in organizational issues. The summary and analysis of the observations is carried out by the organization experts, and they make and upkeep the plan for the regulation of the organizations.

3.7 Event investigation of the quality problems at the Olkiluoto 3 construction site

In 2006 STUK stated that the performance and the interaction of the organisations involved in the construction project of the Olkiluoto 3 (OL3) NPP did not in all respects meet the expectations that STUK has on good safety culture. In order to identify the needs for improvement, STUK appointed an investigation team and asked the team to present an assessment of the performance of the organisations. In addition, STUK asked the investigation team to present recommendations for improving the performance of the licensee TVO, and the vendor consortium CFS, formed by Framatome ANP (FANP, currently Areva NP) and Siemens AG. The investigation team also analysed the needs for development in STUK's own operations and issued recommendations for this purpose.

The investigation team assessed the performance of TVO, the plant vendor and STUK in the light of three case studies selected as examples. The example cases were: concreting of the base slab, manufacturing of the steel liner for the reactor containment, and the design process for the polar crane and the material hatch in the containment. These examples were selected

because there had been some recurrent quality issues related to these components. Thus, the task of the investigation team was to carry out three event investigations and to find out whether there are generic organizational issues underlying the quality non-conformances.

The investigation set up by STUK was looking into the management of safety requirements in subcontracting during the nuclear power plant construction phase. The tasks of the investigation team were:

- to determine and assess any negligence in complying with requirements in selecting and supervising suppliers of safety significant structures, equipment and components
- to determine and assess any quality management deficiencies in the performance of TVO or the plant vendor in selecting and controlling suppliers
- to determine and assess TVO's and the vendor's management views and the attitudes on requirements for the selection and control of suppliers, non-conformances, inspections and implementation of corrective actions
- to establish TVO's and the vendor's procedures for tender invitations, selection of approved suppliers, training of the subcontractors' personnel, supervision of subcontractors as well as the various parties' quality management, and practices for approval of test results
- to establish the passage of information in the selected sample cases
- to improve STUK's regulatory oversight.

An investigation team with six persons was established. The investigation manager from STUK acted as the leader of the investigation team. The team consisted of experts in quality management and human factors (from STUK), safety culture, concrete structures and quality management (independent consultants outside STUK). Various inspectors from STUK served as technical experts in the investigations.

Main sources of information were different types of documentation and interviews of persons involved in the cases from each organization. The investigation team reviewed the non-conformance reports prepared by the licensee, inspection reports by STUK in the area, memoranda and minutes of meetings as well as other associated documents and records. The details of the events were looked into on the basis of interviews and by correspondence, contracts, work orders, test reports, procedures, etc. Comprehensive background material consisted of the following documents:

- description of the consortium's organization as well as descriptions of responsibilities
- the consortium's procedures related to approval and control of suppliers
- TVO's project quality manual, particularly procedures and descriptions related to approval and control of suppliers
- TVO's project plan (including a description of the project organization and tasks)
- STUK's FIN5 project plan
- Inspection reports on quality management and quality assurance
- STUK's Construction Inspection Programme (RTO), decisions and minutes of meetings
- key technical (general) documentation and inspection memoranda for the sample cases.

Even though the analysis of the events did not follow any specific event investigation technique, the basic steps can be identified; First, the team described how the purchasing phase, the quality control and the work itself should have been handled if carried out according to the requirements set by the Finnish authority and the licensee. Then they described the actual chain of events starting from the selection of the subcontractor and ending up describing the processing of the non-conformances. Next, they identified and listed the deviations from the intended work process and concluded how these deviations might have contributed to the problems observed later on. The investigation team also analysed the interviewees' conceptions of the requirements concerning the quality management and safety culture.

Finally the investigation team evaluated their findings regarding the three cases against generic criteria of well functioning quality management (ISO 9001 standard) and high level safety culture (IAEA, 1991, 2002; Weick & Sutcliffe, 2001). They identified a set of evidence pointing out that the activities of the licensee – vendor – subcontractor –chains did not embody the characteristics of good quality and safety culture. They then formulated a set of recommendations to improve the quality of the work and to promote the development of safety culture for the licensee, the vendor and the regulator.

The investigation can be viewed as an assessment of a total of eight distinct but interrelated organizations. The licensee has the responsibility of ensuring that a high level quality and safety culture is achieved in the construction phase but the vendor holds the responsibility of managing the network involved with the construction. In this investigation each of the organizations of the chain were evaluated but the recommendations were directed to the licensee, the vendor and STUK. It is a challenging task to be carried out in a couple of weeks or months which is the typical time frame for a relatively large investigation. However, extending the investigation to all the parties in the chain provided a balanced picture of the complexity of the activities. Since the object of the assessment is so complex the assessment task needs to be narrowed down. In this case the assessment was focused on how the organizations handled the transmission of the safety requirements and the creation of shared safety culture. Still, identifying and collecting sufficient information to inspect the issue requires a solid background theory and systematic data collection methods. In this case the investigation team did not explicitly utilise any event investigation method which would have provided them with a framework for analysing and describing the cases and the meaning of the findings. The investigation team possessed good knowledge on the relevant area but the credibility of the conclusions might have benefited if the analysis model had been predefined. Most of the background theories and criteria for assessments are briefly described in the report, though (STUK, 2006).

3.8 Development of a method for organizational safety analysis (OSA)

Rollenhagen and Kahlbom (2001) have developed a method for organizational assessment based on the identification of a set of key safety activities “experience feedback, risk analysis, verification and validation, quality system related activities, human resource management, and management”. The method also suggests a set of evaluation dimensions, e.g. resources with respect to time, tools, finance and personnel, integrity, communication, effectiveness, training and experience. The method uses a recursive approach in the sense that for each key safety activity the other key activities are assumed as supporting. For example, for the activity of risk analysis, evaluations are made regarding experience feedback, verification and validation, auditing, human resource management, and management. Several pilot tests of the method have been executed. The method has also been used to complement HRA analysis of the shutdown period.

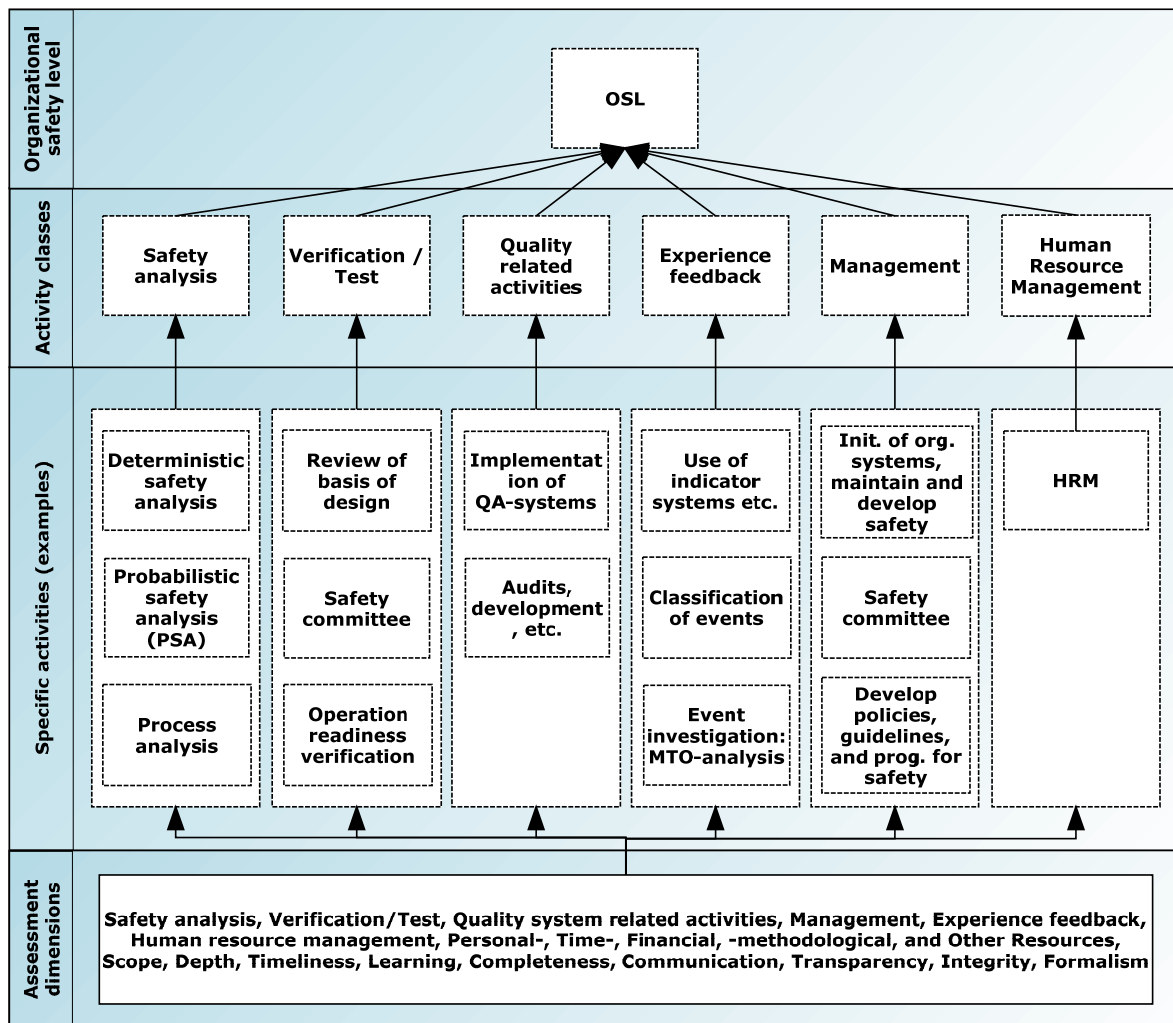


Figure 4. Structure of the OSA-method

In order to assess a key activity, it is first necessary to identify the specific activities which together constitute the key activity. In the figure some examples are given of the specific activities that are part of the key activity safety analysis. The specific activities in this case are deterministic safety analysis, probabilistic safety analysis and process analysis.

In order to assess each specific activity, the 22 assessment dimensions presented in the figure are evaluated. This has been done by setting up criteria for each dimension on a five degree scale, where 1 denotes insufficient support and 5 means excellent support to the specific activity from the relevant dimension.

The result from the evaluation of the 22 assessment dimensions are presented both quantitatively and qualitatively, and are aggregated in order to present a comprehensive description of the specific activity with regard to both strengths and weaknesses.

A comprehensive description of the key activity is obtained by aggregating the results of the relevant specific activities. The overall safety level, finally, is obtained by aggregating the results of the key activities.

The OSA method is an innovative approach to assessment of organisational safety. It is built around the idea that some activities are basic for developing safety in nuclear power plants and

that these activities should have a high quality. Since groups are engaged in the development of assessment criteria relevant for their particular process, the method provides a strong learning opportunity. Another benefit is that the results of the analysis provide an overview of strengths and weaknesses which can be used for assessment of the current situations as well as giving ideas about further developments.

The method is initially time consuming but when the criteria are developed the method is easy and relatively effective.

3.9 Experiences from LearnSafe project during 2001 - 2004

The main objective of the LearnSafe project (2001-2004) was to create methods and tools for supporting processes of organizational learning at the nuclear power plants (Wahlström et al., 2005). The focus of the project was on the senior managers of nuclear power plants. The project was divided into two phases. The first phase was focused on management of change and the second on organizational learning. LearnSafe was carried out in cooperation with several European research institutes and utilities from Finland, Sweden, Spain, Germany, and the United Kingdom.

In the project a framework was constructed for analysing and structuring the empirical material. The framework of key organizational dimensions is presented in Figure 5.

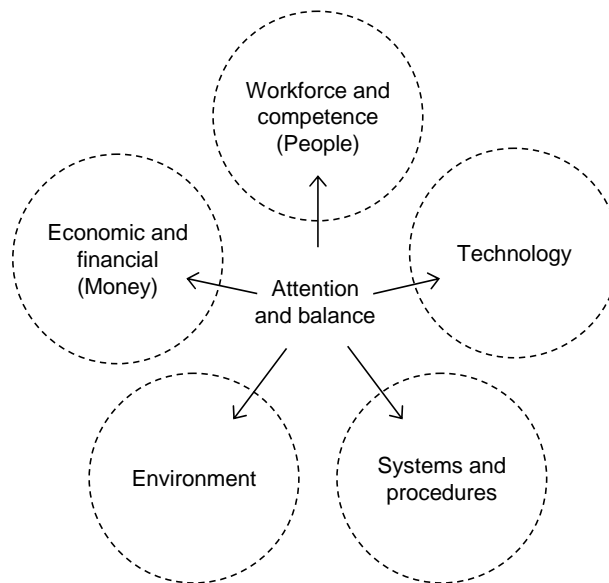


Figure 5. The five-dimensional model used for the classification of data. Note that attention and balance is not a dimension in the model: it has been incorporated in the picture to underline the importance of a proper allocation of time and other resources between the key issue domains (Kettunen et al., 2007).

Data on perceived safety management challenges was collected from more than 300 managers ranging from utility top managers, upper nuclear power plant managers to functional managers from several plant functions such as maintenance and operations (Wahlström et al., 2005). Data was collected in group work sessions (called Metaplan sessions) led by a facilitator.

According to the analysis of the data (Kettunen et al., 2007) the challenges were grouped into nine clusters: (1) Economic pressures, (2) Human resource (HR) management, (3) Nuclear know-how, (4) Rules and regulation, (5) Focus and priorities, (6) Ageing, modernisation and new technologies, (7) Public confidence and trust, (8) Climate and culture, and (9)

Miscellaneous (a number of challenges without a common denominator). These clusters provide an overview of today's challenges to NPP management in the context of safety in Finland, Germany, Spain, Sweden and the United Kingdom. In table 1 the nine clusters are characterised by examples of typical statements brought out by the NPP managers and WANO officers taking part in the study. Note that some statements may have been reformulated for editorial purposes.

Table 1. Identified challenge clusters with representative statements.

1. Economic pressures	2. HR management	3. Nuclear know-how	4. Rules and regulation	5. Focus and priorities
<ul style="list-style-type: none"> • A long-term willingness to invest by the owners • Competition modifies the relationship between operators • Corporate pressures and need to reduce cost • The economy may be a threat for safety • Cost development due to increasing safety requirements from authorities 	<ul style="list-style-type: none"> • Generation change at the NPP • Age distribution of personnel • Early retirements • Recruitment of new personnel • Maintaining competencies 	<ul style="list-style-type: none"> • External support from vendors and contractors • Decreasing number of vendors • Competency of contractors and suppliers • Generation changes among suppliers • Contractor relationships 	<ul style="list-style-type: none"> • Regulatory requirements (no safety benefit) • New methods and principles of regulation • Bureaucracy and paperwork • Lack of recognition of improving world standards • Excessive dependence on rules and procedures 	<ul style="list-style-type: none"> • Management systems • To avoid focusing only on short term issues • Correct priorities in development of plants • Out-of-date procedures • Volume of information / data
6. Ageing, etc.	7. Public conf. and trust	8. Climate and culture	9. Miscellaneous	
<ul style="list-style-type: none"> • Ageing of plant and components • Outdated technological constructions • Change of old technology • Introduction of new technology • Maintaining technical condition of the plant 	<ul style="list-style-type: none"> • Sabotage and terrorism • Securing the future in changing political frameworks • Irrationality in anti-nuclear attitudes • Distrust in local or regional authorities • “An accident anywhere is an accident here” 	<ul style="list-style-type: none"> • Motivation and attitudes • Safety culture • Need to fight complacency • Mental and emotional strain • Organizational and human factors in general 	<ul style="list-style-type: none"> • Balance between safety, plant, people and technology • Development in the nuclear field • Control of maintenance • Consequences of mergers and acquisitions • Decommissioning of plants 	

The largest clusters in terms of challenges included were HR management (22.3%), Climate and culture (17.4%) and Public confidence and trust (12.8%). These three clusters were interpreted as the NPP managers' most important problem areas in terms of the management of safety.

One finding of the analysis was that the challenges seemed to include plenty of statements about tensions between different elements of safety management. Thus, the data was further analysed from that perspective (Kettunen et al., 2007). In the analysis, 12 tensions were identified: (1) General industry and organization-related tensions, (2) Focus and priorities, (3.1)

Economy vs. safety, (3.2) Licensee vs. regulator views on safety and new technology, (3.3) Tradition vs. renewal, (3.4) Operational efficiency vs. personnel development, (3.5) Preparing for a phasing out while ensuring sufficient competences and motivation, (3.6) Short-term vs. long-term optimisation, (3.7) Formalism vs. reasoning, (3.8) Performance vs. risk-based safety assessment, (3.9) Employing specialists vs. generalists, (3.10) Shared vs. personal accountability, (3.11) Competition vs. co-operation between utilities, and (3.12) Old vs. new generation.

Table 2. Identified tensions and goal conflicts with examples of representative statements, from Kettunen (personal correspondence), see also Kettunen et al. (2007).

1. General industry and organization-related tensions	2. Focus and priorities	3.1 Economy vs. safety	3.2 Licensee vs. regulator views on safety and new technology	3.3 Tradition vs. renewal
<ul style="list-style-type: none"> • General industry tensions (3 references) • General organizational tensions (2 references) 	<ul style="list-style-type: none"> • Place the money correctly (that is to be optimised) • Concentration on the essential in the company, "zero" projects away • Volume of information / data • A balance must be struck between safety - plant - people - technology 	<ul style="list-style-type: none"> • Conflicts between economy and safety • Economy - competing with lower safety? • Increasing economic efficiency hand in hand with equal safety standards • Safety-related costs on a deregulated market 	<ul style="list-style-type: none"> • Cost development - increasing safety requirements from authorities • Diverging views on the core business between utilities and the regulator • New regulatory requirements (not sensible) • Technical modernisation of the plant and licensing problems 	<ul style="list-style-type: none"> • Lack of recognition of improving world standards • Issuing new policies instead of amending old ones • Application of new automation technology in safety applications • To modernise the plant in such a way that most safety benefits can be achieved
3.4 Operational efficiency vs. personnel development	3.5 Phasing out vs. personnel development	3.6 Short-term vs. long-term optimisation	3.7 Formalism vs. reasoning	3.8 Performance vs. risk-based safety assessment
<ul style="list-style-type: none"> • Entrepreneurial resources and competency (impoverished due to rationalisations) • Lean organizations - no interest - no time available - no oversight - not my problem • Reduction of personnel without loosing standards • Availability of contractors, scarcity as a consequence of short-term contracts and employment 	<ul style="list-style-type: none"> • Employees' age structure, 15-20 years of operation left, competency disappears • Phasing out nuclear power, maintain competency • Motivation of personnel is low because of the consensus talks • The nuclear field is saturated and on its way down (resources and know-how) 	<ul style="list-style-type: none"> • Chasing costs, short-sighted solutions • Cost development versus owner requirements, long-term outlook, availability, safety • Severe financial restrictions weaken possibilities for research & development • To avoid focusing on only short-term issues 	<ul style="list-style-type: none"> • Excessive dependence on rules and procedures • Excessive rules and procedures regulating human performance in NPPs • Formalism instead of function • Management expectation that safety is reinforced by 'working to procedures' (some significant areas not verified or up-to-date) 	<ul style="list-style-type: none"> • The paradox of success • Being alert also when performance is good • Complacency and low consciousness of possible risks • Fight the belief that good performance is an indicator for good safety

Table 2. Cont'd.

3.9 Employing specialists vs. generalists	3.10 Shared vs. personal accountability	3.11 Competition vs. co-operation between utilities	3.12 Old vs. new generation	3.13 Miscellaneous
<ul style="list-style-type: none"> Excessive number of specialists and reduced number of generalists To have a broad competence base that can balance specialisation 	<ul style="list-style-type: none"> Clear responsibility (organization - individual) Taking responsibility away for your 'own' safety 	<ul style="list-style-type: none"> Competition modifies the relationship between operators Decreased exchange of information due to deregulation 	<ul style="list-style-type: none"> Generation change - company climate Generation change (transfer of knowledge, existing culture vs. requirements and expectations of young people) 	<ul style="list-style-type: none"> Initiative / project overload Balance between (new) business trends and safety management

It should be noted that Table 2 is a researcher's view on the tensions that are either explicit or implicit in the managers' statements. This means that some of the managers probably were not aware of the tension inherent in the safety management challenge, whereas some raised issues where the tension was very explicit (e.g. "Conflicts between economy and safety").

The results suggested that human resource management, organizational climate and culture, and public confidence and trust are the three most challenging areas of management in the context of safety for nuclear managers across Europe. There were significant differences between the participating countries and organizations in the perceived challenges and tensions.

Although the participating NPP managers were requested to pay special attention to safety-related challenges, the picture that emerged from the analysis was rich, covering different aspects of industrial management. In general, the findings suggest that managers require more complex frameworks for structuring their realities and safety management than the five-dimensional classification model (see Figure 5).

Kettunen et al. (2007) note that organizational challenges and tensions can never be totally eliminated but they can and should be openly acknowledged and managed. Their major recommendations for the nuclear power industry are summarised as follows:

- It is of utmost importance to invest in the development of necessary competences, good work motivation and safety culture.
- The challenge of maintaining focus and setting priorities needs to be acted upon. If there are no effective processes in place for managing conflicts between scarce resources and ambitious goals, the situation may result in a paralysis.
- Possible tensions between economy and safety need to be acknowledged. A constructive dialogue is needed to determine and justify what is safe enough and by what means that safety target is to be reached.
- Safety cannot be managed independently of other goals and operations of the organization. Safety management shall integrate all elements, functions and processes of an organization that may impact upon its safety either directly or indirectly.

The data gathering methods that were used in LearnSafe were mostly experienced as interesting and valuable for people participating in the groups. Many people spontaneously expressed that they found it very interesting to reflect on safety related issues in the way that was done in the LearnSafe Project. Also the generic model that was produced as a consequence of the LearnSafe project was found interesting and useful for the managers. LearnSafe was a research project directed towards managers and not an organisational assessment tool in a more conventional sense.

Several articles have been published describing the LearnSafe project in detail, see e.g. Wahlström et al. (2005), Kettunen et al. (2007). See also the homepage of LearnSafe (<http://virtual.vtt.fi/virtual/learnsafe/>) for more information.

3.10 Experiences from assessments of organizational culture

Assessments of organizational culture at the nuclear power plants have been conducted by VTT (e.g. Reiman & Oedewald, 2006; Reiman, 2007) and in some cases in collaboration with Carl Rollenhagen (e.g. Reiman et al., 2005a). The overall aim of assessing culture is to give the organization information on its vulnerabilities and on its abilities to perceive and take care of them.

Three case studies have been carried out at the maintenance units of three Nordic NPPs during 2001-2003. The case organizations were Loviisa NPP, Olkiluoto NPP (TVO) and Forsmark NPP (FKA). Furthermore, a case study at the Nuclear Power Plant Engineering at TVO was carried out in 2005. The specific aim of the case studies was to assess the given organizational culture. In each case multiple methods were used (interviews, survey, seminars, group work) and results were presented to the personnel in several occasions.

The concept of organizational core task (Reiman & Oedewald, 2002, 2007a) was utilized in the assessments to denote the objective of the activity of the organization and the requirements and constraints that it has to fulfil. A basic premise of the assessment was that organizational effectiveness and safety are achieved when the cultural way of responding to the core task demands is based on an accurate image of the organizational core task (OCT) and enables the fulfilment of the OCT demands. The analysis methodology is illustrated in Figure 6.

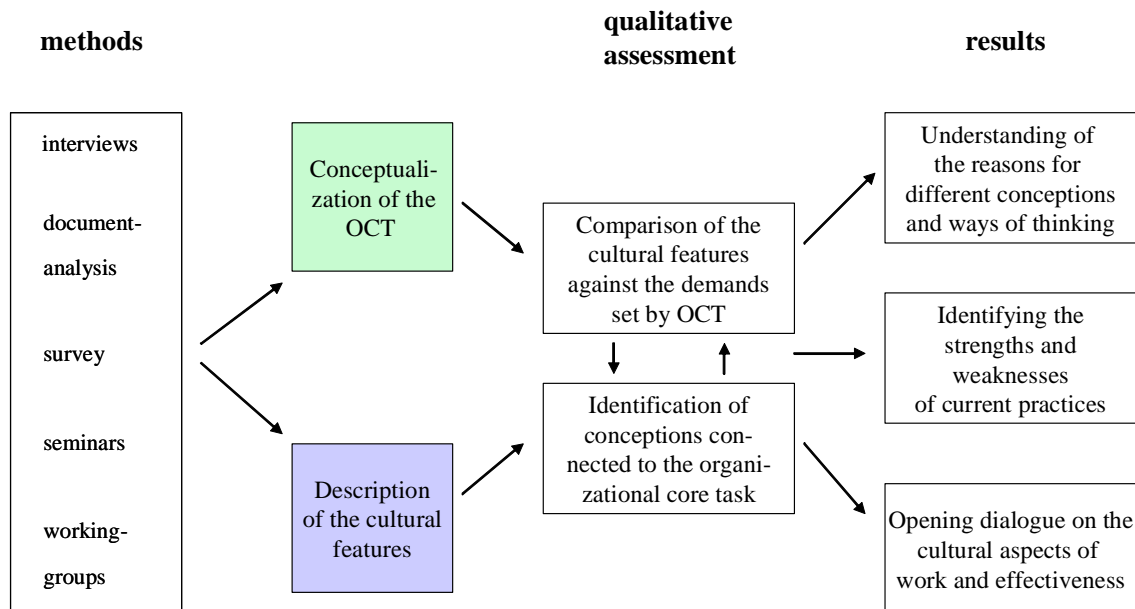


Figure 6. The analysis model of Contextual Assessment of Organizational Culture methodology, from Reiman (2007)

The basic premises of CAOC methodology are (Reiman, 2007; Reiman & Oedewald, 2007a):

- Organizations are treated as organizational cultures. This means that organizations are systems with structural, social, and psychological elements.

- Every organization has a core task, meaning its objective and the constraints and requirements that the physical object of work (e.g. a power plant) and environment (competitors, regulation etc) set for the objective.
- The organizational core task and its demands for the organization can be modelled together with an outside facilitator familiar with cultural theories and task analysis methods
- One the central elements of organizational culture are the conceptions concerning the organizational core task and safety. These conceptions can also be embedded in work practices and tools that guide the way work is conducted.
- By analysing organizational culture and comparing its features against the demands of the organizational core task one can evaluate the safety of the organization.

For more information on the process and results from the assessments of the maintenance organizations, see Reiman et al. (2005), Reiman and Oedewald (2006) and Reiman (2007).

The main weakness of the approach is the time and resources needed for making the assessment. Due to the in-depth nature of the methodology, iterative approach with interviews, survey and personnel seminars is needed. An analysis of the case data also requires organizational behavioural expertise combined with an understanding of the requirements of the particular work. On the positive side, CAOC assessment is always a development intervention to the organization and facilitates the organization's safety management by giving the management as well as the workers information on their culture and concepts with which to deal with cultural issues.

4 Identified issues of organizational reviews and assessments

During this study we have identified a set of key issues that are associated with organizational reviews and assessments. These issues have to be considered in any assessment. Many of the issues are overlapping and without clear right or wrong solutions. In the following we will first discuss the issues of data and criteria. Then we move to the related problem of defining what is the organization that is assessed, aka what are the system boundaries. After that, we discuss the issues of independence and competence required from the assessor, as well as the influence of the organization's motivation to the assessment. Finally, we consider the necessary depth of the assessment, impact of the results of the assessment, and as a summarizing issue, the challenge of planning an assessment and choosing the right method.

4.1 Data

Assessments typically provide vast amount of data. It is crucial to identify explicitly what is considered as relevant in the assessments. There are vast amount of data that is collected continuously, which could and should be utilised in the assessments (e.g. work climate surveys, incidents, development initiatives, ratio of corrective vs. preventive maintenance). This data is seldom utilised in organizational reviews.

In the type of data to be collected there is also a critical question: Is the assessment focused purely on psychological issues, existing formal documents or actual safety performance? Furthermore, there is a question of how the organizational structures and performance should be incorporated into the assessment.

The following model in Figure 7 depicts some of the organizational dimensions on which you can collect data (adapted from Reiman & Oedewald, 2007b).

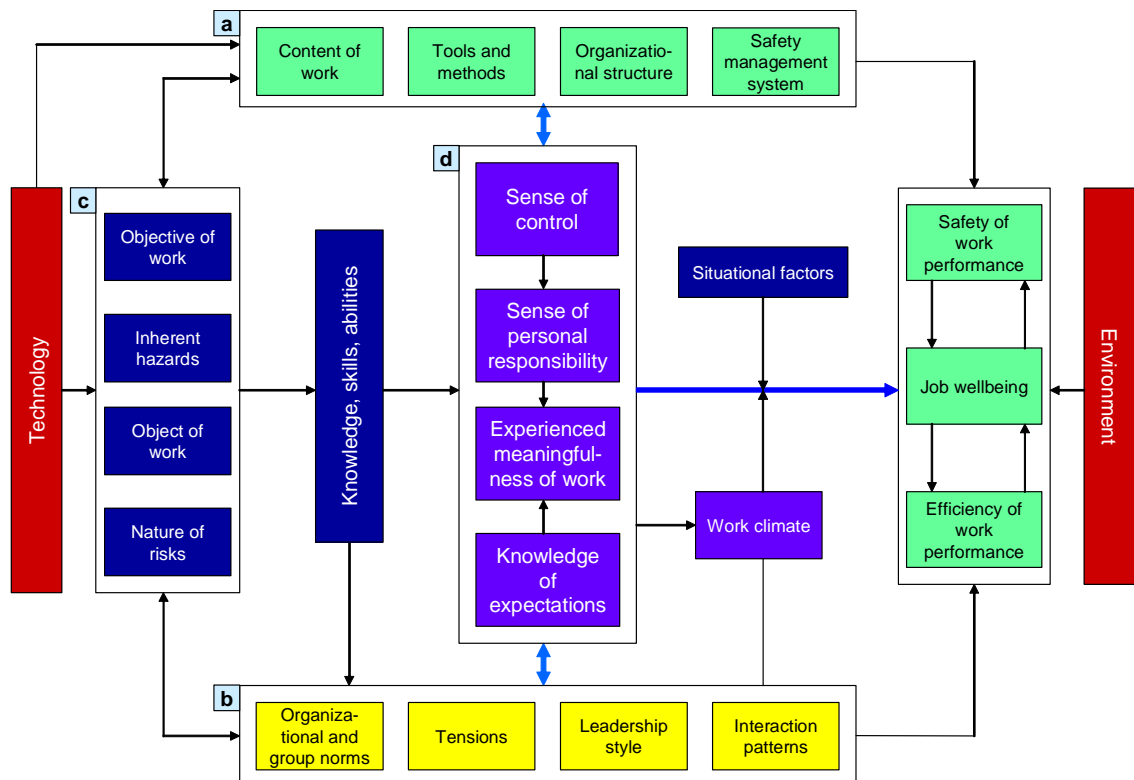


Figure 7. The model of the organizational and work psychological factors influencing the safety effects of human performance (from Reiman & Oedewald, 2007b)

The model in Figure 7 is not only a model of the organizational factors that on which data can be collected. The model also depicts the interrelations between the factors and as such, it act as a model of an organization. The model places emphasis on the influence of the organizational as well as psychological factors on both safe and efficient work performance as well as employee wellbeing. The model includes (a) structural elements of the organization, (b) social integration elements of the organization, (c) conceptions of the personnel and managers concerning the work, safety and the associated risks, and (d) the workers' psychological experience of their work. Context characteristics, group climate and individual knowledge, skills and abilities mediating the effect of the factors on the safety of work performance.

There are several general issue domains each of which is covered in certain extent by organizational safety assessments:

- leadership and communication
- human performance
- rules and procedures
- roles and responsibilities
- values, attitudes, norms
- work practices
- work conditions
- skills, knowledge and abilities
- management system

A general rule is that data should be as valid and reliable as possible in terms of what it is meant to measure. In practice there are many factors hindering the validity and reliability of the data collection. Both quantitative and qualitative data have their strengths and weaknesses in terms of validity, and the best result is usually accomplished by combining various qualitative and quantitative methods (called triangulation). One should also avoid too general criteria for good performance (or at least check their validity in each case) and define the criteria by analysing the demands of the task the organization is carrying out.

4.2 Criteria

A general problem with organizational assessments is, as mentioned above, connected to the criteria to be used in the evaluation process. External regulatory requirements, quality norms and standards as well as internal requirements are often based more on opinions than validated experience. There is no assurance that the requirements are necessary and/or sufficient and the requirements are often fuzzy and can therefore be interpreted in different ways. Several recommendations regarding concepts such as safety culture and safety climate are given, but these are often defined on a general and abstract level that does not give much guidance in the evaluative process. Furthermore, questions about centralization, use of instructions, functional organization vs. matrix organization, etc. are difficult to assess in terms of “best practices”. It is often easier to find weaknesses with current arrangements than to provide recommendations about what would be the “best practices”.

The issues of data and criteria are related, and both concern the model of an effective and safe organization. The model defines what is considered as data and what criteria are used for the assessment (cf. Reiman & Oedewald, 2007a). Often this model is implicit in the assessor’s mind. The main problem is the identification of the relevant factors in terms of organizational safety and the assessment of their significance. Thus, the criteria should also contribute to the prioritisation of identified risks (Manuele, 2003). One of the challenges in defining criteria is that safety is a complex phenomenon that is not easy to define in measurable terms. Sometimes the definitions are simplistic in order to be able to more easily gather data on them, e.g. the number of workers without adequate personal protective equipment (negative indicator of safety culture) or the number times a manager visits the shop floor (positive indicator of safety culture).

For the definition of criteria for an organizational assessment, a model of an organization is needed. Reiman et al. (2006) have constructed a simplified model of an organization consisting of three elements; organizational structure, organizational culture and individual person. These elements reflect the typical issues that are considered in organizational reviews of different kinds. The elements are depicted in Figure 8 together with dimensions that we have found to have special relevance in organizational change situations (see e.g. Reiman et al., 2005a, 2005b; Rollenhagen, 2005).

Structure includes formal procedures, technology, tools and resources of the organization. Culture consists of assumptions and conceptions concerning the work and the organization, values, norms and practices. Individual person -element includes his/her subjective interpretations and experiences, and his/her knowledge, skills and abilities. In order to be able to make sense of the data and decide on the functioning of the organization, one has to understand the overall dynamics of the organization including the interactions between organizational structure, culture and individual persons.

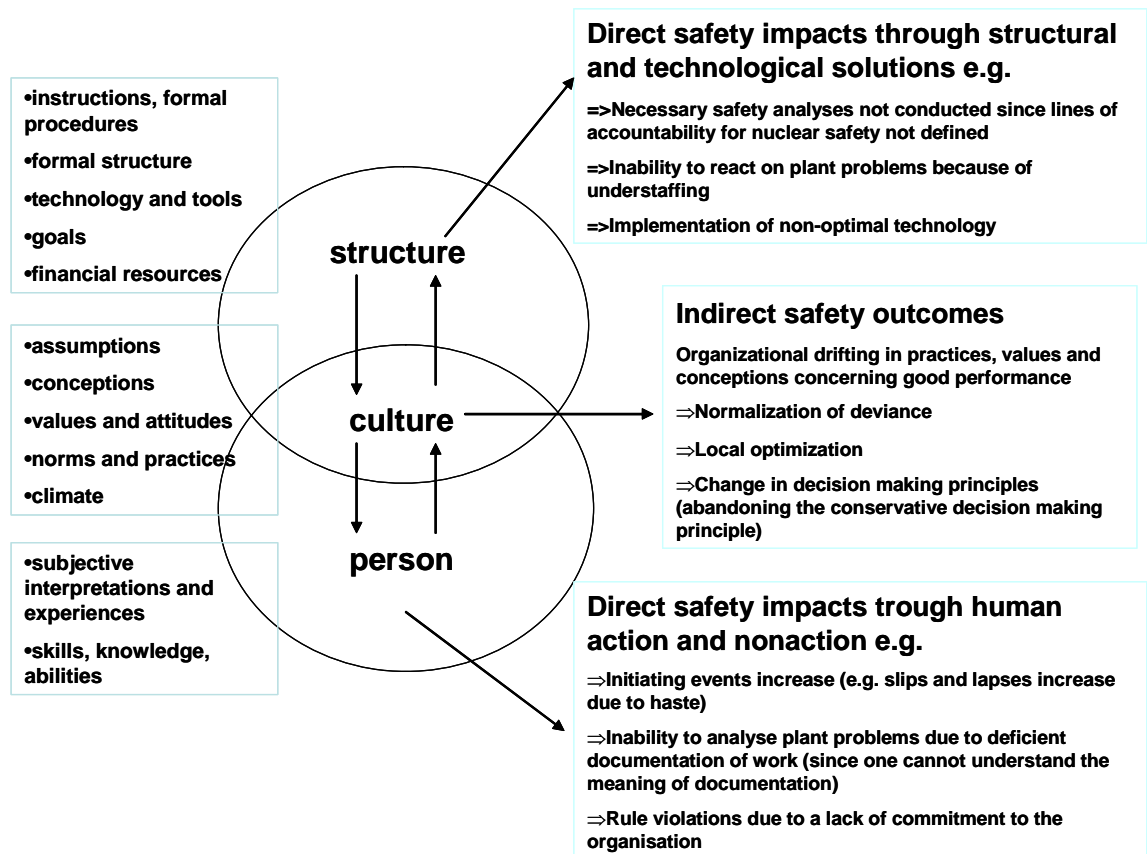


Figure 8. The elements of organization, their interrelations and the possible safety effects in organizational change. From Reiman et al. (2006), refined from Rollenhagen's (2005) original model

The elements in Figure 8 are overlapping and interrelated dimensions with culture combining and facilitating the interaction between structure and individual. In Figure 8 we have also tried to give some examples of the potential safety impacts of the different elements after an organizational change. Even though the emphasis of the model is on predicting the effects of organizational change on safety, it can also be utilised in other types of assessments.

One may think of the criteria for ideal organizations in many different ways. An easy way is to suggest that organizations must be adaptive, and to use that as a criteria for well functioning organization. But the more precise meaning of such a suggestion is more difficult to elaborate on. For example, there seems to be more or less chronic difficulties in nuclear organizations (and similar complex organizations) with respect to handle the trade-off between stability/robustness and flexibility (which among other thing have led to the research tradition focusing on high reliability organizations, HROs). This problem of simultaneously satisfying requirements for stability and at the same time exhibit the dynamic feature of high adaptation may turn out to be one of the more difficult issues for safety science and practice in the future. In the model suggested in Figure 8, we may think about the above problem in the dimensions of structure, culture and individual characteristics. For example, with respect to the cultural dimension, a stable culture usually has the benefit (even if it is not very functional for some given purpose) that people learn both in and outside the given culture the "rules" of the game; that is, what to expect in various situations. Strong culture in turn may hinder individual variability. Whether this is good or bad in terms of safety depends on the content and appropriateness of culture with regards to the task that the organization is carrying out.

The criteria problem was addressed at some level in the ASAR F3 projects (see Section 3.1 in this report). One such “criterion” was for example that if the same underlying weaknesses were observed from two or more perspectives, then it provided reasonable assurance that the issue in question was real. Another strategy employed was to attempt to see functional couplings among observations. In doing so, an MTO-perspective was found to be useful – such a perspective recognizes mutual influences between man, technology and organization. For example, the fact that Forsmark 3 is the newest and most modern station at Forsmark also has had many consequences for its operation and maintenance.

Usually the criteria that are used in the organizational assessment are chosen or created by the assessor. Another option is to allow the employees themselves to generate the criteria for the evaluation. In this case the criteria that the employees choose to evaluate their work on might be as important as the result of the evaluation. This is due to the fact that the criteria they select demonstrate their knowledge of the domain of interest. Thus, by evaluating the criteria one can get information on the level of knowledge that the personnel have of the given work process.

4.3 System boundaries

Another problem concerns the system boundary definition used in the analytical efforts. Modern safety theory often stresses the importance of perceiving risk intensive operations in a broad context. Since the quality of operation and maintenance is influenced by a multitude of “external factors”, there is always a problem of defining the boundary for the organizational assessment. The same problem exists here as in the data issue: the organizational assessment should be focused on the essentials but take into account everything relevant in terms of safety.

The F3 project, for example, had a strong focus on not only the organization within the specific unit Forsmark 3, but also the various supporting technical units. Moreover, the external organizational assessment also investigated processes that influence Forsmark from outside in terms of Vattenfall organizational processes and structures. The investigation of the quality problems at the OL3 construction site was interesting in terms of system boundaries due to the number of distinct organizations forming a “virtual construction organization” formed and managed by Areva, contracted by TVO and regulated by STUK.

Connected to the question about system boundary is also the problem of if “natural” organizational boundaries (plants, divisions, working groups etc) should be used or if one also should attempt to find other types of (sub)system boundaries such as professional groups and informal groups regardless of where these are positioned in the organizational chart. For example, in the study of safety climate of NPP’s in Sweden briefly reported in above, the differences were mainly found between professional groups rather than between plants. Similar results were obtained from a study of three Nordic NPP’s maintenance departments: technicians formed a professional group clearly different from engineers or managers and this professional group shared many characteristics across the plants (see Reiman et al., 2005a; Reiman, 2007).

For the assessment to produce valid results, the system boundaries (aka, what is the organization that is being assessed) should be as clearly defined as possible. In practice this is difficult since in complex organizations there are multiple overlapping systems - both formal and informal. Thus, when defining the organization, one needs to accept and explore multiple system definitions, and transcend organizational units. The assessment method needs to be flexible enough to allow the pursuing of system boundaries as they unfold.

4.4 Independence

Another issue concerns the amount of independence that is required between the assessed and the assessor. Who should make the assessment? What are the strengths and weaknesses of self-assessment vs. outside assessment? On one hand, outsiders do not know the practices and history of the organization and can devote too much attention to trivial issues. On the other hand, "insiders" may be blind to some obvious weaknesses in their culture and the existing social relations might affect their interpretations and motives.

On the one hand, some amount of information on the requirements and characteristics of nuclear power is needed in order to understand the features of culture at the organizations, and on the other hand, some amount of information on assessment techniques and organizational behaviour is needed in order to make a valid assessment. A balance must be maintained between being involved in the organization and knowing its culture and risk of tunnel vision due to too heavy involvement in the given culture. Tunnel vision means that one is no longer able to see any other solutions than the one's provided and legitimated by one's own culture; these solutions taken for granted and accepted as the only possible ones.

Another important issue is one of trust. Trust develops in social relationships, and a certain amount of trust is needed for the assessment to work. It is harder for an outsider to gain the trust of the personnel. On the other hand, as discussed in the Section on system boundaries, organizations are composed of numerous subsystems. A certain level of mistrust can exist between these subsystems (or subcultures) and thus one should not presume ad hoc that an insider assessor is more trustworthy than an outsider. Furthermore, social relationships always include phenomena such as power conflicts and groupthink (Janis, 1982). Groupthink is a form of tunnel vision where the group seeks evidence confirming their assumptions and discarding any opposing information. Power conflicts and hidden agendas affect the way individuals share information and cooperate on a wide range of issues. The assessor should not have any personal agendas or hidden motives in the assessment, but he should remain sensitive to the fact that some in either worker or management level might have their own motives for sharing or not sharing certain information.

4.5 Competence

The competence that is needed for conducting the various kinds of assessments is seldom explicitly defined. As a consequence, assessments have been made from many different perspectives - producing results of various qualities. This could be a good thing if the perspective that one is using is acknowledged. Often the perspective is implicit, and thus also the information from different assessments becomes more difficult to integrate. In Finland, YVL 1.1 states in connection to periodic safety reviews: "In assessing and upgrading the safety culture, the expertise acquired in both organizational studies and practical nuclear safety shall be put to good use." In some cases the exact meaning of organizational studies and the content of organizational expertise has been debated with STUK and the power companies. The question of what kind of competence is needed for organizational assessments is clearly an issue requiring further clarification. The issue of competence relates to the independence problem; what skills, abilities and knowledge are needed for assessments and how well is it possible for an insider or an outsider to have these.

As mentioned in the Section 4.1 on data, one usually needs various methods producing both quantitative and qualitative data. It is unrealistic to assume that one person could be competent in all the methods. Thus, usually a multiperson team is needed for conducting the assessment. Still, competence in integrating the results from various sources is needed.

Vattenfall has established the Vattenfall Safety Management Institute in order to support competence development for managers. During 2006 and 2007 courses for managers have been developed. These courses focus on safety management from a broad perspective. Especially, human and organizational safety issues developed within the context of academic safety science are covered in these courses and lecturers from a great variety of disciplines are invited to describe research and theories in areas such as moral philosophy, organizational culture, and complex decision making. Also other power companies have recently been developing training courses on human and organizational factors.

A valid organizational safety assessment requires good understanding of the technical hazards as well as of the hazards created by the social system. Thus, understanding of the particular organizational including its technology has to be supplemented with understanding of wider organizational phenomena. On the other hand, pure theoretical organizational knowledge is not enough without adequate understanding of the context of the assessment.

4.6 Organizational motivation behind participating in the assessment

Interest in and commitment to the influence of organizational issues on safety is needed in the organization. Most organizations are interested in developing efficiency and effectiveness, but safety is not always considered to be linked to organizational effectiveness. Thus, in these organizations the initiatives aiming at development of safety are seen as unconnected to the economic functioning and overall effectiveness of the organization. This, in turn, has a negative influence on the motivation to participate in the assessment.

Unfortunately, organizations with no interest for in-depth safety assessments are often the ones in the largest need of such. The problem may increase if organizational safety assessments become a compulsory requirement by the regulator, but are not considered important and useful by the power companies. The requirement to perform self-assessments can pose several problems. For example, some of the ASAR management teams had difficulties to obtain useful information whereas other units easily and very openly exposed both weaknesses and strengths in their evaluative statements. Some of these problems were seen as a result of misunderstanding of the strategy and mission the ASAR projects. Units with a more developed safety culture seem to have fewer problems in comparison with units that are less developed in the sense of an understanding for how organizational factors may affect safety and the necessity for evaluations. Thus, units with more developed safety cultures might actually identify more instances of organizational issues needing improvement than the ones with less developed - or complacent - safety cultures.

Assessments conducted by “non-mature” organizations often become self fulfilling prophecies; these organizations doubt the usefulness of organizational assessments, do not commit themselves to a serious assessment process, and consequently the assessment produces results that are useless or self evident. Creation of an initial understanding of the relevance of organizational issues for nuclear safety is a crucial first step in motivating the organization to participate in an assessment.

The motive for doing organizational reviews heavily influences the outcomes of the review and especially the corrective measures that are taken afterwards. If the motive is to fulfil criteria for certification of demand from the regulator, the corrective measures will probably be different if compared e.g. to a motive of genuine interest to continuously enhance safety. The motive for doing the review should be acknowledged by the organization. It should also be ascertained that there are no hidden motives or hidden agendas by anybody that would be served or disserved by some specific findings from the reviews.

4.7 Depth and scope of the assessment

Depth and scope of the assessment deal with the issue of focus as well as with goals and expectations set for the assessment. Several questions are related to this: How deep into the organization and its culture should one go in an assessment and how broad should the assessment be in terms of the scope? Is it enough to evaluate the observable features and official systems (artefacts of the culture) or would it be necessary to go deeper into values, attitudes and beliefs of personnel? Also, should the assessment cover a wide array of issues, or should it focus on only a limited number of dimensions or key issues?

In general, depth and scope of the assessment should be sufficient with regard to goals of the assessment. Due to resource limitations it is often difficult to reach both depth and broadness at the same time. Thus, one needs to balance between focus on details and oversight of the entire organization in the assessment process. In order to do this one has to keep in mind on the one hand the specific goal of the assessment and on the other hand the nature of the hazards that are evaluated. Related to the latter point, Manuele (2003, p. 409) argues that safety audits do not place enough attention to the low probability - high consequence incidents. Those "obscure hazards" should be identified better, since they are also the probable causes of accidents after the high probability hazards have been controlled. This requires going behind the surface levels and analysing also the hazards that the organization initially considers as not significant. It also requires a good understanding of the technical hazards as well as the social system (creating hazards through human action or inaction).

There are some practices that help to solve the problem of depth and scope. For example, if an organization regularly performs assessments or has a well developed performance indicator system, then plenty of useful information already exists. This information can be utilised in the assessment with little extra burden on resources. In order to deal with the existing information effectively it is necessary to assign personnel to collect, integrate and present the information in a summarized and lucid arrangement. This facilitates an easy overview that is useful in screening out important information that can be used to, e.g., direct attention to critical issues.

It is important to acknowledge the tension between depth and scope and make the decision concerning the focus explicit. Broad assessment that only covers surface features of the organization might very well be beneficial for organization as long as they understand that they are dealing only with surface features. On the other hand, an in-depth analysis of some specific issue often needs to be put into a larger context before implementing solutions that usually have an effect also on other parts of the organization.

4.8 Output and impact of the assessment

The long term result of the assessments should of course be to increase the safety level of the NPP's. Some assessments that have been conducted has, however, probably failed in that sense – i.e. no explicit change could be noticed related to the assessment even though the assessments did give recommendations for change. A number of questions could therefore be raised concerning the output and impact of the assessment:

- What kind of criteria should be used for the assessment?
- How should the data be collected?
- What kind of results should the assessment produce in order to facilitate changes?
- How should the results be communicated?

The above are some examples of questions that can be utilised to investigate areas which are related to the power plants position regarding if a decision to introduce some kind of change will take place. Now, even when an organization decides to change there are unfortunately situations when, for various reasons, change doesn't take place. For example, the organization might lack capabilities for perceiving and fulfilling the new requirements, or some element of the

organization resists the change for its own reasons. These situations are to some extent discussed in Reiman et al. (2006).

Theory and methods involved in safety management are usually biased toward the problem identification side of safety. However, it is necessary and vital to focus on how the identified problems are actually solved. Theory and methods for working out robust solutions to identify safety problems need more attention. There might be innovative solutions to safety problems but without a strong attention to the problem solving side of the coin there is a great risk for adoption of standard solutions to identified safety problems – solutions that do not necessarily fit with the particular context at hand.

Finally, the question is how to communicate the results to the power plant in a manner that real changes occur and what kind of results the assessment should produce in order to facilitate changes. There are two main questions:

- Will the organization and the management accept the results, i.e. do they consider the results valid and believable, and
- What will the organization and management do with the results

The answer to these questions depends on how well the organization accepts the criteria used for the assessment. Unfortunately, this is not always the case. For example, experience has shown that plants are more reluctant to accept results of external assessments if they are based on open criteria. Results that are too much against the prevailing self-image of the organization and the managers will usually be denied. On the other hand, results that are considered as self-evident are usually not paid enough attention. Thus, for the strongest effect, the results should be *mildly surprising* for the organization (Wahlström).

4.9 Planning of organizational assessments and selection of the methods

Organizational assessments must be planned carefully and in good time. An unrealistic time schedule is one of the common problems of assessments. It is usual that too optimistic plans are set up. Plans must also leave room for unanticipated and “unplanned” issues. Issues to be considered in the planning stage are:

- what is the reason for the assessment and what are its goals
- how should the assessment be done
- when should the assessment be done
- what are the needed resources in the assessment
- what data from the organization is needed
- what are the criteria that are used in the assessment
- how the results of the assessment are to be reported to the organization
- is there enough commitment in the target organization to allow a neutral assessment
- is the assessment team competent enough to complete the assessment

Organizational assessments may be of two broad types. A first type is the relatively closed assessment where a clear set of criteria is used as a benchmark. These assessments usually conform to the classical audit strategy used in quality assessment where deviations are noted from a set of norms/criteria. Another type of assessment is one where the criteria are much more open or implicit.

In safety culture assessments, for example, it is sometimes difficult to come up with clear criteria, although plenty of potential criteria can be found in the literature. One of the reasons for this difficulty in defining criteria for safety culture assessments is that the question of what is “good” or “bad” safety culture may vary depending on a host of factors such as where in a life cycle an individual organization is positioned. For example, in the design phase partly different factors are more relevant than in an operation phase of an organization. Another problem with safety culture assessments

is that it is reasonable to expect various subcultures with partly different demands of what is important and how their work relates to others.

The issue of open audits has raised a lot of discussion. Often clear predefined evaluation criteria are considered as proof of the quality and validity of the used approach. The problem is that if you do not accept open audits without clear evaluation criteria, you are not exploring the boundaries of your organization's culture. Open criteria can facilitate discussion, but this demands an open climate and supportive attitude toward the audit. From open criteria, on the other hand, it is much more difficult to define clear corrective measures. It demands facing the uncertainty concerning the functioning of the organization and organizational phenomena.

Selection of a right approach and valid methods is very important for a successful assessment. Unfortunately, due to high variability to both methods and outcomes it is difficult to suggest clear criteria for the selection and resourcing of assessment methods. Further problems are raised by the fact that every method is only as good as its user. This means that there is a need for increased awareness of the strengths and weaknesses of various assessment methods as well as of organizational factors in general.

4.10 An overview of the identified themes

At the beginning of the report we raised three issues that needed clarification in the context of organisational safety assessment

- The focus of traditional auditing strategy
- The use of culture assessments
- Integration of findings from various methods

Next, we will discuss these themes in light of the findings of this study. Then we will summarise the identified key issues of organizational assessment.

The traditional auditing strategy is often focused on formal and structural issues rather than performance. However, a formal safety management system with all documents in place does not necessarily reflect how this system is utilised. The distinction between formal aspects of a safety management system and performance aspects are of course essential to keep in mind in discussions about organisational assessments. Some of the methods covered in this report have a bias toward structural formal characteristics, such as the OSA method, whereas other methods such as the one exemplified in the ASAR project covers both formal aspects and performance. A finding that an observed performance does not conform to a given set of rules is not necessarily a sign of a weak safety culture – the rules themselves may be such that they are difficult or impossible to follow. But on the other hand, such deviations may be indicative of weaknesses in safety culture and consequently it is important to always make a more elaborate evaluation on the reasons for the gaps between formal structures and performance. In conclusion, it is necessary to include both formal/structural aspects as well as performance aspects in organizational assessments – they both give partly different pictures of the organization but if these respective parts are perceived in isolation they might be misleading.

The use of culture assessments and the body of literature associated with these culture assessment practices are often used in parallel with traditional auditing. The issue of how these two strategies can be used together and how the findings can be integrated is not well developed. Much more focus has to be invested in how cultural assessments can be made in a nuclear organization, and particularly how safety culture surveys stand in relation to other more general organizational culture assessments. Safety culture represents a subset of a broader organizational culture, but these interactions have been little investigated in the safety literature. Safety culture assessments and more traditional auditing strategies should complement each other and their results should be integrated when conclusions about organizational aspects of safety are made.

Integration of findings from various methods and data sources is usually very unsystematic. For example, event investigation techniques are usually performed as part of the safety management strategy. How these findings are integrated with other processes of organizational assessments needs to be clarified. We find that very little of the data used for event investigation projects makes use of previous safety climate surveys. There is not typically any clear function at the power plants that collects, analyses, and integrates data concerning organizational issues. It is usually nobody's responsibility to do this kind of integration, and consequently it is often left undone. It can be argued as how much this responsibility for integration belongs to managers. However, they usually lack skills in interpreting data of various kinds (see Sections 4.1 and 4.5 in this report).

In our opinion organizational safety assessments in general have been too reactive in the past. Assessments have been conducted after incidents or other notable decrease in safety levels, or when required by the regulator for various reasons. However, it has to be noted that recently there has been examples of proactive approaches, e.g. in the assessment of risks associated with organizational changes. There has been a rather rapid progress and awareness about risks associated with organizational changes in the Swedish utilities. The regulators' attention to the subject is paralleled by a more broad and general international attention about how organizational changes may contribute to both risk and safety in the nuclear industry (IAEA, 2001, 2003a; OECD, 2004; Reiman et al., 2006). The classical management literature about organizational change has had relatively little to say about the possible safety significance of organizational changes – the interest has mainly been devoted to financial aspects of changes. Because of this situation there is relatively little methodological support for doing safety assessment of organizational changes and few readymade methods are available in the literature. This situation may seem somewhat strange in view of that many event investigations have found that organizational changes have been a contributory factor in the accident (Baram, 1998; Wright, 1998; Hopkins, 2000; Bier et al., 2001).

In conclusion, many of the tools used for assessing organisational systems or parts of such systems are too far separate from each other both in the assessment process and in the utilization of the results from individual tools. We recommend that organizations should develop structures and functions for making integrated assessments of all the information that often is available in the organizations.

In the study we identified nine key issues that relate to the organizational safety assessments. An overview of the identified themes, requirements, central challenges and potential solutions is presented in Table 3.

Table 3. Overview of the identified themes, requirements, central challenges, tradeoffs and solutions

Issue	Requirement / ideal	Central challenge	Tradeoffs / solutions
Data	Valid and reliable data.	Qualitative data is filtered and biased and quantitative data is often simplistic.	Triangulation of methods is needed.
Criteria	Clear and consistent criteria.	There might be issues where no clear criteria exist. Safety is a complex phenomenon that is not easy to define in measurable terms.	To combine formal criteria with open assessment is one possible solution to the problem of criteria. The definition of criteria requires an explicit model of the functioning of an organization. This also allows an evaluation of the appropriateness of the criteria after the assessment.
System boundaries	Well-defined system boundaries	There are multiple overlapping systems in complex organizations	It is usually necessary to accept and explore multiple system definitions, and transcend organizational units.
Independence	Existing social relations should not affect analysis	Trust develops in social relationships, and trust is needed for the assessment to work. Social relationships involve power and groupthink issues.	Balance between being in the organization and knowing its culture and risk of tunnel vision regarding the weaknesses of the culture. The assessor should not have any personal agendas or hidden motives in the assessment, but he should remain sensitive to the fact that others might.
Competence	Competence of the assessment team should in minimum match the competence of the assessed functions and also include competence in organizational issues.	In multi competence organizations it is difficult to match the competence of the organization. Competence in organizational issues is scarce in many companies.	Balance between relying on insiders' competence and outsider evaluation. There is a need to involve the personnel in the assessment, e.g. by utilising focus groups. Assessment requires good understanding of the technical hazards as well as hazards created by the social system.
Motivation for the assessment	Personnel are motivated to identify both the strengths and weaknesses of the organization	Many factors may influence motivation, e.g. work pressure, blame culture, need for regulatory approval, need for a certification.	Understanding of how organizational factors affect safety can increase motivation for the organizational assessment. The assessor needs to acknowledge the motivations and implicit goals that the organization has concerning the assessment.
Depth and scope of the assessment	Depth and scope are sufficient with regard to goals of the assessment	Due to resource limitations it is often difficult to reach both at the same time.	Details versus oversight of the assessment need to be balanced. If the organizations regularly perform assessments, have well developed indicator systems etc., plenty of useful information already exists. A well developed screening methodology may direct attention to critical issues.
Output and impact of the assessment	Relevant outcomes are initiated as a result of the assessment	It is sometimes difficult to come up with clear solutions to address the weaknesses found in the assessment	Follow-up of the carrying out of previous recommendations and access to relevant external experiences is important. A proper balance between analysis and problem solving phases of the assessment is required.
Planning and selection of methods	Clear criteria exists for selection and resourcing of assessment methods	Due to high variability to both methods and outcomes it is difficult to suggest clear criteria.	Awareness of the strengths and weaknesses of various assessment methods needs to be raised by both research and practical work. A database of available methods is needed together with guidelines for their use and selection.

Table 3 shows that organizational safety assessments involve plenty of issues where choices have to be made regarding what is considered valid information and balance has to be struck between focus on various organizational phenomena. It is very important that these choices are based on a sound theoretical framework and that they can later be evaluated together with the assessment findings.

5 Conclusions

5.1 Lessons learned

5.1.1 *Motive for organizational safety reviews*

Organizational safety reviews are done as part of safety management. In order for the assessments to contribute to the overall effectiveness of the organization, the following premises of safety management have to be remembered:

- Management of safety requires the management of the organization; safety management is a control problem (cf. Rasmussen, 1997), which requires the definition of the system to be controlled
- Balance of attention between various organizational issues and goals is one key requirement for organizational management
- Organizations are complex phenomena; they are socio-technical systems with unique cultures and unique "best practices"

The main reason for conducting organizational assessments is the identified tendency of any given organization to gradually drift into a condition where it has trouble identifying its vulnerabilities and mechanisms or practices that create or maintain these vulnerabilities. Some reasons for this inability to perceive the organizational vulnerabilities are:

1. The demands of the work are not always obvious to the personnel at every level of the organization. This is especially so in complex socio-technical systems where the uncertainty and ambiguity of information are prevalent and the effect of local changes to the entire system is difficult to notice. There are often incorrect or outdated conceptions or unpractical work methods in an organization. Also, expectations, demands and the consequences of one's own work are often vague. It should be noted that the demands of the work are neither obvious to the outside observer. Thus, care should be utilised when devising criteria for organizational assessment.

2. The culture of the organization - including its structure, norms and conceptions of the personnel - embeds ideas on current risks and ways to achieve safety. Tools and official practices highlight some aspects of the work, but at the same time they cloud other aspects.

3. Both the organization and the demands of the task of the organization are in continuous and gradual change. The constraints and requirements that stem from the concrete object of the work might change. For example the aging of the technical infrastructure generates new phenomena (e.g., corrosion or increase in the frequency of technical faults). Thus, the appropriate means to guarantee safety also change. At the same time, work practices are constantly optimized locally (cf. Snook, 2000) according to subunit goals. Norms and attitudes gradually change and safety or minor hazards began to be taken for granted (cf. Vaughan, 1996). What was once new and required attention now becomes known and as something that is considered taken care of. (Reiman, 2007)

4. The different units of the organization often develop distinct subcultures that can hinder communication and cooperation if not taken properly into account. The conceptions in the organization are not inevitably uniform, e.g. different organizational levels or occupational groups may have a different view on the risks and demands of the work.

5.1.2 *Focus of organizational safety reviews*

The nuclear power plants and the regulator both carry out various types of organizational assessments. In these assessments, more emphasis is still placed on the evaluation of technical solutions and structures than on organizational performance. In order to understand the overall vulnerabilities of the system there should be more work done to integrate the views. The technical solutions, organizational norms and values and the workers' understanding about the overall task and the boundaries of safe activity should be analysed hand in hand because these organizational elements always affect each other. On the one hand, technical solutions affect the way people see their task and risks. On the other hand, the values and attitudes of the people affect the way they utilize new technology. We recommend that assisted self assessments should be conducted e.g. when there are changes in the organizational structures, new tools are implemented, when the people report increased workplace stress or decreased working climate or when incidents and near misses increase.

Assessment of the overall functioning of the organization has been considered demanding since simple methods and tools are rare and the validity of the various performance indicators is unclear. A comprehensive organizational assessment requires integration of information from different sources and a well planned assessment process. The most critical phase in the organizational assessment is the understanding of what to look for, where and when, not the selection of the assessment methods per se. Interviews, working climate surveys and descriptions of the actual work processes (e.g. those that can be seen in event reports) provide valuable information about the general challenges and help in creating possible risk scenarios. Furthermore, the subjective perceptions of the people working with these complex systems are indicators of the overall state of the organization.

An interesting question seldom discussed in-depth is the relation and interaction between "soft" and "hard" issues in organizational assessments and safety development. For example, there has been a concern that the current strong focus on the importance of human and organizational factors may direct attention away from more traditional technical solutions to safety problems. It is often claimed that since technology in many branches is so well developed the gains are foremost found in the "soft factors". However, some "soft" problems found in organizational assessments are in fact a consequence of less than adequate technical design and the solutions should consequently address the design issues as well. Thus, a strong safety culture focus should never be an excuse for weak engineering. People, technology and organization together create safety (or accidents), and each of these three "factors" needs attention in safety management and organizational assessments as well.

5.1.3 *Defining and measuring organizational safety*

One of the main lessons learned in this study is that the concept of safety has seldom been explicitly defined in the previous organizational assessments. This partly explains the diversity of the used approaches, methods and indicators. The neglect of the definition of the concept of safety is quite common in safety science as well as practice. Safety and its sister term security can relate to five different objects (Reiman & Oedewald, 2008, p. 22): personnel (one's own or subcontractors'), production / process, environment, plant assets / infrastructure and information. Adding to the confusion, in the Nordic languages there is for each language only one term meaning both safety and security; the Finnish term is turvallisuus, and the Swedish term is säkerhet. The literature about the influence of organizational factors on safety usually assumes a one-dimensional and simplistic concept of safety. However, the organizational factors of greatest importance for occupational safety on the one hand and system safety on the other (e.g. nuclear safety, safety of aviation etc) may not necessarily be the same. For instance, studies of safety culture do not normally differentiate among different kinds of safety in the

ambitions to develop generic safety dimensions. Nuclear safety, for example, involves highly abstract dimensions which may be difficult to assess with the same methods as occupational safety, e.g. by asking people who are not necessarily personally involved in and knowledgeable of the particular work process. One main problem is that there is insufficient understanding of how organizations that produce safety actually function including their internal dynamics. Thus, an increase in understanding of organizational issues would also increase our understanding of what safety is and how it is achieved (Reiman & Oedewald, 2008).

One of the challenges facing projects to conduct organisational assessments concerns the issue of causality. It is far from clear how various organisational subsystems interact in the process of producing safety and risk. Much of organisational analysis is based on beliefs about causal interactions but little is known in detail about such relations among subsystems. Since the interactions and influences among organisational components are often fuzzy, it is sometimes rather easy to neglect various findings and claim that they might reflect coincidences or less important issues.

The safety culture assessments and other organizational measures tend to assume a straightforward connection between safety performance of the organization and attitudes towards safety. In case of performance failures it seems to be easier to blame bad attitudes than lack of technical (safety) knowledge. Although nuclear organizations in general have highly experienced employees it should be recognized that misunderstandings, narrow expertise areas, forgetting basic definitions and concepts, and the inability to follow the development of the technology can be found also among the nuclear power plant personnel. The organizations may be unaware that there exist misunderstandings about basic safety principles. Thus, it is advisable to evaluate the basic training needs from time to time.

5.1.4 Criteria for improvement actions

One should avoid hasty judgments concerning the appropriateness of the methods used for organizational assessments. The first bad experience from an organizational safety review does not necessarily mean that the method itself is useless or bad. It takes time (and practice) to make even the good method work. For example, the safety culture survey used in Sweden was in the beginning too much focused on the statistical findings and not so much on the free text section. When also the free text section was utilised the usefulness of the method improved. Also, it should be acknowledged that it often takes long time for safety improvements to have a measurable effect even when they are successful. In organizations that already have a high safety level, safety managers work for their successors, as Amalberti (2001) has noted. This means that they seldom see the results of their successful efforts to improve safety. This is due to the fact that it takes time for the improvement to become noticeable in terms of increased measurable safety levels.

For example, sometimes there is a tendency to expect very fast progress in safety culture programs, which reflect an ignorance of what culture really is. Basic values and conceptions of importance for safety can not be expected to change overnight. Connected to this question is the issue of how long lasting various cultural and organizational change programs are: many questions related to safety culture and organizational factors need constant attention and can not be expected to produce results when managed in "projects": safety management must be institutionalized into the culture of the organization in order to function well.

5.2 Recommendations for conducting organizational safety assessments

The purpose of the organizational safety review should be clearly defined. At its best, the organizational safety reviews can be utilised as a source of information concerning the changing vulnerabilities and the actual safety performance of the organization. In order to evaluate the

actual safety performance of the organization certain recommendations can be made. These are issues that should be considered and taken into account as far as is practically applicable in any assessment where organizational safety issues are considered.

Basic principles of organizational safety assessment:

- Organizational assessments that require a large degree of participation from the personnel should be planned well in advance. Resources should also be reserved for unanticipated problems and changes in schedules.
- Integration of different methods for organisational assessments is an important basic principle in organizational assessment. How such integration should be made should be part of the organizational assessment plan.
- One should make more use of the previous organizational reviews when conducting new reviews. There is an emerging awareness that you can monitor a kind of a cultural trend by looking at the old reviews.
- In any comprehensive assessment, both structural and performance aspects of the organization have to be considered.
- Neither the assessor nor the assessed should nurture an oversimplified image of an organization. Especially the assessor should acknowledge that organizations are complex and dynamic social structures the understanding of which requires proper theories and concepts. Organizations are more than the formal structure implies; they have plenty of informal and social features which influence the daily work and safety.
- Organizations are political entities – that should not be forgotten. Individuals and groups are not keen on talking negative things about those things that are important to their social identity and things they consider as being “private to their own group” - the group being either some department or the entire organization. On the other hand, people’s opinions about other functions and departments can be equally coloured by their own interests and presuppositions, but usually to the opposite direction.
- People skilled in human and social sciences should be utilised in organizational reviews due to their ability to question taken-for-granted assumptions, utilise both quantitative and qualitative research methods, utilise the latest theoretical and methodological results of their field, and understand organizational phenomena. In addition to social scientific expertise, you also need experts of the particular domain in the assessment.
- Strict criteria in the assessment process are valuable but one should also be open to issues where no criteria have yet been developed – i.e. to strive for a balance between closed and more open assessments. A third way is to make use of criteria in the project itself i.e. to utilize the personnel of the given organization to develop usable criteria based on their judgement of what they consider important for their process.
- Assessments should provide guidelines for the prioritisation of the findings and development targets.
- Analysis of organisational issues usually produces lists of weaknesses but an important phase of such projects is to develop recommendations for remedial actions. This process of organisational redesign and change seem to be less focused in comparison with the problem finding phase. For example, most event investigation manuals have a strong focus on problem identification but much less on the problem solving phase.
- On the other hand, one should avoid too hasty conclusions and solutions to issues that are not analysed in-depth. The solutions are then usually targeted only to superficial issues and coloured by the assessors’ preconceptions.
- The feedback to the personnel involved and affected by organisational assessments is crucial for maintaining interest in organizational issues and getting the recommendations of the assessment implemented into practice.
- It should be borne in mind that it takes time for the effects of any intervention done on the basis of the assessment to show. Furthermore, the better the initial safety level, the more time it takes for the effects of the interventions to be measurable.

The aforementioned principles offer a set of guidelines for planning and conducting organizational assessments as well as for designing effective interventions.

5.3 Further research needs

A general problem with organizational assessments is that organizations are more or less mature. Of course one could trust a normative strategy and assume that the organization should match certain absolute criteria regardless of its position in a maturity scale. For an organization to change in a positive direction it is, however, not always reasonable to demand characteristics that are too far away from what the organization perceives is reasonable to obtain. One of the conclusions following this argument is that it would presumably be fruitful to attempt to develop a theory of organizational maturity and safety culture development that can be of use in the process of change management.

There are several research projects trying to incorporate organizational issues into PSA, mainly in the USA (Galána et al., 2007). The success of these methods for modelling organizational influences is, according to our evaluation, still an open question. The methods can, however, provide important information on the relevant organizational factors in terms of nuclear safety.

Moral and ethical issues are closely associated with many aspects of safety culture. It is, however, rather unusual in the literature about safety culture and organizational aspects of safety, to directly focus on ethics. Ethical theory may provide an interesting departure for exploration of organizational aspects of safety.

What are also needed is a more in-depth study of the pros and cons of different methods of organizational assessment and also guidelines for the selection and use of the methods. This research should also address the issue of various assessment needs and their influence on the use of the methods.

Finally, more research is needed on organizational factors and organizational phenomena having safety relevance as well as on general organizational theory. Currently there are few comprehensive theories and too little public empirical evidence on the influence of organizational phenomena to organizational behaviour and outcomes including safety. Most of the evidence is anecdotal and the safety models are lacking a sound theory on organizational behaviour. Consequently, it is not easy to assess the validity of organizational safety review methods either.

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Title	Conducting organizational safety reviews – requirements, methods and experience
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Abstract	<p>Organizational safety reviews are part of the safety management process of power plants. They are typically performed after major reorganizations, significant incidents or according to specified review programs. Organizational reviews can also be a part of a benchmarking between organizations that aims to improve work practices. Thus, they are important instruments in proactive safety management and safety culture. Most methods that have been used for organizational reviews are based more on practical considerations than a sound scientific theory of how various organizational or technical issues influence safety. Review practices and methods also vary considerably. The objective of this research is to promote understanding on approaches used in organizational safety reviews as well as to initiate discussion on criteria and methods of organizational assessment. The research identified a set of issues that need to be taken into account when planning and conducting organizational safety reviews. Examples of the issues are definition of appropriate criteria for evaluation, the expertise needed in the assessment and the organizational motivation for conducting the assessment. The study indicates that organizational safety assessments involve plenty of issues and situations where choices have to be made regarding what is considered valid information and a balance has to be struck between focus on various organizational phenomena. It is very important that these choices are based on a sound theoretical framework and that these choices can later be evaluated together with the assessment findings. The research concludes that at its best, the organizational safety reviews can be utilised as a source of information concerning the changing vulnerabilities and the actual safety performance of the organization. In order to do this, certain basic organizational phenomena and assessment issues have to be acknowledged and considered. The research concludes with recommendations on issues that should be considered and taken into account as far as is practically applicable in any assessment where organizational safety issues are considered. Finally, further research needs in the area of organizational factors and organizational safety assessment are outlined.</p>
Key words	Safety reviews, safety culture, organizational factors, safety management