Nordisk kernesikkerhedsforskning
Norrænar kjarnöryggisrannsóknir
Pohjoismainen ydinturvallisuustutkimus
Nordisk kjernesikkerhetsforskning
Nordisk kärnsäkerhetsforskning
Nordic nuclear safety research

NKS-131
ISBN 87-7893-193-2

Nordic perspectives on safety management in high reliability organizations: Theory and applications

Ola Svenson et al. (Eds.)
Stockholm University, Sweden

April 2006

nks

Abstract

The chapters in this volume are written on a stand-alone basis meaning that the chapters can be read in any order. The first 4 chapters focus on theory and method in general with some applied examples illustrating the methods and theories. Chapters 5 and 6 are about safety management in the aviation industry with some additional information about incident reporting in the aviation industry and the health care sector. Chapters 7 through 9 cover safety management with applied examples from the nuclear power industry and with considerable validity for safety management in any industry. Chapters 10 through 12 cover generic safety issues with examples from the oil industry and chapter 13 presents issues related to organizations with different internal organizational structures.

Although the many of the chapters use a specific industry to illustrate safety management, the messages in all the chapters are of importance for safety management in any high reliability industry or risky activity. The interested reader is also referred to, e.g., a document by an international NEA group (SEGHOF), who is about to publish a state of the art report on Systematic Approaches to Safety Management (cf., CSNI/NEA/SEGHOF, home page: www.nea.fr)

Key words

Safety management

NKS-131
ISBN 87-7893-193-2

Electronic report, April 2006

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

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

NORDIC PERSPECTIVES ON SAFETY MANAGEMENT IN HIGH RELIABILITY ORGANIZATIONS

Theory and applications

Edited by Ola Svenson, Ilkka Salo, Pia Oedewald, Teemu Reiman and Ann Britt Skjerve

Nordic perspectives on safety management in high reliability organizations: Theory and applications

Edited by

Ola Svenson, Ilkka Salo, Ann Britt Skjerve, Teemu Reiman and Pia Oedewald

Svenson et al. (Eds.) Nordic perspectives on safety management in high reliability organizations: Theory and applications.

Stockholm: Stockholm University, Department of Psychology
S - 106 91 Stockholm Sweden

AUTHORS

Pernilla Allwin
Stockholm University, Stockholm, Sweden

Sven Ove Hansson
Royal Institute of Technology, Stockholm, Sweden

Jari Kettunen
VTT Technical Research Centre of Finland, Espoo, Finland

Øyvind Lauridsen
Institute for Energy Technology, Halden, Norway.

Lars Lindblom
Royal Institute of Technology, Stockholm, Sweden

Svein Nilsen
Institute for Energy Technology, Halden, Norway

Pia Oedewald
VTT Industrial Systems, Finland

Teemu Reiman
VTT Industrial Systems, Finland

Carl Rollenhagen
Mälardalens University, Västerås and SwedPower,
Stockholm, Sweden

Helena Rådbo
Karlstad University, Karlstad, Sweden

Ilkka Salo
Lund University, Lund and Stockholm University,
Stockholm, Sweden

Per-Olof Sandén
Swedish Nuclear Power Inspectorate (SKI), Stockholm, Sweden

Ann Britt Skjerve
Institute for Energy Technology, Halden, Norway

Inge Svedung
Karlstad University, Karlstad, Sweden

Ola Svenson
Stockholm University, Stockholm, Sweden

Ingemar Torbiörn
Stockholm University, Stockholm, Sweden

Björn Wahlström
VTT Technical Research Centre of Finland, Espoo, Finland

CONTENT

Preface i

Chapter 1
A Frame of Reference for Studies of Safety Management
Ola Svenson 1

Chapter 2
Efficient Inspections
Lars Lindblom and Sven Ove Hansson 9

Chapter 3
Feedback for Pro-activity: Who Should LearnWhat from Events, When and How
Inge Svedung and Helena Rådbo 21

Chapter 4
On Safety Indicators From a Regulator Perspective: Some Methodological Aspects
Per-Olof Sandén 35

Chapter 5
Safety Management in Luftfartsinspektionen – Swedish Civil Aviation Safety Authority
Pernilla Allwin 45

Chapter 6
On Event Reporting in the Swedish Health Care and Civil Aviation Systems
Ola Svenson 67

Chapter 7
Safety Management of Nuclear Power Plants - Values and Balance of Attention
Carl Rollenhagen 75

Chapter 8
Analysis of Challenges to Nuclear Power Plant Safety Management: Finland, Sweden, and the European Context
Jari Kettunen, Teemu Reiman and Björn Wahlström 95

Chapter 9
Organizational Culture and Social Construction of Safety in Industrial Organizations
Teemu Reiman and Pia Oedewald 115

Chapter 10
Norwegian Petroleum Operations and Regulatory Activities from a System Safety Perspective
Ilkka Salo 131

Chapter 11
Factors Affecting Employees' Willingness to Use Mindful Safety Practices at Norwegian Petroleum Installations
Ann Britt Skjerve and Øyvind Lauridsen 151

Chapter 12
Challenges to Safety Management when Incorporating Integrated Operations Solutions in the Oil Industry
Svein Nilsen 171

Chapter 13
Elements of uncertainty and risk in intercultural contact
Ingemar Torbiörn 183

Preface

This volume has its origin in a series of seminars sponsored by Nordic Nuclear Safety Research (NKS). The book is the result of support form many other different funding sources including the Swedish Nuclear Power Inspectorate (SKI), but also from support from the authors themselves, who devoted so much of their time writing chapters, and the editors who reviewed the chapters. The volume is published as an open- access document, and the copyright of each chapter is owned exclusively by the authors of the chapter. The volume is distributed for free (except for eventual mailing costs) from the editors as long as the printed version will be available. There will also be a CD version of the volume.

Stockholm, Lund, Helsinki and Halden
October 2005

The Editors

Introduction

The chapters in this volume are written on a stand-alone basis meaning that the chapters can be read in any order. The first 4 chapters focus on theory and method in general with some applied examples illustrating the methods and theories. Chapters 5 and 6 are about safety management in the aviation industry with some additional information about incident reporting in the aviation industry and the health care sector. Chapters 7 through 9 cover safety management with applied examples from the nuclear power industry and with considerable validity for safety management in any industry. Chapters 10 through 12 cover generic safety issues with examples from the oil industry.

Although the many of the chapters use a specific industry to illustrate safety management, the messages in all the chapters are of importance for safety management in any high reliability industry or risky activity. The interested reader is also referred to, e.g., a document by an international NEA group (SEGHOF), who is about to publish a state of the art report on Systematic Approaches to Safety Management (cf., CSNI/NEA/SEGHOF, home page: www.nea.fr)

In Chapter 1 Svenson proposes a theoretical framework for studies of safety management. The framework is generic and does not go into great detail. The starting point is the interaction of living and non-living systems in high hazard industries. The chapter stresses the dynamic systemic character of management and safety management in those industries and other high-risk activities. The chapter covers many different forms of feedback and system adjustment processes in the organizational context. One important form of feedback is provided by safety inspections.

In Chapter 2 Lindblom and Hansson analyze safety inspections of workplace organizations starting from a simple theoretic model. They discuss criteria for inspections and explain difficulties in designing and interpreting results from studies of the efficiency of inspections. The chapter also contains information about some empirical studies of efficiency of inspections. Chapter 3 by Svedung and Rådbo also treats the issue of feedback in organizations. In particular they stress the important role of learning from events at different levels as a function of feedback. In Chapter 4 Sandén discusses what measures that can be used as indicators of the safety of a management process in an industrial organization, such as the nuclear power industry. He points out that only recently the focus was shifted from technical and operator safety analyses to organizational issues and proceeds to present and discuss safety indicators in more detail.

Allwin gives an account of safety management in the Swedish Civil Aviation Safety Authority in Chapter 5. She illustrates how a system perspective is used, how threats are identified and how information is fed back into the system. In Chapter 6 Svenson continues on the theme of aviation by providing some information about event reporting in the Swedish aviation industry. The chapter also includes information about event reporting in the Swedish health care system including some advantages and shortcomings of different kinds of reporting systems and their legal frameworks.

In Chapter 7 Rollenhagen gives a theoretical perspective on safety management in nuclear power plants and stresses the issue of the managers' attention to different subsystems of a plant and its organization. He uses a model with different focus areas among which attention resources of the management have to be properly balanced (viz., strategic economic issues, technology, competence and human relations, and quality system issues.

In Chapter 8, Kettunen, Reiman and Wahlström give an overview of the most important safety management challenges, in the European nuclear power industry as seen from top and middle management positions. They report interesting similarities across countries and differences even within the Nordic countries. Chapter 9 by Reiman and Oedewald acknowledge the increasing complexity in industrial organizations and stress that safety and efficiency can be modeled as social and subjective constructions. They illustrate how perceptions, shared norms and beliefs influence technical solutions, strategic decisions and everyday practice and ultimately the risk profile of an industry.

Chapter 10 by Salo gives an overview of the regulator of the Norwegian oil industry. The Norwegian Petroleum Directorate applies a system model for regulating the industry. In Chapter 11, Skjerve and Lauridsen suggest mindful safety practices as a mean of avoiding accidents. They illustrate this approach with an empirical study of staff on Norwegian platforms in the North Sea to find out what contextual factors may facilitate employees' willingness to use those practices in everyday work. In Chapter 12, Nilsen treats the challenges posed by the change of an organizational structure. He describes how the oil industry now is changing including new planning routines based on uncertain information and how this leads to extra stress on communication and safety awareness. In Chapter 13,Torbiörn treats international organizations, cultural differences and uncertainty. His concise contribution rounds off the present volume.

The Editors

Chapter 1: A Frame of Reference for Studies of Safety Management

Ola Svenson
Risk Analysis, Social and Decision Research Unit
Department of Psychology
Stockholm University
S-106 91 Stockholm
osn@psychology.su.se

ABSTRACT

The chapter gives a theoretical framework for studies of safety management based on a system approach. Safety management is considered a process, in which, industries, societal representatives and the public interact in finding a balance between the benefits, costs and risks of products, activities and processes. The purpose of the chapter is to provide a framework based on a system perspective that is general enough for application in different approaches to safety management. A system theoretic perspective supports a safety manager in his/her analysis of and work in an organization.
Keywords. System theory, living systems, feedback, adaptation, adjustment, power

INTRODUCTION

The purpose of the present chapter is to provide a theoretical framework for studies of safety management in high-risk industries or activities with safety as an important concern.. There are a number of definitions of management and safety management. In the present context I shall start using the following general definition: " safety management is a process in which industries and producers, societal representatives and the public interact in finding a balance between the benefits, costs and risks of products, activities and processes".

From a normative point of view, it is reasonable to state that the goal should be to find a balance, which is the best for most of the people in the society and at least acceptable for everybody. From a descriptive point of view this goal is not always reached. This may depend on, for example, lack of facts, poor distribution of information and societal conditions including different actors' power and power relations. Safety management is executed on all levels of an organization. The organization itself must also be integrated in a greater context (e.g., society, environment) in any framework for safety management.

There are a number of different system approaches for analyzing social systems like a business, a firm or an industry. The interested reader can find a list of scientists who have done research using system theory at http://pespmc1.vub.ac.be/CSTHINK.html. The aim of the present chapter is to stay at a generic level and not to go into detail or introduce more specific theories. Under the umbrella of the framework, the authors of each chapter develop more specific approaches to management for their own contributions.

A SYSTEM APPROACH

The management literature is quite diverse and different authors use their own perspectives that often differ widely from each other (Salo & Svenson 2001). However, there seems to be some concepts that are fairly general and that can be translated into living systems terms. One advantage of interpreting the management concepts into living systems terms is that the living systems perspective can create a meta perspective avoiding the use of only one or the other approach to management. The reader of this volume is invited to test this hypothesis in her/his daily life and when reading the chapters of this volume.

In this section, I shall present a theoretical framework that can be used for modeling a suprasystem, such as a nuclear power plant, consisting of subsystems that are both living (e.g., a person, the organization) and non-living (e.g., the technical systems of the plant). Following this, I shall link some concepts from organizational management and safety management to the framework.

Living systems, such as, an organization exist in space and consist of matter and energy that are organized by information (Miller 1978). Living and non-living systems can be described in terms of *structures* and *processes*. The processes are governed by information and driven by energy. If we want to study a process, we have to *define a structure* including the primitives (smallest units) that we want to use. In other words, a process is always observed through changes in structure. (The primitives could also be processes and in this case the "structure" would concern "the structure of processes".)

Correspondingly, *we must use a process to map a structure*. To exemplify, if we want to understand the structure of attitudes of the people working in a nuclear power plant, we ask them to process the information of a questionnaire and to give us an output on paper, that we in turn can process to reach a conclusion about the structure of attitudes.

Systems often form hierarchies with subsystems. As mentioned in the introduction, a nuclear power plant or any other industry/human technology activity can be modeled as a suprasystem with two subsystems on the next lower level. Normally, the subsystems interact to keep themselves and the suprasystem in a steady state when it performs what it is intended to produce, e.g., electricity. But also in other steady state conditions, e.g., when the systems enter outage, stay in outage and when started again.

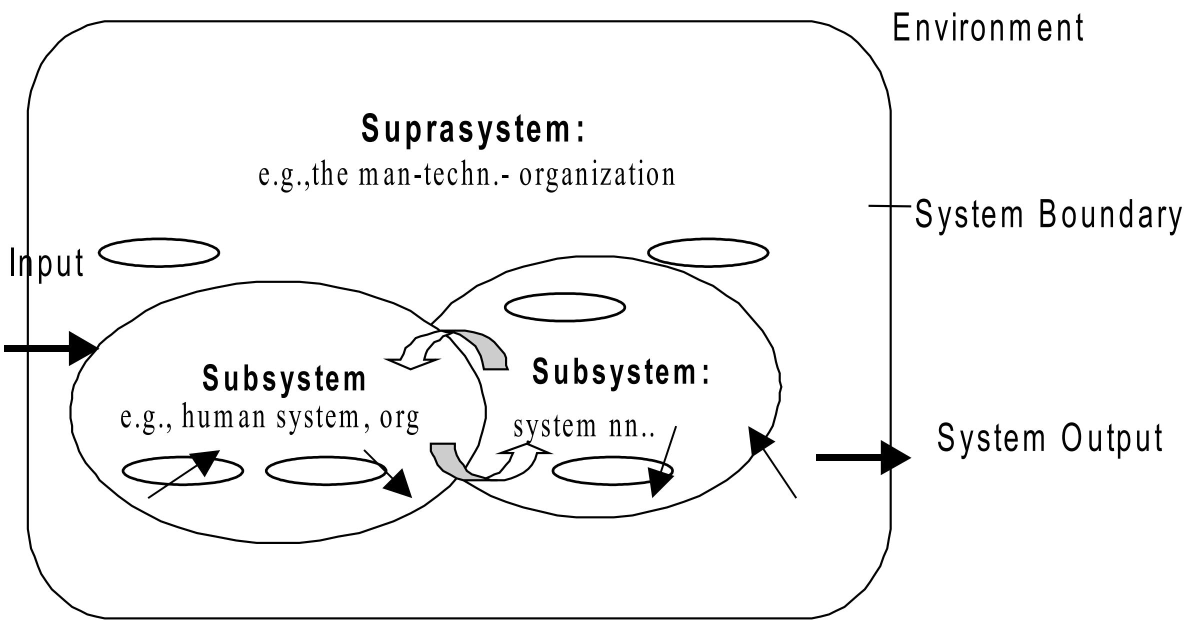


Figure 1. A schematic illustration of the structure of suprasystem and subsystems with process arrows of flows of information, matter and energy.

As mentioned above, what we call a plant or an industry system consists of one subsystem, which is a concrete constructed, technical *non-living system* and another other subsystem, which is the organization of people constituting a concrete *living system* (cf., Miller 1978). The purpose of the organization is to keep the suprasystem, including the technical and the organizational systems and their subsystems, within the limits of a steady state when producing electricity at a rate determined by other suprasystems (e.g., economic and political systems). That is, managing the suprasystem so that it is kept in a steady state with the all the variables within the range of stability prescribed by that steady state. If this is not done, the system's structures and processes change, and the system moves towards another steady state. In this change the system may even have difficulties to survive, but ideally it should adapt to the new environmental requirements.

"A system is adjusted to its suprasystem only if it has an internal purpose or external goal which is consistent with the norm established by the suprasystem " (Miller 1978, p.40) and therefore it is interesting to know to what extent the subsystems of a nuclear power plant or any industry share information and values with the suprasystem.

A system receiving positive feedback for change that is sufficiently strong will tend to change accordingly. For example, if more food (money) is available somewhere, a group of animals (firms) will tend to expand into that territory and increase in number. If there are incentives for change on the super level of a system, the subsystems may resist that change if they do not benefit from the change themselves.

If one of the variables moves towards the limit of stability, the system strives to counteract the movement through negative feedback. This is normal regulation of the system. Both the plant technical subsystem and the organization subsystem have lower level subsystems and some of these have the purpose of keeping variables within their ranges of stability. Figure1 is an attempt to visualize supersystems and subsystems at different levels.

Threats to the stability of a system appears when the system is exposed to stresses threatening to move its variables outside the range of stability and the system out of its steady state. Then it is important that adjustment processes keep the variables within their ranges of stability despite the stresses. In this situation, special subsystems (e.g., barrier function systems, Svenson 1991, 2001) are activated to preserve the steady state of the system. There are also cases in which there is a wish to change a system from one state to another. Then the key issue is whether this change is controlled or not and who controls it.

Barrier function systems are a kind of subsystems performing processes with the purpose of retaining a system within a steady state even under stress, for example, by means of blocking malign processes (e.g., a lead wall to protect the environment from radiation). If one barrier function system cannot handle the situation there are usually other backup systems (this is often called defense in depth). In a nuclear power plant, the organization and the plant are designed so that for most threats, other barrier function systems are activated to keep the suprasystem in a stable steady state. In living systems, such as humans there are normally so many coupled adjustment processes that the system can be called ultrastable (Miller 1978, p. 36).

Adjustment processes rely on negative feedback with the purpose of decreasing the deviation of a variable from the steady state of a particular variable and there are different kinds of negative feedback used to keep a system in a stable steady state. Among these one finds the following that are interesting for safety management.

(1) *internal feedback* has a feedback loop that never crosses the boundary of the system (e.g., temperature control functions in mammals). The interior of the organization of a nuclear power plant is full of such feed backs on all levels.

(2*) external feedback* goes outside the boundaries of the system receiving input from other systems (e.g., legal action against a system). This includes all input from the outside that can be interpreted as responses to the behavior of an industry, owner reactions, public opinion, market reactions political, reactions etc.

(3*) output feedback*, where the output regulates the output at a steady state level (e.g., rate of production). This is a feedback that can be used to achieve goals determined by other feedbacks and strategies (e.g., constant production to save energy or to keep a price high and stable).

(4) *input signal feedback* uses the input to regulate the input (e.g., if too much information reaches the system the information can be buffered or slowed down). It also covers more material things, such as of how much is kept in stock by a company etc

(5*) passive adjustment feedback,* which reaches a steady state through altering environmental variables (e.g., the system of a heater controlled by a thermostat that cuts off power when the environment has reached a certain temperature). This is a very important kind of feedback because it involves changing the environment, e.g., in terms of legislation, attitudes etc. The feedback can be executed in the form of physical change of the environment, research, advertising, influencing the media, lobbying, bribing etc

Loose feedback is a feedback that permits errors or marked deviations from the steady state before corrections are initiated. The opposite is *tight feedback* with a feedback loop that is quick and immediately corrects a deviation. It has been shown repeatedly that humans have great problems with *delayed feedback*, in particular when they control dynamic systems.

Adjustment of a system to its environment or interrelated systems can also take place through *changes in the system itself* in terms of its structures and internal processes. If the environment changes new positive or negative feedback will appear. Positive feedback will change the system until negative feedback is encountered All adjustment processes have their costs. The costs of changing a system can be in terms in terms of people and of information, energy, material, money, time etc and scarcity may affect how close to the goals the system can operate.

Optimal resource allocation processes are important in all system management including safety management. Note, that optimal does not mean maximum resource utilization because there must always be resources in reserve when the system is threatened. In the past, living systems have adapted resource allocation admiringly well in their normal natural environments with time horizons of resilience far beyond the life of the individual .

However, when the environment changes drastically and the systems are not prepared for this, the systems may become exposed to serious threats and have great problems with, for example, information overload, system resource scarcities and improper output. This perspective may also apply to the individual operator or group of operators as subsystems in safety management of an industry.

Power represents one system's ability to control another system at the same or at another level. Power and control is initiated, carried out and terminated through a sequence of information exchanges. A system transmits a message or command signal to another system and there are a number of specific characteristics of such messages. The message has an address (receiver), a signature, contains evidence that the transmitter is legitimate, expects compliance and the message specifies an action the receiver is expected to carry out.

A great deal of the communication within an organization can be seen in a perspective of formally defined and informal power. The relationships between a regulatory body and a regulated industry should illustrate such a relationship. *Competence of power* means that those in power are able to understand and influence subsystems essential for keeping a system in a stable state or for changing the system safely from one stable state to another.

ON SAFETY MANAGEMENT

As mentioned above the purpose of a nuclear power plant system is to remain in a preferred steady state that is partly defined by external rewards and punishments and partly by internal factors. One kind of external goals of a nuclear power plant system is to produce electricity as cheaply as possible. Another kind of goals consists of safety management goals. Such a goal can be to operate the plant more safely than the year before, another goal that the plant should be safer than other plants. Or there may be the goal to fulfill regulator safety regulation without improvements or increased safety in comparison with the officially required safety levels. The two kinds of goals (production and safety goals) sometimes coincide and sometimes they are antagonistic. Adequate management in a plant supersystem and its subsystems implies that adjustment and feedback functions are maintained so that the plant remains in a steady state during its life time, even under conditions of threat and stress.

Generally speaking, safety management entails the establishment of a management process committed to determining the threats to a system or its environment, the risk level of a particular activity or product, and instances in which deviations from normal or desired processes can be associated with risks. The safety management process of high socio-technical activities, such as those in the process industry or in a transportation system, addresses issues of how to cope with the complexity of all of the factors, which are relevant to management and regulation (cf., Hale, Heming, Carthey & Kirwan 1997). Hale and his co-authors (1997, p.121), also emphasize the dynamics of safety management as a process, they want to consider safety management "as a set of problem solving activities at different levels of abstraction in all phases of the system life cycle".

Safety in a risky activity/industry can be given different roles. To exemplify, (a) an organizational system can treat the external feedback of minimum safety levels (c.f., societal regulating authority rules and legislation) as *limiting conditions* within which the organization is free to behave. No deviations outside the permitted limits are allowed.

It is also possible to (b) treat the external minimum safety level feedback as information also about the *costs of behavior in violation of the safety limits*. For example, an organizational system may calculate the costs of following the safety limits, the gain of exceeding the limits, the probability of detection and the penalty of doing so if detected. This can be illustrated by a decision to drive faster than the speed limit or not to do it. An organization may find that the expected value of not following the external safety limits is greater than if they are followed and decide to violate the safety rules in a trade off decision. Alternatively, it is also possible for the system to find that safety violations are detected with such a probability and cost so much that it is economically wiser to introduce more strict internal safety limits than regulated to insure against big losses (production losses, material losses, economic losses etc).

There is also a possibility (c) to use external safety limits as a *parameter of competition*. Then the external safety limits are seen as the first steppingstones towards system safety levels that are stricter than those imposed externally. This presupposes that there is a "market" (of reputation, economy, influence etc) for safety. The Volvo car company viewed safety in this way for many years. In this case the organizational system could influence societal external safety limits so that they become even stricter, forcing competitors to spend resources on corresponding safety measures.

However, it is also (d) possible that an organization attempts to *influence the external safety limits negatively* towards more lax levels (through e.g., lobbying, economic threats, moving a factory).

APPLIED CONSIDERATIONS

The remaining chapters of this volume will provide many applied examples of the system approach to safety management. Here I just want to draw attention to a few general themes that could be attended to and which may support a safety manager in her/his work in a risky industry/activity. For example, one may try to generate possible threats to the system beyond those already predicted by most people in the business. What are the safety consequences if the threat becomes real? What are the relations between different subsystems and with the supralevel of the organization in a future perspective? Can you find any safety consequences beyond those already attended to in the organization? System theory underlines the feedback concept. What are the formal and informal safety feedback loops within the organization and with the environment of the organization that have not been already been taken care of in a satisfactory way?

REFERENCES

Hale, A.R., Heming, B.H.J., Carthey, J., & Kirwin, B. (1997). Modelling of safety management systems. *Safety Science*, 26 (1-2), 121-140.

Miller JG (1978) *Living Systems*. McGraw-Hill, New York.

Salo,I. & Svenson, O. (2001) Organizational culture and safety culture: A selective review of the studies in the field. *SKI Report* , 01:40.

Svenson, O., & Salo, I. (2003). *Safety management: A frame of reference for studies of nuclear power safety management and case studies from non-nuclear contexts.* Report submitted to to NKS.

Acknowledgment

This chapter includes Svenson's part of the earlier study by Svenson and Salo (2003) with some elaborations of the system perspective. Comments from Ann Britt Skjerve, Carl Rollenhagen and Ilkka Salo were very helpful when finalizing the chapter.

Chapter 2: Efficient Inspections

Lars Lindblom and
Sven Ove Hansson
Department of Philosophy
and the History of Technology
Royal Institute of Technology
Teknikringen 78
S - 100 44 Stockholm
Sweden
lars.lindblom@infra.kth.se

ABSTRACT

Workplace inspections are undertaken because they are believed to lead to better conditions on the workplace. It is therefore essential to know if inspections have the desired effects on working conditions. We introduce a theoretical framework for the evaluation of workplace inspections with respect to their effects on working conditions. Criteria of efficiency and priority-setting are discussed. Some empirical results concerning priority-setting in Swedish inspection agencies are presented. Further, we argue that in order to obtain reliable information about the effects of different inspection methods, it is necessary to perform controlled comparative studies in which different methods are used in different workplaces. Given the facility with which such studies can be performed, it is surprising how few such studies have been made. We conclude by surveying some empirical studies that concern the issue of efficient inspections.
Keywords: risk management, inspection, regulation, evaluation.

INTRODUCTION

The efficiency of safety inspections is an essential issue in safety management. However, surprisingly little is known about whether (and then to what degree) inspections and other enforcement activities have the desired effects on working conditions. “[L]ittle research exists on the actual regulatory experience: that is, how enforcement encourages compliance and how compliance behavior influences enforcement allocation”. (Gray and Deily 1996, p. 96) We have only fragmentary knowledge about the effects of enforcement on compliance behavior and working conditions. The field is characterized both by a lack of reliable empirical data and by a lack of theoretical underpinnings for the interpretation of such data. In this chapter we give an outline of the present state of knowledge in this area and propose further research that can provide us with more, and more reliable, information about the efficiency of inspections.

EFFICIENCY

In order to clarify what we mean by efficient inspections, it is useful to take as a starting-point the general notion of efficiency, as it is used in economic theory and elsewhere. Efficiency means satisfaction of goals (criteria, standards). To determine the degree to which goals have been reached means to determine the degree of efficiency in satisfaction of these goals. In some cases, we refer to only one single goal. Then, efficiency (in this case more commonly called effectiveness) means that this goal is satisfied to as high a degree as possible. In most cases however, efficiency refers to two or several goals. Then, efficiency has been achieved with respect to the given goals if and only if none of these goals could have been achieved to a higher degree without some of the others being achieved to a lower degree (LeGrand, 1991).

Discussions of efficiency are often confused by a lack of precision with respect to the identity of the goal dimensions. In most contexts, the two most important notions of efficiency are effectiveness and cost-efficiency. A measure is *effective* to the extent that it solves the problem that it is intended to solve. It is *cost-efficient* to the extent that it is efficient with respect to two goals: improvement and cost minimization.

An obvious success criterion for workplace inspections is the degree to which they lead to increased compliance with regulations. However, compliance as such is not in general the intended final outcome. There is an underlying assumption that rule compliance will lead to more concrete effects such as lowered injury rates and other improvements in working conditions. Although this assumption is in most cases reasonable, the step from rule compliance to improved conditions is not in all cases automatic. It may be fairly automatic for a regulation about machine safety, but far less so in the case of a regulation about the internal health and safety organization of the regulated companies. As can be seen, for instance, from Hutter's (Hutter 2001) in-depth study of occupational health and safety in the British railroad system, the relationship between rule-setting, compliance with rules and actual workplace conditions is complex and may be different in different types of companies and workplaces. In explaining the safety performance of British Railways, Hutter found little support for the profit-maximization hypothesis. Aspects such as company culture and tradition had more explanatory power. The research also suggested that that a general lack of coordination in large companies may be a major reason for failures in the health and safety field.

The model shown in Figure 1 is proposed as a conceptual framework for the relationship between rule compliance and improvements in working conditions. The major intended mechanism by which inspections reduce risks is through increased compliance. (Arrows 1 and 2 in the diagram.) In addition, inspection can also have direct effects, not mediated by compliance with the written regulations. (Arrow 3 in the diagram.) For instance, inspections may lead to improved safety routines or heightened health and safety consciousness in an organization. For a deeper empirical understanding of the effects of inspections, each of the three links in the diagram should be studied as much in isolation as possible. This means that if possible, the effects of inspections should be studied *both* in terms of rule compliance and in terms of indicators of the quality of actual working conditions.

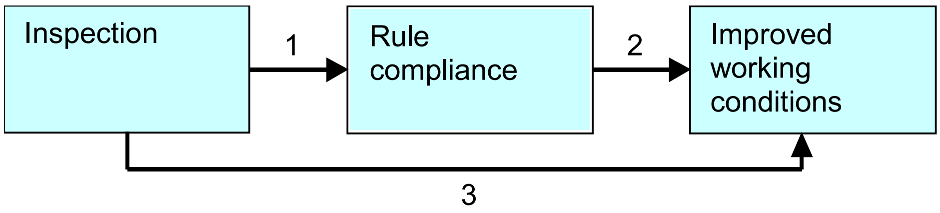


Figure 1 A framework for studies of efficiency in inspections

PRIORITIES

The concept of efficiency is rather theoretical and it is not often used in the everyday practice of safety management. However, the notion of priorities and priority-setting are often referred to, and there is a close relationship between criteria of efficiency and principles of priority-setting. We will therefore treat the two types of criteria in parallel.

The following is a simple principle that focuses on workplace conditions and does not take costs into account:

(1) *Worst things first*:
Priority-setting: The highest priority is assigned to the worst working conditions.
Evaluation: Efficiency is achieved when the quality of the worst working conditions is maximized.

From the viewpoint of justice, strong arguments can be made in favor of (1). The employees who are exposed to the worst working conditions have a reasonable claim to receive help from the responsible authorities before help is given to others with less serious problems. (1) can also be seen as an analogue to the difference principle that is one of the most characteristic elements of John Rawls's (Rawls 1972) theory of justice. According to that principle, the degree of justice in a society is determined by the living conditions of those who are worst off in that society. According to (1), the success of attempts to improve working conditions in a society is determined by the state of the worst working conditions in that society.

Until recently, the Swedish labour inspectorate used as a result indicator that 55 % of the inspections should lead to written injunctions. (Johannesson et al 1999) This indicator urges inspectors to visit the workplaces where they expect to find the worst working conditions, and can therefore be seen as an attempt to implement priority principle (1).

From an economical point of view (1) is far from unproblematic. Arguably, when used for priority-setting, this criterion can lead to the misuse of resources, since "it is crucial to tackle not only issues that are important, but problems that are amenable to solution". (Wirth and Silbergeld 1995, p. 1878) The following is an alternative criterion that shares with (1) the property of focusing entirely on working conditions, and not mentioning costs:

(2) *Maximal total improvement:*

Priority-setting: The highest priority is assigned to the alternative that maximizes total improvement.
Evaluation: Efficiency is achieved when total improvement is maximized.

To clarify the difference between (1) and (2), we can use the following schematic example: An inspector can choose between two activities A and B. Activity A is aimed at a small company in which 50 persons are exposed to conditions such that 10% of them contract a certain disease. Activity A reduces this frequency from 10 to 0 %. Activity B is aimed at a large company in which 5000 persons are exposed to conditions such that 1% of them contract the same disease. Activity B reduces this frequency from 1 to 0 %. According to priority-setting principle (1), activity A should be given higher priority since an individual risk of 10% is worse than one of 1 %. According to priority-setting principle (2), activity B should be preferred since it leads to a much higher reduction of total risk. Activity B is expected to save 50 persons from the disease whereas activity A is only expected to save 5 persons. Although this example is rather extreme (in order to make the differences as clear as possible), it presents a type of choice that inspecting agencies often have to make in practice.

Next, let us turn to criteria that take costs into account. In the context of measures taken by public agencies, the notion of cost efficiency is ambiguous since it may refer either to (i) costs in terms of agency resources or (ii) costs in terms of total social resources. These two delimitations of costs are both relevant, and so are the two notions of cost-efficiency that they give rise to.

The following principle seems to have some influence in public agencies:

(3) *Best use of agency resources*:
Priority-setting: The highest priority is assigned to the alternative that maximizes the total improvement per agency resource input.
Evaluation: Efficiency is achieved when the total improvement per agency resource input is maximized.

In this form of cost efficiency, only those costs are taken into account that pertain to the agency's own resources. In the agency's own deliberations, in which the resources available to the agency have to be taken as a given, fixed amount, priority-setting principles (2) and (3) will yield the same policy recommendations although (3) but not (2) mentions costs explicitly.

Several studies indicate that prioritizations are sometimes made in approximate accordance with principles (2) and (3). Hence, a series of studies conducted by David Weil (1991, 1992, 1996) show that OSHA (Occupational Safety and Health Administration) inspectors focus their attention on large unionized establishments. Similarly, in Norway, plants with strong local unions were inspected more often by the Labour Inspectorate than plants with weak local unions. (Halgunset and Svarva 1980, pp. 125-126) One plausible explanation of these results is that unions facilitate the implementation of the inspector's injunctions, so that less agency resources have to be spent in these plants to obtain compliance. Another possible explanation is that agencies prefer to work with companies in which negotiated compliance is achievable, and therefore do not give priority to plants that are less willing to comply (Johnstone, 1999). A quite different approach is to take not only agency resources but total social resources into account.

(4) *Best use of social resources*:

Priority-setting: The highest priority is assigned to the alternative that maximizes the total improvement per total social resource input.

Evaluation: Efficiency is achieved when the total improvement per total social resource input is maximized.

Contrary to (3), (4) cannot be reduced for practical purposes to a one-dimensional measure. It requires that the agency continuously optimizes its activities according to estimates of total costs. Unfortunately, total social costs are often very difficult to estimate, due to lack of information and to the unpredictability of technological and social change. Often agencies depend for these estimates on information from companies. Cost estimates based on presently available technologies can be misleading in areas with a large potential for technological innovation.

Other principles for priority-setting and evaluation are of course also possible. Although it is common to accuse regulators of not setting the right priorities, critics often leave their audience ignorant of exactly what is the criterion against which they measure actual performance. Studies of actual priority-setting that take these basic distinctions into account would be valuable contributions.

PRIORITY-SETTING IN SWEDISH INSPECTION AUTHORITIES

Whereas national differences in regulation and enforcement have been the subject of several studies (Vogel 1986; Jasanoff 1992; Münch 1995), much less research has focused on how policies and practices differ between different policy areas. In a recent study (Lindblom et al. 2003) we investigated the nature of such differences, among eight Swedish government agencies with inspection tasks in the areas of health, safety, and environmental protection, namely the authorities responsible for nuclear safety, radiation protection, railway, marine and aviation safety, environmental protection, chemicals control, and health and safety on workplaces.

As already mentioned, the The Work Environment Authority seems to adhere to priority-setting principle (1). This authority sets priorities according to the principle "worst work environment first". The Chemicals Inspectorate gives priority to companies with large production volumes, many products, dangerous substances, and substances with an extensive distribution and potential for human exposure. This can be seen as a combination of principles (1) and (2).

The Radiation Protection Authority gives priority to objects that may yield high doses of radiation, or that may involve many people with small but not negligible doses, or that the authority needs to know more about. When asked about the four above-mentioned priority-setting principles the Authority says that it mainly adheres to priority-setting principle (1) in the areas of industry and research, principle (3) in the area of nuclear energy, and principle (4) in the area of medicine.

The Environmental Protection Agency seems to be closer than some of the other agencies to priority-setting principle (2). The significance (risk) of an environmental problem is balanced against the expected effect of a particular effort as well as the company's own ability to solve the problem. Situations in which the environmental problem is significant and the company's ability to solve the problem inadequate are prioritized. Similarly, the Railway Inspectorate gives priority to companies and activities that have the most profound effect on traffic safety ("largest improvement effect").

The Nuclear Power Inspectorate gives priority largely to problem areas with high risk significance or potential risk (corresponding to priority-setting principle (1)), but also to new technologies. Random checks unrelated to risk estimates are also made. The Aviation Safety Authority has not developed priority-setting principles for the choice between inspection objects. Hence, in summary, there are large differences between the agencies in the ways that they set priorities. These choices are so important for the effects of their inspecting activities that cooperative endeavours to clarify the issues and to better relate priority-setting principles to operative goals should be a useful activity.

DESIGNING EVALUATIVE STUDIES

Ideally, we would like to know the total effects on working conditions of the inspection activities of a country's health and safety authorities. We would like to know, for instance, if and to what extent workplaces are improved and work-related illness is reduced when more resources are spent on government activities in this area. There are two methods that could, at first glance, be expected to provide such information, namely time series and international comparisons. On closer inspection, it turns out that neither of these can provide us with reliable information on the total effects of agency activities.

Time series are of very limited use since the development of working conditions in a country is influenced by many other factors than agency activities. Therefore, even if we find for instance that total accident rates have increased (or decreased) after a decrease (increase) in an agencies resources or a change in its methodologies, no conclusion can be drawn from this. It is in practice impossible to exclude that the observed changes are not instead due to the influence of other factors such as new technology or the general economic development.

For similar reasons it is very difficult to draw conclusions from international comparisons. There are many factors in addition to agency activities that can lead to differences between countries in the quality of workplace conditions. Some of these factors correlate in complex ways with agency resources, so that the effects of the latter are in practice impossible to isolate. In addition, it is very difficult to compare the extent and the character of workplace inspections in different countries.

Therefore, on the whole, the idea of evaluating total effects is not feasible in practice. What can be done with hope of success is to find out the effects of single measures. Even this, however, is far from simple. The usual evaluation method, in which the state of the working environment before and after measures is compared, is problematic for much the same reasons as the use of time series in the evaluation of total agency activities. Suppose for instance that a new inspection method, or intensified use of traditional inspections, is tried out in a particular branch of industry, and that a substantial improvement in working conditions is found to take place. This may of course depend on the inspection activities, but it may also depend on other factors such as voluntary measures that industry would have taken even in the absence of inspections.

By far the best way to isolate effects of inspections from effects of other causal factors is to perform studies in which different but comparable and matching workplaces are treated differently with respect to inspections. This means that companies are inspected with different methods, in accordance with a study design that has been constructed to detect differences in working conditions that may be the result of these differences in inspection.

It is important to note that the reason why the efficiency of single measures and methods but not that of total agency activities can be determined is exactly this: Controlled comparisons are feasible in the former case but not in the latter. To obtain results that are fully reliable from a scientific point of view it is not sufficient to shift focus from total effects to effects of single measures. It is also necessary to implement stringent study designs in which the effects of inspections are isolated as far as possible from the effects of other causal factors.

As we have already indicated, the current standard procedure is to design evaluation studies only after all decisions on the actual inspections have been made. This procedure makes the task of evaluators next to impossible. In order to make well-informed methodological development possible, evaluation must be integrated in the general planning of inspection activities. This means that (new and old) methodologies, as well as different intensities of inspection, should be distributed among companies in ways that are compatible with the design requirements of evaluation studies.

It is instructive to compare the epistemological conditions for evaluating workplace inspections with those of clinical research in medicine. The randomized clinical trial, in which treatment of patient groups is organized in ways that facilitate the evaluation of treatment effects, is the only scientifically accepted methodology. It would be a big step backwards to replace this method by outside evaluators who evaluated treatments that had not been organized in this way. Such outside evaluators would miss most of the effects that can be discovered in well-organized clinical trials and fall victim to the judgmental biases that the randomized clinical tests are designed to avoid.

Few other organizations have better opportunities than inspection agencies to determine the effectiveness of their activities by systematic testing and evaluation of alternative methods – provided that inspection activities are planned in accordance with the requirements of evaluation design. If there are, say, 100 companies in a certain branch of industry to be inspected, then they can be randomly divided into two groups of 50 that are inspected by different methods. Possible evaluation methods include studies of injury records and later inspections with uniform methodologies. Inspection methods that can be evaluated in this way include:

- announced vs. unannounced inspections
- short, frequent or fewer, more extended inspections
- inspections focusing on compliance with specific rules or on routines for self-control
- different degrees of stringency, e.g. in terms of formal ticket-writing

WHAT WE KNOW

Surprisingly few evaluation studies of inspections have been performed that satisfy the quality criteria outlined in the previous section. In this final section, we will give a brief overview of studies that allow for conclusions on the efficiency of inspections. Our survey consists of two parts. In accordance with the distinction between inspections' effects on rule compliance and on improved working conditions presented in Figure 1 A, we will first discuss studies that show the former effect and then research that has focused more directly on working conditions.

Several American studies indicate that OSHA inspections result in improved rule compliance among regulated establishments. Hence, a longitudinal study of the custom woodworking industry showed that compliance with machine-guarding standards was substantially increased after inspections (Weil 1996).

According to another study of OSHA inspections, enforcement actions against firms with 100-500 employees had larger impact than enforcement directed against larger or smaller firms. Furthermore, this study indicates that the size of penalties was inconsequential. Smaller penalties had equal effects as larger ones, but took considerably less inspection time (Gray and Scholz 1991).

In a large material based on OSHA inspections in the years 1972–1983, the effects of inspections were measured in terms of the number of citations on subsequent inspections. This study showed that the initial inspection of an establishment rather drastically reduced subsequent violations. (Citations were reduced by about 50% and exposures above OSHA limits by 42%.) In contrast, subsequent inspections had little effect on compliance. "The results suggest that, on the margin, substantial gains could occur if inspection resources were reallocated from the intensive margin to the extensive margin of OSHA's inspection strategy" (Gray and Jones 1991a and 1991b).

It is interesting to note in this context that the intuitive opinions of inspectors on the efficiency of prosecution are not uniform. Hence in a study by Hawkins (2001), half of the interview factory inspectors believed that prosecution has an impact on the behavior of employers, whereas the other half did not share that opinion. Unfortunately, there is insufficient research data to adjudicate between the two opinions: Although evidence is available that indicates positive effects of corporate sanctions, there also seems to be contexts in which sanctions adversely affect compliance with the law. (Makkai and Braithwaite 1994)

Wilthagen (1993, p. 268) summarizes a follow up study of inspections by the Dutch Labour Inspectorate.

> "In 55 percent of the cases the employer had met the wishes or demands of the inspector after the initial visit. In 10 percent the firm had complied after two or more visits. In 22 percent the problems had only partially been solved. In about 10 percent of all cases the employer hade not (yet) taken the measures required by the inspector. On further examination it turned out that the Labour Inspectorate was notably successful when minor measures had been demanded. Major, that is structural, safety and health problems in firms are less easily influenced and solved by labour inspectors. The intervention of labour inspectors hence runs the risk of appearing [to be] of a non-lasting and non-substantial nature."

In a study of the so-called macro method (a method for intensive systems inspections developed in the Malmö branch of the Swedish labour inspectorate), compliance with rules of internal control was investigated with extensive structured interviews with the local parties on the workplaces. An index (the IK index, internal control index) was used to summarize the level of internal control on the workplaces. Similar workplaces on which the macro method was not applied were used as a control group. The results indicate that the macro method gives rise to improved internal control on inspected workplaces (Levin 2002).

The studies referred to this far have all concerned the effects of inspections on compliance with regulations. Even more interesting is their effects on the final outcomes that these regulations aim at, improved working conditions. Several studies have shown effects of OSHA inspections on injury rates. (For an early study showing no effect, see McCaffrey 1983. See also Smith 1979, in which evidence for an effect was found.) One study showed that for plants with 200 or more employees, OSHA citation activities substantially reduced the number of days lost due to injury. Furthermore, this study gives indication that plant-specific programmes (jointly administered with unions) were more efficient in reducing injuries than OSHA activites, but the limited statistics makes this last conclusion uncertain (Cooke and Gautschi 1981).

A study of the impact of OSHA inspections between 1979 and 1985 showed a significant effect: Inspections imposing penalties induced on average a 22% decline in injuries in the inspected plant in the following few years. (Regression to the mean was controlled for.) There was also a decrease in workday losses, more precisely a return of 15–18 fewer lost workdays per 1 inspector workday. (Gray and Scholz 1993) In another paper, the same authors have estimated that a 10% increase in OSHA enforcement activity reduces injuries by 1% in large, frequently inspected firms (Scholz and Gray 1990).

A more recent study (Baggs, Silverstein and Foley 2003) compared the effect of inspections with those of consultations on claims rates for workman's compensation. A strong association was found between enforcement visits and a decrease in claims for compensation. The decline from the baseline year when enforcement took place to the next year was 25%. No significant effects were found for consultations.

In summary, the literature that is available on the effectiveness of inspections gives us strong reason to believe that inspections can have positive effects on working conditions. However, not much can be inferred from these studies about how inspections should be conducted in order to maximize these effects. That remains to be investigated in future controlled studies of inspections methodologies. Such studies would aim at investigating all the correlations represented by the three arrows in Figure 1 A, and should have a clear definition of the criterion of efficiency used.

REFERENCES

Baggs, James, Barbara Silverstein and Michael Foley (2003) "Workplace Health and Safety Regulations: Impact of Enforcement and Consultation on Workers' Compensation Claim Rates in Washington State", *American Journal of Industrial Medicine* 43:483-494.

Cooke, William and Frederick H Gautschi (1981) "OSHA, Plant Safety Programs and Injury Reduction", *Industrial Relations* 20:245–257.

Gray, Wayne B and Mary E Deily (1996) "Compliance and Enforcement: Air Pollution Regulation in the U.S. Steel Industry", *Journal of Environmental Economics and Management* 31:96–111.

Gray, Wayne B and Carol Adaire Jones (1991a) “Are OSHA Health Inspections Effective? A Longitudinal Study in the Manufacturing Area”, *Review of Economics and Statistics* 73:504–508.

Gray, Wayne B and Carol Adaire Jones (1991b) “Longitudinal Patterns of Compliance with Occupational Safety and Health Administration Health and Safety Regulations in the Manufacturing Sector”, *Journal of Human Resources* 26:622–653.

Gray, Wayne B and John T Scholz (1991) “Analyzing the Equity and Efficiency of OSHA Enforcement”, *Law and Policy* 13:185–214.

Gray, Wayne B and John T Scholz (1993) “Does Regulatory Enforcement Work? A Panel Analysis of OSHA Enforcement”, *Law & Society Review* 27:177–213.

Halgunset, Joralf and Arne Svarva (1980) *Arbeidstilsynet – politi eller rådgiver*, Trondheim, Institutt for Industriell Miljøforskning.

Hawkins, Keith (2002) *Law as Last Resort: Prosecution Decision-Making in a Regulatory Agency*, Oxford, Oxford University Press

Hutter, Bridget M (2001) *Regulation and Risk: Occupational Health and Safety on the Railroads*, Oxford, Oxford University Press

Jasanoff, S. (1992). ”Science, politics, and the renegotiation of expertise at EPA”. *Osiris, 2nd series* 7:195–217.

Johannesson, Mikael, Sven Ove Hansson, Christina Rudén and Mats Wingborg (1999) “Risk Management – the Swedish Way(s)”, *Journal of Environmental Management* 57:267-281.

Johnstone, Richard (1999) “Improving Worker Safety: Reflections on the Legal Regulation of OHS in the 20th Century”, *Journal of Occupational Health and Safety*, Australia and New Zealand 15:521-526.

LeGrand, Julian (1991) *Equity and Choice. An Essay in Economics and Applied Philosophy*, London, Harper Collins Academic.

Levin, Rikard (2002) *Utvärdering av makrometoden vid AI/Malmö*. Slutrapport, Arbetsmiljöverket, Stockholm, Rapport 2002:4.

Lindblom, Lars, Jonas Clausen, Karin Edvardsson, Madeleine Hayenhielm, Hélène Hermansson, Jessica Nihlén, Elin Palm, Christina Rudén, Per Wikman and Sven Ove Hansson (2003) *How Agencies Inspect – A Comparative Study of Inspection Policies in Eight Swedish Government Agencies*, SKI Report 2003:36, Statens Kärnkraftinspektion.

Makkai, Toni and John Braithwaite (1994) ”The Dialectics of Corporate Deterrence”, *Journal of Research in Crime and Delinquency*, 31:347-373.

McCaffrey, David P (1983), “An assessment of OSHA's recent effects on injury rates”, *Journal of Human Resources* 18:131–146.

Münch, R. (1995) ”The political regulation of technological risks. A theoretical and comparative analysis” *International Journal of Comparative Sociology* 36:109–130.

Rawls, John (1972) *A Theory of Justice*, Oxford, Oxford University Press.

Scholz, John T and Wayne B Gray (1990) “OSHA Enforcement and Workplace Injuries: A Behavioral Approach to Risk Assessment”, *Journal of Risk and Uncertainty* 3:283–305.

Smith, Robert Stewart (1979), “The impact of OSHA inspections on manufacturing injury rates”, *Journal of Human Resources* 14:145–170.

Vogel, D. (1986). *National styles of regulation. Environmental policy in Great Britain and the United States*. Ithaca: Cornell University Press.

Weil, David (1991) “Enforcing OSHA: The Role of Labor Unions”, *Industrial Relations* 30:20–36.

Weil, David (1992) “Building Safety: The Role of Construction Unions in the Enforcement of OSHA”, *Journal of Labor Research* 12: 121–132.

Weil, David (1996) “If OSHA is so bad, why is compliance so good?”, *RAND Journal of Economics* 27:618–640.

Wilthagen, ACJM (1993) *Het overheidstoezicht op de arbeitsomstandigheten*, Wolters-Noordhoff, Groningen, PhD thesis, University of Amsterdam.

Wirth, David A and Ellen K Silbergeld (1995) “Risky Reform”, *Columbia Law Review* 95:1857–1895.

Chapter 3: Feedback for Pro-activity: Who Should LearnWhat from Events, When and How

Inge Svedung and Helena Rådbo
Karlstad University
Dep of Social Science
Public health sciences / Risk research
SE 651 88 Karlstad, Sweden
inge.svedung@kau.se

ABSTRACT

In this chapter the adaptive dynamic behaviour of individuals and groups is discussed to stress the importance of pro-activity in the governance of the socio-technical systems they are part of. Following this we discuss the importance of knowledge, situation awareness and dedicated information governed by local requirements. Knowledge is seen as a result of learning based on experience or information feedback. Such feedback can either be immediate or more delayed, indirect and generic regarding content of information. These processes of learning from events can therefore be categorised with respect to timely and functional directness but also regarding how formal they are. Dynamic decision-making refers primarily to every day activities in settings that, for reasons that is discussed, are dynamic in nature. This decision-making is based on individual and rather direct experience feedback on system response and with no formal methods of learning associated with it. This type of process where individuals handle own experiences is referred to as *single loop learning*. Event investigation processes on the other hand are more formal and performed either to make detailed in depth analysis of single cases and the developments behind them or to encompass data from several events within a certain arena or type of context. Such processes of collecting, analysing and demonstrating event-experiences are performed to create data adapted to the needs of many actors performing different functions on different hierarchical levels in socio-technical systems. When performed within an organisation these processes are referred to as *double loop learning*. When encompassing several organisations and levels in society the process is called societal or *triple loop learning*. The main purpose of this chapter is to shed some light on the process of event data collection, handling and utilization in terms of “Who”, “What”, “When” and “How”.
Keywords: dynamic decision-making, pro-activity, feedback, individual learning, organisational learning, societal learning.

INTRODUCTION

Pro-active management

Management is about many things and in many respects the understanding of it is based on theories about control of systems that encompass, not only the physical level (technical and environmental parts), but also individuals, organisations and society.

All such systems are exposed to external influences or pressures and manned with individuals with the ability to realise demands for streamlining and to identify possibilities for improved efficiency in a local operational and organisational context. These individuals also have the ability and the motivation to test such possible improvements and to adapt their future performance based on the experiences gained from such attempts. For good and for bad these adaptive manners are behind systems dynamic developments and they constitute management as a dynamic control issue. This multidimensional control issue can be illustrated in analogy with a closed loop negative feedback control model as in figure 1, where tree dimensions are indicated together.

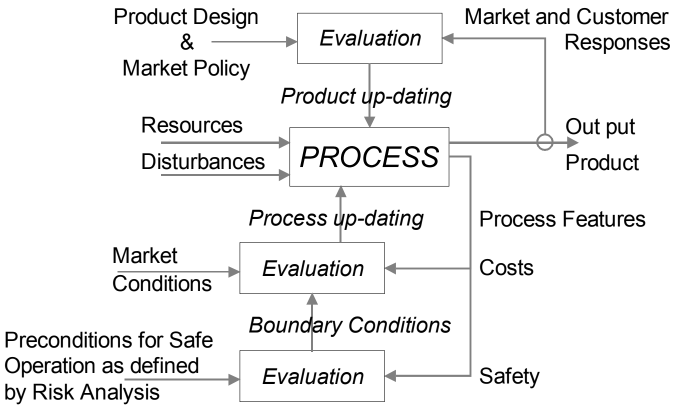


Figure 1. Management can be seen as a control issue with many dimensions. (Rasmussen & Svedung 2000)

The term *Re-activity* is about preventing the re-occurrence of identical events in identical settings. *Pro-activity* is about preventing undesired events form occurring in dynamically changing settings. All socio-technical systems should be seen as dynamic due to functional and organisational coupling between many actors with confined situation awareness, performing different tasks with a variety of goals and acting adaptively

Accidents and near accidents can be seen as unplanned side effects of normal forward-focused activities performed more or less in line with plans and designs. Accidents and near accidents constitute the experiences that create the resistance or "counter gradient" to unrestrained focus on efficiency and workload that could lead to a drift toward unsafe conditions as indicated in figure 2 (from Rasmussen 1994). The term "gradient" originate from the thermal diffusion or "Brownian motion" analogy introduced by Rasmussen. In that context it refers to the spatial variation of a concentration of some element.

Safety can be considered as a state supported by visible borders of safe operation. Such borders can be of two kinds. One is constituted by the presumptions that were used as basis for the design of processes, routines and equipment. The other is constituted by the experiences of different kinds drawn by actors in the system and communicated to others

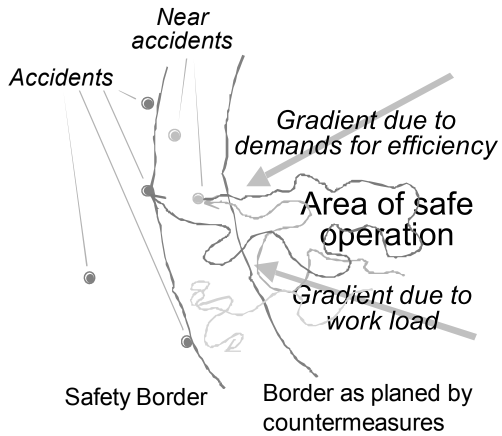


Figure 2. Accidents and near accidents constitute the experiences that create the resistance or counter gradient to unrestrained focus on efficiency and workload. Safety can therefore be considered as a state supported by visible borders of safe operation. (From the "Brownian motion model" by Rasmussen 1994)

Therefore, from a safety management point of view, the knowledge on all hands involved is of vital importance; knowledge of what is critical with reference to system's functionality and safety. From a control point of view, critical knowledge is about a system's way of functioning on the one hand and the system state as it is and with reference to the desired state on the other. If these conditions for internal feedback control are satisfactorily fulfilled and the capability, awareness and priorities are right, the dynamic decision-making within a system and the corresponding adaptive behaviour can be allowed for and utilised in a secure and profitable way. But this means that also the design process performed to define and create such conditions has to guarantee full knowledge and situation averseness within itself. And it has to do so while encompassing all the functions that the system to be designed will utilise when maintained and in operation.

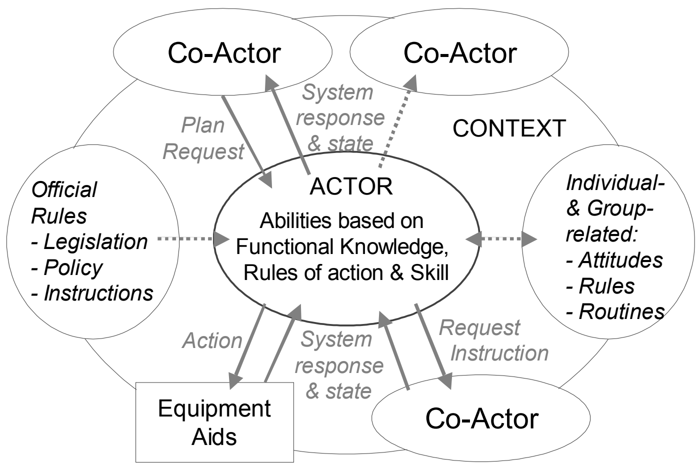


Figure 3. All actors perform their functions in co-operation with others within a local context. They interpret signals from around and react on them based on their own personal cognitive strategies that in turn are based on knowledge, personal rules and skill. When doing so they are influenced by official rules and group-related rules, attitudes and routines.

Proper feedback also supports the development and maintenance of people's functional knowledge, awareness and promptness to consider safety. Improper feedback may lead to the opposite. By functional knowledge we mean knowledge about causal factors influencing the systems way of functioning (What will be the system's reaction to what and way). Factors influencing an individual actor in a system of actors are illustrated in figure 3.

One function of critical importance for proactive management by closed loop negative feedback control is the information management itself. All information, from simple alert signals to intricate statistical data, theoretical explanations, rules and regulations has to be presented when needed and in a form that supports the cognitive processes of the receiving individual and her/his functional understanding of what is at hand. Information that is planned to elicit strong cognitive vigilance with respect to a certain issue has to be distinct and associated with a complete set of what is considered by the receiver to be needed for performing this issue.

Learning processes

Knowledge can be seen as a result of learning processes that in turn are seen as fruits of experience, of questions asked and answers received, of trial and error or other information feedback. These learning processes can be categorised with respect to timely and functional directness and also with respect to the degree of formal organisation by which the processes are performed. Dynamic decision-making is *forward* oriented in time, based on rather direct functionally and timely tight-coupled experience feedback and with no formal methods of data handling and analysis associated with it. This process is referred to as *single loop learning*.

Event investigation on the other hand is mainly *backward* oriented in time and not primarily meant to function dynamically but to supply the actors involved with more basic understanding of the system. The process is more formal and performed either to make detailed in depth analysis of a single case or to encompass data from several events within a certain arena or type of context. The purpose can be twofold. One can be to show the state and trends of maters and to elucidate needs and possible methods for changes. The other purpose can be to utilise the investigation process as a learning experience for the actors involved. Feedback based on official investigations can be categorised as loops with respect to time but also, in a way, with respect to content since data normally are generalised and details are removed when gathered and presented to suit many situations and purposes. This process is referred to as *double loop learning*.

This process of learning from events is about collecting, categorizing, storing, quality securing, analysing and demonstrating event related experiences. It is accomplished by companies, trade associations and on national and international scales, to create data that suit the needs of many actors performing different functions on different hierarchical levels within different sectors in extensive and comprehensive socio-technical systems. The process by which it's accomplished depends on the culture and traditions associated with the context in which the event has taken place and the actual or conceivable outcome of it. It should also be performed in accordance with theoretically framed methods to support analysis and communication of findings.

So events take place in settings where the actor's perspectives are forward oriented. If the circumstances are not perceived as a state of alert they are believed to be under reasonable control with respect to safety and to internal purposes and productivity goals. The context of an event can be given by clarifying and making explicit the co-operating actors, the functions they perform, the flow and functionality of information, what the technical utilities are, how they function and what their constraints are. Also relevant are the constraints imposed by the environment, the economy, the resources, the workload, the regulations, the rules and the attitudes.

The process of context related event data management is discussed below in terms of “Who” should learn, “What”, “When” and “How”.

WHO SHOULD LEARN: ACTOR CATEGORIES AND SYSTEM LEVEL

Events take place in socio-technical systems operated by actors performing different functions on different system levels. These systems are influenced by external factors like; competition, public opinions, technological developments and changing level of education. The way systems perform and develop is also influenced by internal flow of information within and between system levels. The socio-technical system with the vertical flows of information between nested levels is demonstrated in figure 4 (After Rasmussen, 1997 and Rasmussen & Svedung, 2000).

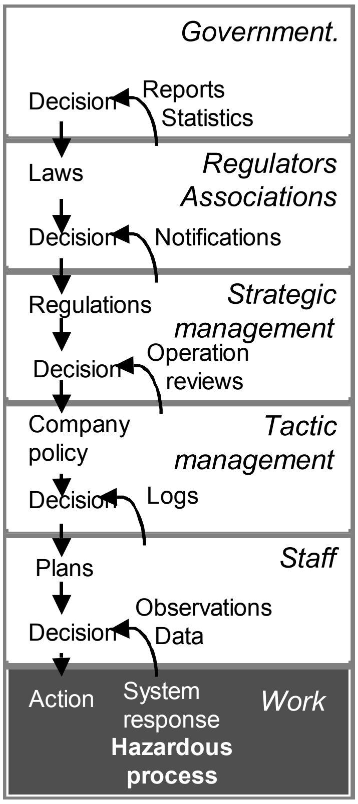


Figure 4. The socio-technical system and the types of information flowing between actors or functions on the different levels. (From Rasmussen & Svedung 2000)

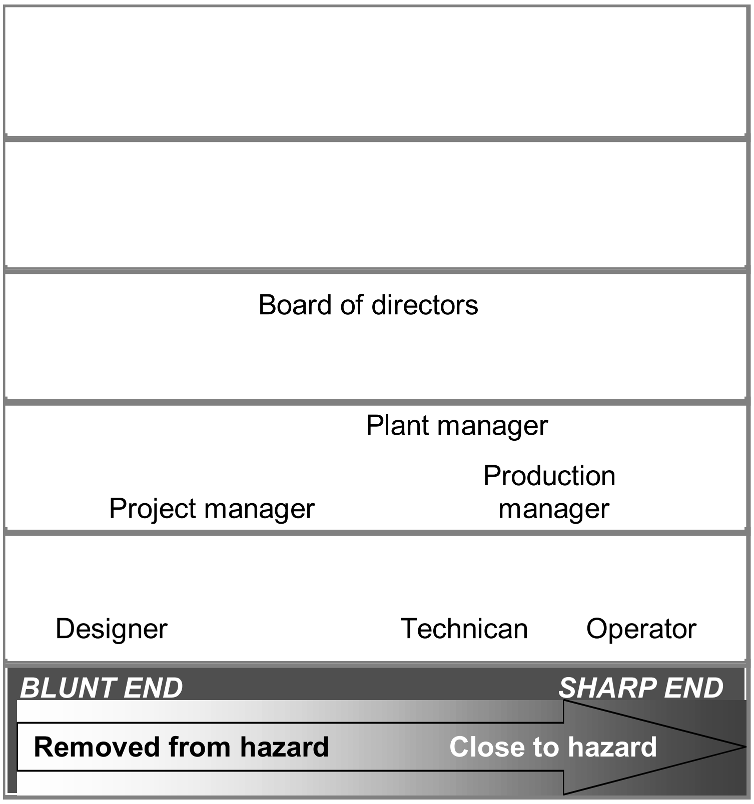


Figure 5. Actors with different functions in the system with reference to how close they work to the hazard and how direct they influence any event that might lead to accidents. (After Rosness, Guttormsen, Steiro and Tinnmannsvik, 2002)

In the same framework of interacting system levels the actor categories performing different types of functions can be identified and indicated as illustrated in figure 5. The position of the specific type of actor along the horizontal lines indicates the actor’s operative distance to the physical hazard (after Rosness, Guttormsen, Steiro & Tinnmannsvik, 2002)

It is clear that the functions performed by the actor in the different categories indicated in figure 5 are not only geographically and functionally but also timely separated. Still it is well recognised that they influence the way the system functions and develop and thus the varying state of safety.

From a broad systems point of view there are a great variety of actors that in their normal every day activities can and do influence the systems development. To perform well, situated as they often are within rather narrow contexts, these actors should have proper opportunities to learn from events that occur. Not only about what their own role has been in an event and how they might have influenced system performance. But what others have done and how this can influence the system and why and how they themselves have to adapt their behaviour when considering this. Therefore it is important to involve, in the event reporting and analysis process, locally active individuals with different roles in the system.

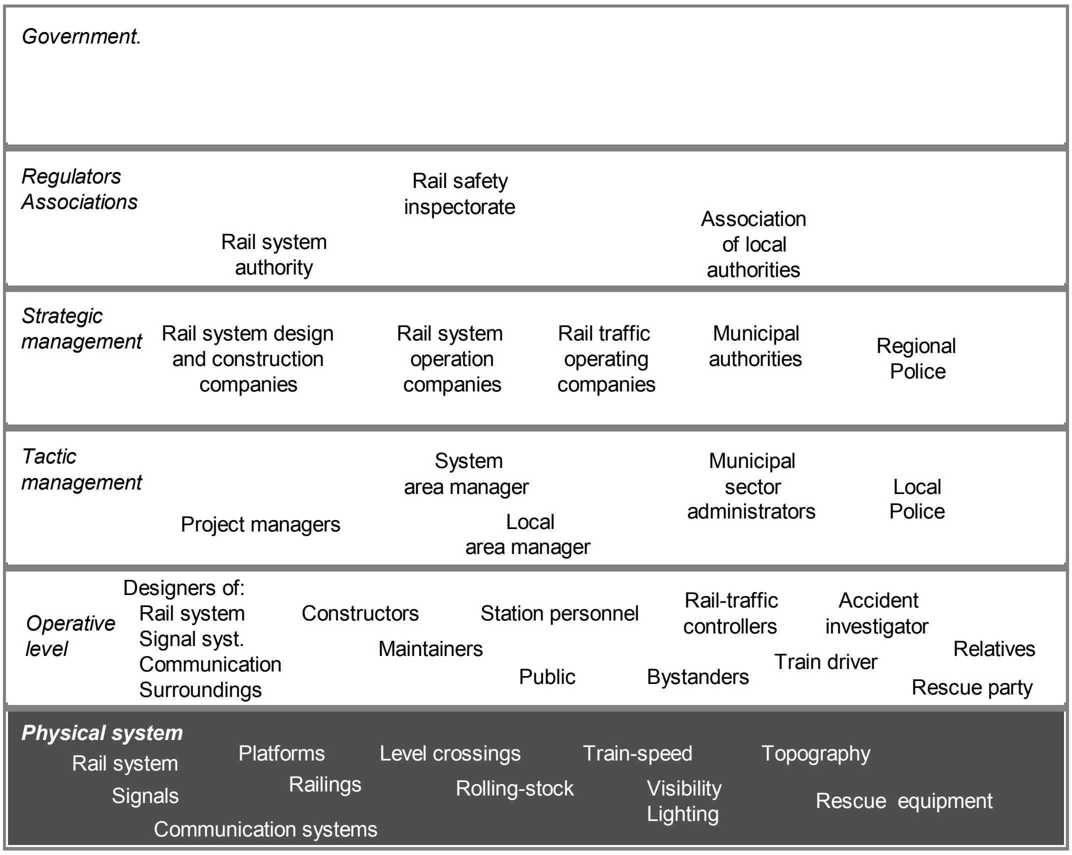


Figure 6 A sketch for an ActorMap with actors distributed on different socio-levels of the system where the preconditions for a train – person collision may develop, where the rescue operation is then performed, where the event is investigated and where the findings handled are utilized in future activities.

When defining what actors should be involved in an event investigation it is also important to recognise those, that during normal system performance might be considered to function outside the system, as it's normally defined. This is especially important if not only the preconditions of an accident are under investigation but also the rescue processes that are carried out in connection with an accident. Figure 6 gives an example of an attempt to identify and categorise what actors that might be engaged in the situation behind and around a fatal injury due to a train – person collision. The format used, an ActorMap (Svedung &

Rasmussen 2002), is in line with the socio-technical model format used in figures 4 and 5.

WHAT SHOULD BE LEARNED: LEVEL OF GENERALISATION

It is of general interest to all actors on all levels to get a picture of their own roles seen in a wider context and if they have their situation awareness and the priorities right. What signals have they received and how have they interpreted them, what signals have they sent out and have they understood how these signals were received and reacted upon?

What event related data that needs to be looked for and analysed more specifically varies with who she or he is that should learn from that process or rather what function she or he performs. This is not just a simple question about content but also about level of detail or to what degree the collected data should be categorised and generalised. The general picture is that details are excluded and data are turned more generic when findings about events are addressed to higher system levels. This trend is indicated in figure 7 and described below based on a system structure as presented in figure 5.

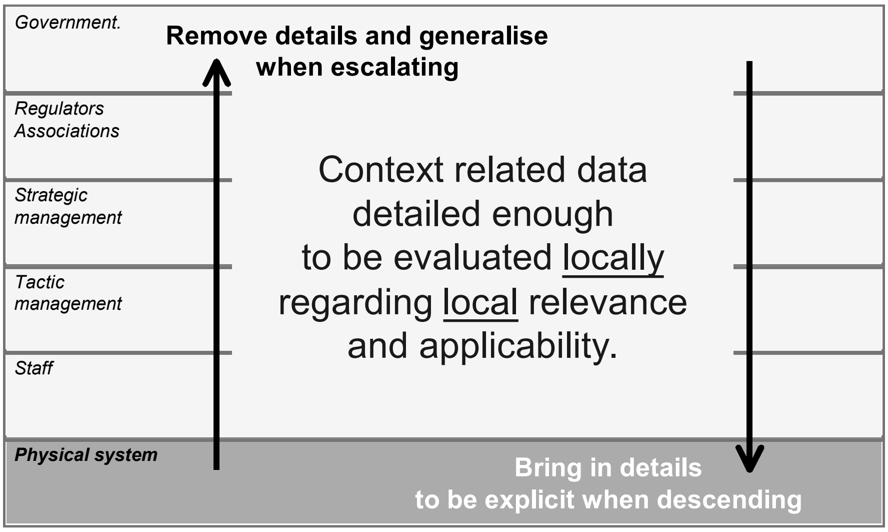


Figure 7. Event related information to actors on different levels in the system should be adapted and the degree of detail and focus on developments on the physical level should be given according to the understanding and needs of the target group.

Operative level

An actor operating at the sharp end of the system with what might have gone wrong or an actor who has a similar role within a similar system, hopefully and most probably has a good understanding of that context. To be of any value to her or him the information gained through event investigations should be presented with clear reference to that context in a way such that she or he could evaluate it regarding local relevance and applicability. If this is not the case the information is likely to be neglected. Information of special importance could be about timely developments, intensity and character such that the data can fit into the mental model by which the operator understand the functional properties of the system and interpret the event as it developed. But also the situation characteristics as they presented themselves to the operator in place are vital, i.e. the mode of operation, the workload, the manning situation, disturbances and other extraordinary circumstances.

Actors further away from the sharp end towards the blunt end, as indicated in figure 5, might have an interest in information on the same level of detail even if the content of the information requested may differ. A designer's prime interest could be to learn about how her or his designs are handled and perceived from a users perspective and what basic design assumptions that might need to be made clear in order to work during maintenance and operation as visible borders of safe conditions.

In cases where the system of interest is associated with a physical hazard source with potential to cause severe harm and tightly coupled with the environment, then this system in some way should be designed for in depth protection of safety. Both technical, operative and organisational issues is then addressed in that design process. This means that the actors involved have many different types of competence that should be used also in an event investigation process. The data to be communicated and analysed in connection with different events are therefore comprehensive. They should be defined and presented at a level of detail relevant for the different types of design processes and they should be explicit about what are considered as critical restrictions with respect to safety.

Tactic management level

Actors on the next higher levels in the socio-technical system might still be interested in detailed data about conditions and developments with reference to a certain event. One reason for that is that they have a direct responsibility for what happens in their own or similar parts of the system. Normally they also have a fair functional understanding of what happens on the level directly under their own so the more detailed data make sense to them and can be evaluated and used as a basis for action.

Actors on this level also need to learn about beliefs, attitudes and priorities among their co-workers, especially those at the operative level below. Therefore it is vital to analyse what is stated on that level as critical preconditions for the events investigated and what circumstances should be attended to. It is also vital to investigate what type of information is meant to function as alerting signals up and down in the system, how these signals are interpreted and whether they are brought to the attention of others who need to know.

Strategic management level

Actors further up in the socio-technical system often have other educational backgrounds and ways of understanding or interpreting data presented to them then those on lower levels. It also happens that actors on the strategic level find little use of the detailed information from a single event since their responsibility is more about long term resource management and policy making. What they need to know is what the trends are, what actors on lower levels are concerned about, how resources are utilized and if there are any special threats developing that need to be taken care of. So they need data where specific details, that they do not understand or that they do not have the time to go in to, have been removed and where different events are categorised and the corresponding findings are assembled and presented in ways that address their needs. To present data in the "scorecard" format have been suggested. This means that different types of vital data are presented graphically as outcomes compared with plans or goals. The scorecard format is in use to present i.e. production related data and earnings in a condensed format where the outcome can be directly compared with plans and budgets. Several different data categories can be presented in one polar diagram, shaped as a "compass card". People familiar with a special card format can quickly read and interpret the data presented by analysing the card as a picture or signature. Data not in line with expectations or goals will stick out and reveal themselves.

What actors on high management levels also need to have very clearly presented to them is the vulnerability of what constitutes safety and the need at all times to secure necessary knowledge, competence and power of operators at lower system levels for them to manage more directly the hazards they operate. By defining such characteristics in "measurable" terms and stating to what goal levels they should be reached these data can be compared with findings from auditing and event reporting exercises and presented in the scorecard format.

Regulator level

Actors on the regulator level have two distinctly different but coupled functions. One is about developing and implementing legal rules of conduct and the other is about rule enforcement by e.g. inspection. The need to learn about events differs clearly between these two functions.

Rulemaking. To run the rulemaking process actors on that level should learn about the effects and efficiency of different regulatory strategies and the actors need to understand on what to react, when and for what reasons. Epidemiological data regarding injuries and damages on arenas that are relevant to their area of responsibility, data that are analysed with reference to relevant attributes or determining factors are all data adapted to the need of rulemaking actors.

Table 1 Findings from an epidemiological investigation of the accidents related to person–train collisions that occurred within the Swedish railroad system during the time-period 2000 - 2002.

• Number of fatalities		
o Total	192	
o Suicides	145	75%
o Accidents	15	8%
o Unclear intention	32	17%
• Location		
o Station area	55	29%
o Populated area (not station)	110	57%
• Time of day		
o 00-06	28	15%
o 06-12	43	22%
o 12-18	61	32%
o 18-24	57	30%
• Victim sex		
o Male	136	71%
o Female	52	27%
• Victim age 20-59	134	70%
• Victim's activity		
o Standing/walking	87	45%
o Lying/sitting	58	30%
o Jumping in front	25	13%

Table 1 presents an example of this kind of data. They are the findings from an epidemiological study of fatal accidents related to person–train collision (Rådbo, Andersson

& Svedung, 2004). The data were retrieved by analysis of events of this type, events that occurred within the Swedish railroad system during the time-period 2000 - 2002. Police investigation protocols are the main source of data. All percentages refer to the total number of fatalities.

Rule enforcement. Actors performing official inspections adjust their strategies and focus on what is stated as explicit demands or restrictions in the rules/ directives. Modern rulemaking is mostly about policies to be demonstrated, processes to be performed and plans to be created and documented. Inspection officials therefore do not get much practical knowledge about the actual every day conditions prevailing on the operative level. In the long run this will impair their competence and ability to evaluate the plans and management processes presented to them. To compensate for this it is vital that inspectors are involved in a selection of event investigation processes in order to judge the role of plans, how they are implemented and evaluated, and what their impact are.

WHEN TO GO FOR IT: SEVERITY, POTENTIAL TO CAUSE HARM, COMPLEXITY

In all fields and types of activities there are a great number of events that can and should be used as learning experiences. All events that are recognised as having some potential to cause harm should be reported and analysed, even if that analysis in more trivial cases is of a standard categorizing nature. The actors directly involved in the events normally perform such handling of event data. Recording and reporting data over time also from events that appear to be trivial can reveal developments which in turn trigger more comprehensive investigations and follow ups.

Events that have led to severe damages will catch attention in wider circles. In all cases when people are harmed or killed the event should be reported to the proper authority and an official inquiry should be performed. Such inquiries often focus on who is to blame. Still they may reveal some factors of organisational and resource management nature and about attitudes among actors on different system levels. Thorough investigations of that kind can therefore add important understanding of safety management and its shortcomings.

In most severe cases, where the outcomes are devastating and encompass society as a whole, like in the air transportation or energy industries different directives regulate the investigations, how, when, by who and for what purposes they should be performed. Often a number of commissions are designated to address different aspects of the event, what the direct causes were, how they came about, what the different consequences were and what the more basic preconditions might have been. In such cases also the rescue activities and the handling of traumatised people are investigated.

Since one cause behind a system's severe hazard potential is tight coupling to the environment with its different vulnerable objects and this is normally well recognised, such systems are often designed in a complex manner with different preventive and confining measures taken. To find out the role of such measures these are often addressed explicitly.

HOW TO LEARN: DATA GENERATING PROCESS AND PARTICIPATION

The processes of data collection and analysis are coupled with the theories applied. The choice of theories depends in turn on the questions asked. Therefore, there are many methods utilised in event investigations. Some are about the process of on the spot data collection, some about reconstructive data generation and others about ways to go about to collect information through statements and interviews. A schematic process model of how a more detailed accident investigation can be arranged in two main steps is presented in figure 8.

Theories used to support analyses of accidents are also of different kinds and framed by different models. There are direct process models representing the event chain as it developed. There are causal presentations indicating conditions that prevailed and strictly determined the way the event developed, see the upper part of figure 8. The interpretations of findings based on such models are often supported by other models that i.e. deal with functional coupling, with transfer of energy and matter, with exposure–response relations.

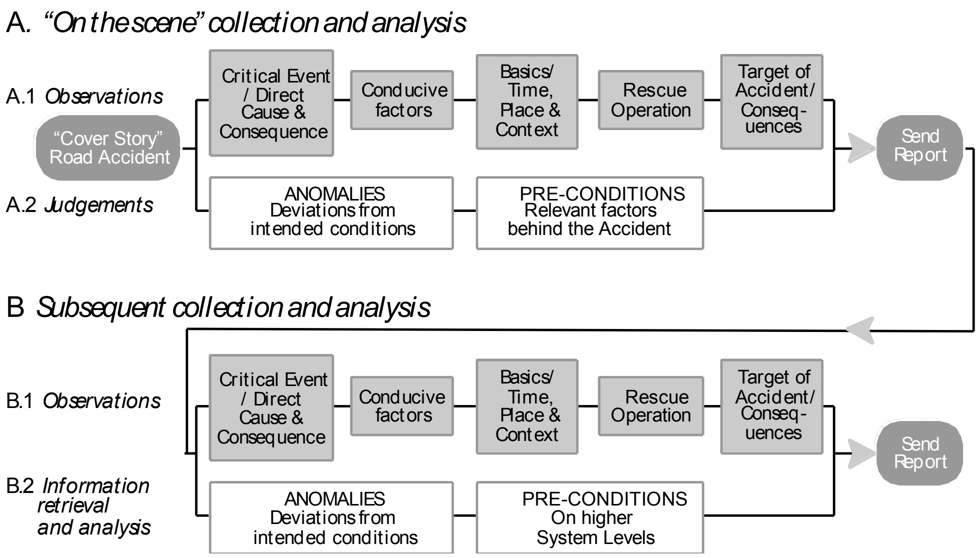


Figure 8. A schematic model of how a more detailed accident investigation can be arranged in two steps. The issues that should be addressed to support analysis of the preconditions are indicated. The way safety was affected by developments over longer time periods and by actors on different system levels is a main issue. These actors should have the opportunity to learn from the investigation. The model was originally designed to support analysis of road accidents but it is applicable also in other contexts. (From Rasmussen & Svedung, 2000)

From a safety management point of view focus has been on prevention of harmful impact from critical exposures and in that context the barrier concept has been introduced. In cases where preventive barriers have been implemented event analysis normally focus on their reliability and efficiency. The findings presented in table 1 can be looked at as the outcomes of event chains and mechanical impacts and the barrier concept, as sketched in the lower part of figure 9, can be introduced to illustrate and analyse the applicability of different types of barriers. From a rail way system point of view possible barriers could be; fences/railings, early detection of dwellers, train speed adjustment, "soft" engine fronts, rail track selection, light and sound warning signals. To evaluate such possible barriers more detailed investigations of the event conditions are necessary. This means that context-specific data about accidents have to be analysed, data that might call for more event-specific investigations where actors at lower system levels are addressed (See figure 6)

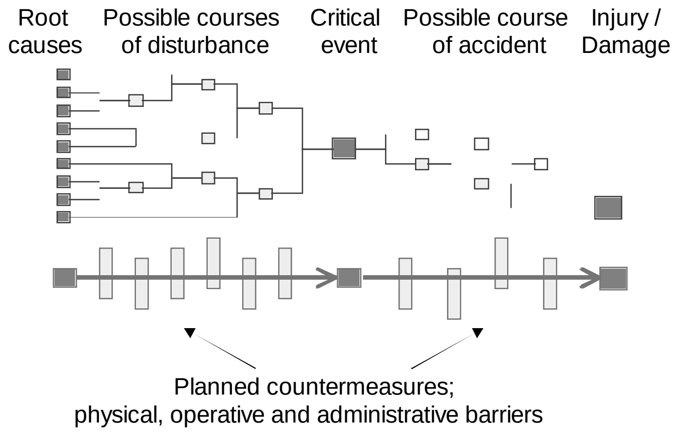


Figure 9. Two modelling formats used to describe events as functionally restricted developments. The upper can be recognised as a Cause Consequence Diagram and the lower format a Dynamic Barrier Diagram. Here dynamic refers to the vulnerability or variability of function of barriers that normally prevails even if they once were designed, tested and believed to function.

There are also models that frame events as organisational accidents by applying the three perspectives; man, technique, and organisation (MTO). These perspectives can be linked with time by addressing how the preconditions of an event and the event as such develop before, in direct connection with and after the critical event. However, when learning about the roles of individuals, groups and organisations with reference to a specific event it is important to bear in mind that these actors function with a *forward* perspective, even if they learn by reflecting on the *past*. This means that the analysis should focus not primarily on mistakes or misjudgements in a specific case, but on functions performed within the system, the way these functions are supported by resource management and information. From there then the outcome of the processes performed should be analysed.

To support the data collection process, the analysis, the communication of findings and the reasoning behind them a format has been developed for presentation and description of data regarding functions performed by the system. This format has been called AcciMap (Svedung & Rasmussen, 2002). It is framed by the socio-technical model in figure 4 and in line with the ActorMap concept as presented in figure 6.

The AcciMap format is presented in figure 10 and an example of what an AcciMap may look like is presented in figure 11.

It should be stressed that these models resembles all other models in that they are not comprehensive and correct in every respect, no models are, but that they may be useful.

The usability of the AcciMap format has been well demonstrated by i.e. Hopkins, A., 2000 and by Woo, D.M.., and Vicente K.J., 2003.

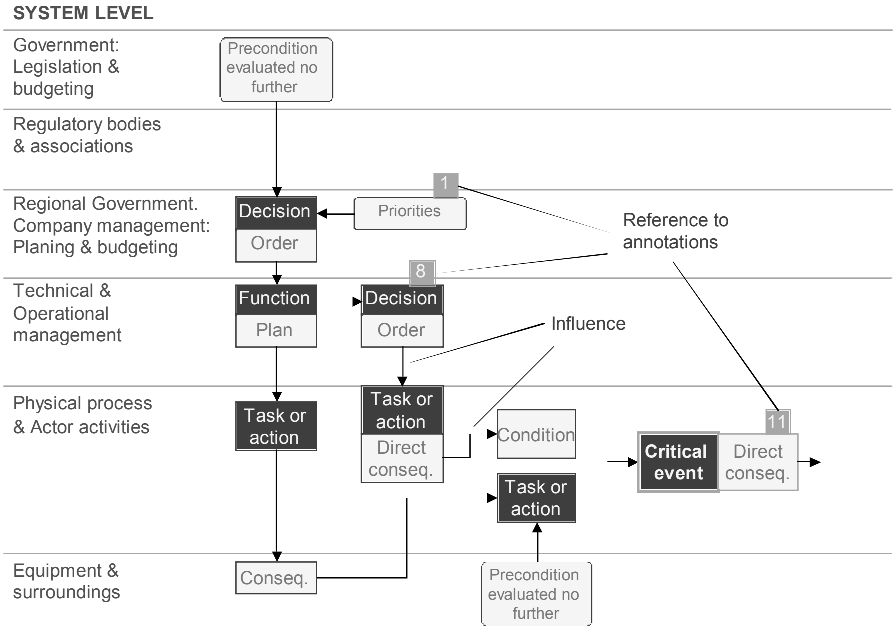


Figure 10. An approach to structure an AcciMap and a proposed legend of standardized symbols.

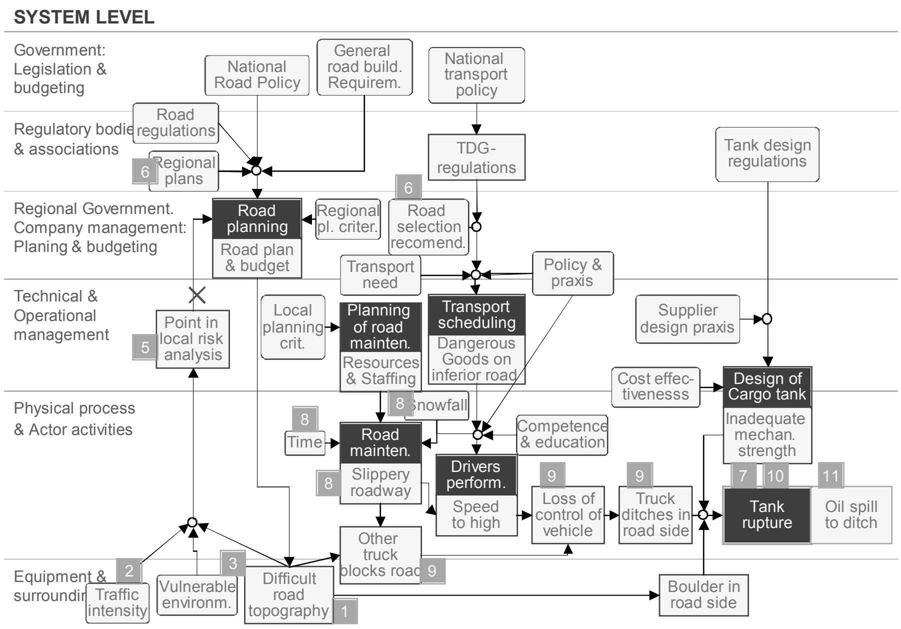


Figure 11. An AcciMap that demonstrates the pre-conditions of a dangerous goods accident. The physical accident process prior to the critical event is presented at level 5. The second part of the AcciMap, after the critical event, is presented together with the annotations referred to by the numbers indicated in the figure can be found in reference 2 and 4 together with other examples of AcciMaps.

CONCLUDING REMARKS

Hopefully the line of remarks made and framed by theories in this paper form a ground for the conclusions presented under the different headings Who, What, When and How. Much more can and have been stated by others. The most important remark is that learning is about different things for different actors performing different tasks, with different responsibilities and with different interests, priorities and way of inquiring and interpreting information. This leads to many different needs and requests. One cannot meet them all but to meet some for some actors one has to start identifying the "market" for information. That should be done in terms of Who, What, When and How.

REFERENCES

Rasmussen, J. (1994) *Risk Management, Adaptation, and Design for Safety* in Sahlin, N. E. and B. Brehmer (Eds.): Future Risks and Risk management. Dordrecht: Kluwer.

Rasmussen, J. (1997): *Risk management in a Dynamic Society: A Modelling Problem,* Safety Science, 27 (2-3), pp. 183-213.

Rasmussen, J. & Svedung, I. (2000): *Proactive Risk Management in a Dynamic Society* (Swedish Rescue Services Agency, Karlstad, Sweden).

Rosness, Guttormsen, Steiro and Tinnmannsvik, (2002) *Organisational Accidents and Resilient Organisations: Five Perspectives*, (SINTEF, STF38 A 02413)

Svedung, I. & Rasmussen, J. (2002) *Graphic representation of accident scenarios: mapping system structure and the causation of accidents*, Safety Science 40, 397-417.

Rådbo, H. Andersson, R. and Svedung, I. (2004) *Självmord och andra dödsfall genom tågpåkörningar på det statliga svenska järnvägsnätet 2000-2002*, (to be published).

Hopkins, A. (2000) *An AcciMap of the Esso Australia gas plant explosion,* Proceedings of the 18th ESReDA Seminar, Karlstad, Sweden, Ed. By Svedung, I., Cojazzi, G:G:M:

Woo, D.M., and Vicente K.J (2003) Sociotechnical systems, risk management, and public health: comparing the North Battleford and Walkerton outbreaks, Reliability Engineering and System Safety 80, 253–269.

Chapter 4: On Safety Indicators From a Regulator Perspective: Some Methodological Aspects

Per-Olof Sandén
Swedish Nuclear Power Inspectorate (SKI)
SE-106 58 Stockholm, Sweden
E-mail: perolof.sanden@ski.se

ABSTRACT

Safety indicators have been used as long as nuclear power plants have been in operation. Historically, the focus in selecting safety indicators has been on the results of the management of safety of the plant, i.e., so called output indicators (such as, collective radiation exposure to the personnel, number of forced power reductions and outages due to internal causes, the frequency of events or near misses, number of failures in safety systems). Since the early years of nuclear power production the challenge and ambition has been to find measures of early signs of deterioration of safety. However, it was not until in the middle of the 90's that the focus on safety shifted from a more technical and human error to a safety management and organisational point of view. This shift in focus towards safety management and management systems made it possible to find early warning signs of deteriorated safety in terms of "input indicators", i.e., indicators/measures monitoring the implementation of safety management processes and programmes. However, it still remains a challenge to find relevant and effective safety input indicators. This paper is focused on general methodological aspects of safety management and provides some guidance for how to select indicators that are important for how well safety management processes and programmes are implemented in an industry.
Keywords: Regulator, safety indicators, safety culture, input safety indicators, lagging safety indicators, leading safety indicators.

BACKGROUND

The use of safety indicators has a long history in the nuclear industry, and for as long as nuclear power plants have been in operation. Historically, safety indicators were characterized as so called "output indicators" (or "lagging indicators"), i.e., the results of the management of the safety of a plant. Examples of output indicators are: collective radiation exposure to the personnel, number of forced power reductions and outages due to internal causes, the frequency of number of events or near misses, number of failures in safety systems, number of scrams.

Since the early years of nuclear power production the challenge and ambition has been to find measures of early signs of deterioration of safety. However, it is not until the middle of the 90's that the focus on safety was shifted from a more technical and human error to a safety management and organisational point of view. This shift in focus to safety management and management systems made it possible to find early warning signs, in a more systematic way, in terms of so called "input indicators" (or "leading indicators"), i.e., indicators/measures used when monitoring the implementation of safety management processes and programmes. Examples of management processes are the management of: competence and staff resources, management system (quality assurance system), self-assessment (safety audits), operation, maintenance and outages, the management of technical and organisational modifications, incident investigations and systems for learning from experience, emergency preparedness, safety reviews, physical protection/security, and the safety management of contractors/ vendors etc. Indicators of safety culture have also been discussed, and a recent way of looking at the concept of safety culture is to regard it also as an important component of safety management. This integration can be seen in the ongoing work of International Atomic Energy Agency (IAEA) on revising its safety standards and guidance on management systems.

There is a major challenge in finding a useful method to support the selection of indicators that reflect safety management and overall plant safety. There are examples in the literature of methods (IAEA 2000, IAEA 2003) pointing out both the difficulties to select “input indicators” and relate these to safety, and the importance of selecting indicators focusing on the implementation of safety improvements. These examples propose a stepwise and hierarchical method starting from defining the areas of importance for plant safety, selecting the attributes in terms of safety for the defined areas, and selecting indicators on different levels. They also points out the importance of:

- selecting a reasonable and manageable amount of indicators related in an obvious and understandable way to safety,
- not to treat isolated indicators only, but relate them to other performance indicators (a system view)
- to find a balance in the selection of both so called leading (input) and lagging (output/result) indicators to give early warning signs
- to include indicators of how and to which level the safety improvements are implemented in the organisations
- selecting manageable and countable indicators, not susceptible to manipulation.

ON THE DEFINITION OF SAFETY MANAGEMENT AND MANAGEMENT SAFETY SYSTEMS

To be able to select suitable indicators of safety management, it is important to have a good idea about what is safety management. An example of definition is mentioned in the introductory chapter where it is defined as follows: in system theory terms safety management is a characterization of a human organizational system controlling and interacting with technical systems. Safety management is also about *power* (i.e., the ability of the management system to carry through safety policies and plan in an organization), *competence* and *integrity* of the management process at each level of an organization. Motivated personnel are another characteristic of a successful safety management.

In the IAEA report, *Management of Operational Safety in Nuclear Power Plants - INSAG-13* (IAEA 1999) we find a definition of safety management system: “The safety management system comprises those arrangements made by the organization for the management of safety in order to promote a strong safety culture and achieve good safety performance”. The general aims of safety management systems are: “to improve safety performance of the organization through planning, control and supervision of safety related activities in normal, transient and emergency situations: and to foster and support a strong safety culture through the development and reinforcement of good safety attitudes and behaviour in individuals and teams so as to allow them to carry out their tasks safely”. Also, the organization’s safety management system is generally considered to be an integral part of its quality management system, and should embrace all those arrangements that are needed to ensure that safety is properly managed.

Other examples of definitions of safety and safety management we can find in the discussion of safety performance indicators (Wahlström, 2002). Safety can be characterised by an absence of risks, meaning that threats are known and have been acted upon in a proper way. In practice, his means that the basic safety principles: prevention, control, protection and mitigation of possible threats have been applied as both physical and administrative barriers in the case of any event (for more information about basic safety principles see the report of IAEA (1996), “Defence in depth in Nuclear Safety”, IAEA-INSAG-10). Necessary preconditions for the defence in depth are: a plant and its technical systems have to be in good conditions, there should be well trained and committed personnel, and a well structured organisation with a clear division of authority and responsibility. Another important precondition for safety is the knowledge and awareness in management as well as among the personnel that minor deviations and failures in the daily operation can in the long run lead to incidents and accident if not being continuously addressed in a proper way.

The management of safety includes all the work processes (such as management, operation, outage planning, maintenance, plant modification, safety review, incident investigation and experience feedback, emergency preparedness, etc.), activities and tasks that are needed to maintain all these preconditions. These work processes also include support systems such as: methods for risk and event analysis, equipment failure data collection, monitoring of ageing, inspection and review. Implementation of processes for learning from experience both within the organisation as well as between organisations is a natural component of safety management. Striving for improvements continuously is a characteristic of a successful organization. Management can also be seen as implementing a loop of visions, strategy, communication and linking, planning and target-setting, and feedback and learning.

To summarize, the definitions of safety management seem to have in common at least the following characteristics:

- safety is an integral component in the management system of the organization
- the safety management system is an integral part of the quality system
- it concerns the management of all necessary arrangements or work processes to have a plant in a good technical condition and with well-trained and committed personnel
- the aim of a safety management system is to improve performance and to foster a strong safety culture.

Safety performance indicators

During the last 5-10 years there has been an increase in interest and activities among both licensees and regulators to find suitable safety performance indicators including *safety management, organisation and safety culture* as a tool for evaluating the safety of a nuclear power plant.

Among both regulators and licensees there is an agreement that the use of safety performance indicators as a tool for evaluating safety at a plant is only one tool of several others (i.e., regulatory inspections, quality assurance and self-assessments (quality audits), PSA (Probabilistic Safety Assessment), safety reviews, peer reviews etc.) and should be used in conjunction with these tools. One challenge in selecting suitable safety performance indicators is to find indicators that will be able to show *early warning signs* in case of deteriorating plant safety. Recent activities can bee seen in, e.g., efforts made by: The International Atomic Energy Agency (IAEA) in a project for developing a framework for identification of performance indicators to safe operation (IAEA 2000), and in the project on developing safety culture indicators (IAEA 2003). Other activities can bee found in the work of OECD/NEA (Nuclear Energy Agency) and the workshop on "Regulatory Uses of Safety Performance Indicators – Needs, Uses and Developments"(OECD/NEA 2005); and the EU project "SPI-project" (Safety Performance Indicators). Package 4: Impact of organization and safety culture on SPI:s (5th EURATOM FRAMEWORK PROGRAMME 1998-2002).

However, the EU-project and the workshop of OECD/NEA show that regulators in most countries are developing safety indicators to be used together with the results of regulatory inspections and safety reviews. An ongoing activity of OECD/NEA in the area of safety performance indicators is to collect good practices from the member countries. Also, there is an ongoing project at SKI with the purpose to develop safety performance indicators to support other regulatory activities (Carlsson 2004).

As mentioned above, a major effort in developing safety indicators was done by IAEA in the late 1990´s leading to a *framework for identification of performance indicators to safe plant operation* (IAEA 2000). In this work it is pointed out that safety is difficult to define but easy to recognize. However, it is stated that a high level of safety is the result of the complex interaction of excellent design, operational safety and human performance. It is important to ensure a reasonably complete set of operational safety indicators and thus not to focus on any single aspect of safety performance.

The starting point for creating a framework (Figure 1) and a reasonable complete set of safety performance indicators was to focus on: normal operation, emergency operation and the attitude of nuclear power plant personnel towards safety. For each of these three aspects a safety attribute related to plant safety was chosen. These attributes were: *plants operate smoothly, plants operate with low risk, and plants operate with a positive safety attitude*. Since these attributes can not be directly measured, IAEA developed a hierarchical structure of indicators until a level of indicators was found that could be easily quantified and directly measured. The levels of indicators were: *overall indicators, strategic indicators and specific indicators*.

For example, the *overall indicators* related to the *attribute* "plant operates smoothly" are: operating performance; state of structures, systems and components (SSC); and events. On the next level i.e., the *strategic indicators* associated to these three overall indicators are: forced power reductions and outages; corrective work orders issued, material condition, state of the barriers; reportable events and significant incidents. Examples of *specific indicators* for the strategic indicator "corrective work orders issued" are: number of corrective work orders issued for the safety systems, and ratio of corrective work orders executed to work orders programmed.

Another example of an *overall indicator,* related to the *attribute* "plant operates with a positive safety attitude", is "attitude towards safety" which covers implementation and attitudes towards managerial programmes necessary to operate the plant in a safe manner. The *strategic indicators* are: "compliance with procedures, rules and licensing requirements"; "attitude towards procedures, policies and rules"; "radiation protection programme effectiveness"; "human performance"; "backlog of safety related issues"; and "safety awareness". Examples of *specific indicators* for the strategic indicator "human performance" are: "percentage of events due to human error"; "percentage of events due to training deficiencies"; "percentage of events due to deficiencies in procedures"; "number of human related incidents during testing, maintenance, or restoration".

The *attribute* "plant operates with low risk" concerns both the deterministic and the probabilistic approach. One example of an *overall indicator* with a deterministic approach is "plant ability to respond to a challenge". The proposed *strategic indicators* here are: "safety system performance", "operator preparedness" and "emergency preparedness". For example the *specific indicators* proposed for "emergency preparedness" shows aspects of safety management in the area of emergency preparedness. These indicators are: "findings during emergency drills, "findings during emergency plan audits", "number of hours devoted to training on the emergency plan" and "number of staff receiving training on the emergency plan".

A very important *overall indicator* for safety in the long run is "striving for improvement". Here we find a proposal of two *strategic indicators*: "self-assessment" and "operating experience feedback". For "self-assessment" five *specific indicators* are proposed: "number of independent internal safety and QA inspections and audits; "number of findings from QA and safety reviews and audits"; average time to clear findings from safety reviews and audits"; number of external review findings not previously identified by internal reviews"; and "number of repeated findings in internal reviews and audits".

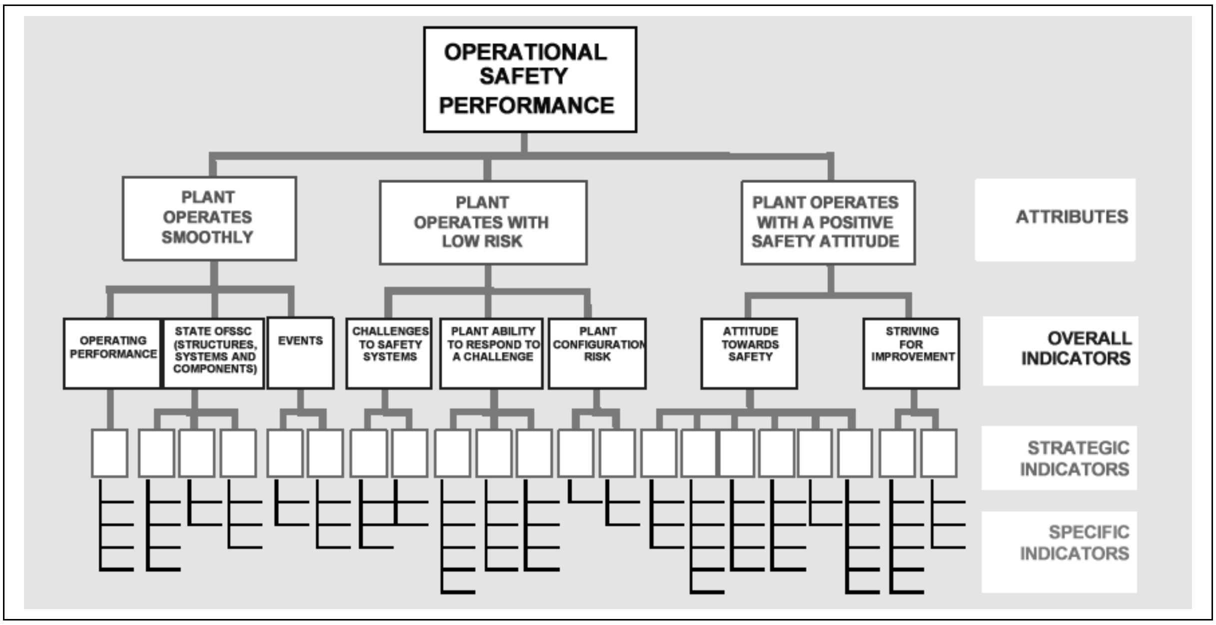


Fig. 1: Safety performance indicators. Framework proposed in IAEA-TECDOC-1141

This framework was developed with the purpose to support the licensees in creating a tool/programme to monitor operational safety performance. It is important to note that there are some requirements on ideal characteristics of safety performance that have to be met.

IAEA (2000) proposes that, in order to secure a high quality of the information provided by the selected performance indicators, the following characteristics should characterize them:

- there is a direct relationship between the indicator and safety,
- the necessary data are available or capable of being generated,
- indicators can be expressed in quantitative terms,
- indicators are unambiguous,
- their significance is understood,
- they are not susceptible to manipulation,
- they are a manageable set,
- they are meaningful,
- they can be integrated into normal operational activities,
- they can be validated,
- they can be linked to the cause of a malfunction,
- the accuracy of the data at each level can be subjected to quality control and verification, and
- local action can be taken on the basis of indicators.

Also, the selection of safety performance indicators to a monitoring programme should include a combination of indicators reflecting actual past performance (so called *lagging indicators*) and indicators providing early warnings of declining safety performance (so called *leading indicators*).

Safety culture indicators

IAEA continued its work on safety indicators focusing on *safety culture indicators.* In a working paper it (IAEA 2003) points out that there is no simple set of indicators to measure safety culture and it is an ongoing challenge to device a set of performance indicators to monitor the safety culture at a plant. Also, elements of safety culture, such as values and believes are not directly observable and measurable. However, IAEA has recently published guidelines on self-assessment and enhancement in safety culture (IAEA 2002).

IAEA points out that, managers of nuclear facilities should be able to track and trend the development of safety culture, since safety culture is an important aspect of *the effectiveness in an organization*. Using safety culture indicators is one way of trending this development. Also, a set of safety culture indicators can help in getting *early warning signs* of a weakening safety culture before weaknesses are showed in the operational indicators. Another benefit of using safety performance indicators, stated in the report, is that it gives the management a way of demonstrating to the personnel the performance level achieved and an opportunity to discuss performance levels to be achieved in the organisation.

Based on the safety culture characteristics (IAEA 2002), these characteristics were organized in five *dimensions of safety culture*: “Accountability for safety is clear”, “Safety is a clearly recognised value”, “Safety is integrated into all activities”, “Safety leadership is clear” and “Safety is learning driven”.

A series of questions were used as criteria to select and organize the characteristics into the five dimensions of safety culture. The questions were: “Would the presence of this characteristic influence how I would think or behave?", "Would the presence of this characteristic influence how others would think or behave?", "If I move to an environment where this characteristic was present would I be more satisfied or less satisfied?", "Would it make any difference to the way I feel if this characteristic was missing?". If the answer was "yes" to all the questions, the characteristic was chosen and this is called an *attribute.* Examples of attributes are "View of people", "Organisational learning", "View of mistakes"; and "High priority to safety".

The next step was to identify criteria for each attribute i.e., an indicator, and identify for each indicator a quantitative or qualitative measure. Many examples of different indicators and measures are given in the report, e.g, for the *dimension* "Safety leadership is clear", the *attribute* "Top management commitment to safety" is mentioned, and the possible *indicator* might be "Leadership competence is developed through training". One of the *measure* in this example is "Percentage of managers that have received initial and continuing leadership training". Thus, the sequential steps in the methodology are: *Dimensions - Attributes – Indicators – Measures.* In the report there are also the different kinds of indicators to monitor and measure safety and their advantages and disadvantages are discussed. Two kinds of indicators are recognized i.e., "output indicators" often called *lagging indicators*, and "input indicators" called *leading indicators*. The *lagging indicators* show safety performance in terms of measures of past performance e.g. injury rates, event rates etc. This type of indicator can indicate a decline in performance but are usually too late to give an "early warning". The *leading indicator*s monitor the processes that are effecting and maintaining safety. These indicators are the implementation of safety management processes and programmes which are designed to improve and maintain safety performance.

According to the report, the majority of safety performance indicators used by the industry are *lagging indicators* with quantified measures such as event rates. These indicators are the results of both safety management and safety culture of a company. The disadvantage of this type of indicator is that it does not give much help in assisting for improvements. But they can be used for benchmarking. Since the *leading indicators* are monitoring the progress of implementation of safety management, e.g. % of the completion of improvement programmes, these indicators can give information about how successful the implementation of this programme has been. The difficulty is that the indicators do not identify weather you are really getting the improvement of performance expected by expending the planned effort.

The difference between *safety management indicators* and safety *culture indicators* are also discussed in the report. Safety management indicators are monitoring the implementation of safety management systems whereas safety culture indicators indicate how safety is implemented and monitored in the organisation. It is also stated in the report that, in selecting indicators, a well formulated range of indicators are needed which reflect every activity from top management decisions to workforce behaviour.

The safety culture of an organisation is supposed to develop in stages. A model is proposed and it consists of three stages (see IAEA 2002). These are: "Safety is based on rules and regulations" (Stage 1), "Safety is considered an organisational goal" (Stage 2), and "Safety can always be improved" (Stage 3). The relevance of selected safety culture indicators can be different depending on which stage an organisation has reached. As a help for judging the quality of selected indicators and number of indicators IAEA (2003) has developed characteristics of indicators (also partly described above):

- "Recognised relationship with safety and Valid in terms of relationship with safety" (Meaningful & Valid),
- "Explicitly defined and not susceptible to manipulation" (Unambiguous),
- "Significance clear and should be wide acceptance and appreciation at 'local level' of their need" (Understandable),
- "Unlikely to cause undesirable actions to get good results" (Behaviour),
- "Minimised overlap with other indicators" (Independent),
- "Measurable from physical results" (Quantitative),
- "Data should be easy and quickly obtainable" (Ease of measure),
- "Should be able to set targets and goals" (Goal setting),
- "Local actions can be taken on basis of outcomes" (Local action),
- "Data should be able to be verified and QA" (Data), and
- "The number of indicators can be managed easily" (Manageable).

CONCLUSIONS

So far, most methodological work in the area on how to develop safety performance indicators and safety culture indicators has been performed by IAEA. However, there are many other attempts to develop safety performance indicators both internationally by OECD/NEA and nationally by regulators in different countries.

The methodological knowledge on how to develop and select safety indicators and relate these to safety management has increased over the last decade. Still, the challenge exists to both regulators and licensees to use this knowledge in systematic ways in their work of developing systems of safety performance indicators. The recommendations from the literature to bring into such an effort include:

- define the areas of safety management to be includes (there are lots of safety processes to choose between in the management of a nuclear power plant complex and its management system
- define the attributes related to safety
- select a reasonable and manageable amount of indicators related in an obvious and understandable way to safety
- do not look at isolated indicators only, but relate them to other performance indicators (system view)
- find a balance in the selection of both so called leading (input) and lagging (output/result) indicators to give early warning signs
- include indicators of how and to which level the safety improvements are implemented in the organisations
- select manageable and countable indicators, not susceptible to manipulation.

REFERENCES

Wahlström B (2002). *Safety performance indicators for nuclear power plants*, Paper presented on a workshop arranged by the EU-project "Evaluation of Alternative Approaches for Assessment of Safety Performance Indicators for Nuclear Power Plants, SPI" (contract number FIKS-CT2001-20145), Stockholm, Sweden

IAEA (1999). *Management of operational Safety in Nuclear Power Plants*, INSAG -13, A report by the International Nuclear Safety Advisory Group, International Atomic Energy Agency, Vienna

IAEA (2000). *Operational safety performance indicators for nuclear power plants*, IAEA-TECHDOC-1141, International Atomic Energy Agency, Vienna

IAEA (2002). *Self-assessment of safety culture in nuclear installations, Highlights and good practices,* IAEA-TECDOC-1321, International Atomic Energy Agency, Vienna

IAEA (2002). *Safety culture in Nuclear installations, Guidance for use in the enhancement of safety culture*, IAEA-TECDOC-1329, International Atomic Energy Agency, Vienna

IAEA (2003). *Developing safety culture indicators*, The report of an Agency Sponsored Consultants' Meeting held at the IAEA in Vienna on 15-19 September, (Working paper)

Carlsson L (2004). *Effektiviserad tillsyn med indikatorer,* SKI Nucleus nr. 4/2004

OECD/NEA (2005). *Regulatory Uses of Safety Performance Indicators*, CNRA/CSNI Workshop Proceedings, Workshop held 12-14 May 2004 in Granada, Spain, NEA/CNRA/R(2005)2, OECD Nuclear Energy Agency, France

Chapter 5: Safety Management in Luftfarts-inspektionen – Swedish Civil Aviation Safety Authority

Pernilla Allwin
Risk Analysis, Social and Decision Research Unit
Department of Psychology
Stockholm University
S – 106 91 Stockholm, Sweden
Present affiliation:
Scandpower Risk Management AB
Box 1825 S-751 48 Uppsala, Sweden

ABSTRACT

In this chapter the system approach outlined in chapter 1 is applied to the analysis of safety management in the Swedish Civil Aviation Safety Authority-SCASA, the regulating authority of Swedish civil airline operations (Luftfartsinspektionen). The methods used were both document analysis and interviews with key persons within SCASA. The results generated an interesting narrative of safety management in the studied organization. Examples of safety management according to core concepts of the system theoretical framework were illustrated, among them safety management in relation to the system structure, identification of threats, and information feedback.
Keywords: air transportation, threats, feedback, incident reports

INTRODUCTION

The management process addresses issues of how to cope with the complexity of all of the factors which are relevant to the management and regulation of a high sociotechnical activity, such as in the process industry or a transportation system. This process of management is often referred to as safety management which, according to Svenson and Salo (2003) becomes a part of the overall management, defined as "...a process in which a producer, societal representative and the public interact in finding a balance between the benefits, costs and risks of an activity or a product". "The goal of this process should be to find a balance which is best for most of the people in a society and at least acceptable for everybody" (Svenson, 1984, p. 486).

Complex sociotechnological systems, such as, a nuclear power plant, the aviation and petroleum industries, are examples of systems in which safety has to be managed in an effective and efficient manner. A 'system' refers to a set of components acting together as a whole to achieve some common goal, objective or end (Leveson, 1995). Effective management is imperative to the avoidance of organizational accidents, and other catastrophic, albeit rare, events that can occur within such complex, modern systems (Reason, 1997). The aviation industry possesses great resemblance with the nuclear power industry, also being a complex sociotechnological system in where an accident could have disastrous effects not only to the individual, but also to the subordinate society and to the environment. The nuclear power industry also uses similar methods in incident/accident analysis as well as having great familiarity with the concept of safety management.

Despite the importance of safety management, more initiative has been directed toward the improvement of technology than to the improvement of safety management within technological systems (Martin, 2002). It must be understood that technological development and the safety management of technological system cannot be handled separately. However, researchers today have universal acceptance of the significant impact that management and organizational factors have over the safety of complex industries such as the nuclear industry and aviation (Martin, 2002). It is also believed that the interaction between 'hard' and 'soft' sciences, in other words, the interaction between man, technology and organization is an important factor contributing to the success of safety management. It is now generally assumed that most accidents on the job are the result of human error, and that these errors are the result of carelessness and incompetence. Investigators, however, are discovering that this assumption is a fallacy, and that humans are the last link in the causal chain of a given accident (Transport Canada, 2001). Although one may argue that humans are the first link, having constructed and developed the technology and devised the operational activities, various authors refute this claim. These authors (as cited in Martin, 2002, p.11), assert that there are today a held view that any significant accident will always be an organizational accident, "i.e. the multiple failures or error involved in the accident are only symptoms of organizational and management latent deficiencies that went undetected or uncorrected".

Currently, due to unprecedented financial hardship, the subject of safety management is particularly important to the aviation industry. With a market that was never before so unstable, significantly increasing economic pressure on managers and external threats, it is even more important to focus on safety maintenance and improvement practices and ensure that they are not overwhelmed by economic concerns.

To provide an understanding of theoretical reasoning behind the present study, it will begin by presenting a general system theory, followed by an outline of organizational theories and behaviors. It will then put forward some theoretical and currently used regulatory strategies in the nuclear industry, and seek to summarize the material collected from the qualitative interviews, and finally, the study will suggest how the SCASA needs to improve its safety management in an already relatively safe activity.

General system theory

Ludwig von Bertalanffy (1973, p. 124) noted that, "modern science is characterized by its ever-increasing specialization, necessitated by the enormous amount of data, the complexity of techniques and of theoretical structures within every field. This, however has led to a breakdown of science as an integrated realm: The physicist, the biologist, the psychologist and the social scientist are, so to speak, encapsulated in a private universe, and it is difficult to get word from one cocoon to the other." This statement summarizes von Bertalanffy's opinion of certain limitations of science in coping with complex systems. Von Bertalanffy came to a notion of a general system theory as an elucidation of handling systems (Ruben *and* Kim, 1975), though science is presumably still facing the 'cocoon' phenomena. Along with Bertalanffy's notion of a general system theory, Miller (1978) saw similar complications in his studies of living systems and their characteristics. He emphasized that any system, be it social, technical, living or non-living, can be modeled as a suprasystem consisting of various subsystems. The interaction of the subsystems ensure that the suprasystem remains in a steady state when it performs what it is intended to produce*,* a safe aviation industry. The steady state, in this particular activity, is characterized by the system's ability to keep the system in such way that it provides safe civil aviation. The development of systems theory began in the 1930's and laid the foundation for a new way of dealing with complex systems (Leveson, 1995).

Arguably, any system characterized by its industry/human technological activity can be modeled as a suprasystem in which two subsystems interact. In one possible composition, the suprasystem can be described as the total activity of air transportation and corresponding ground activities. The ground crew, maintenance, security, the Air Navigation Services Division (ANS) and the Swedish Civil Aviation Administration, SCAA (Luftfartsverket-LFV), exemplify such activities. The subsystems, then, constitute the SCASA and the airline companies- the market (see figure 1). These systems can be further divided into technological non-living systems and living systems constituting the organizations and its members.

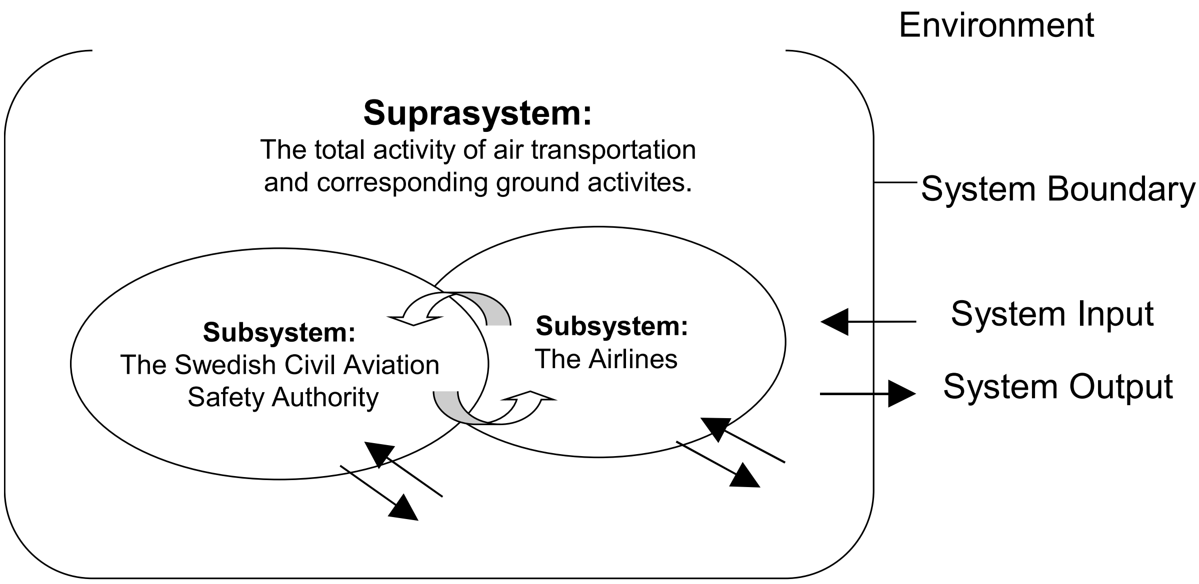


Figure 1: Based on Leveson's (1995) definition of a system, the figure illustrates the interaction between the suprasystem and the subsystems, input and output.

However, this is only one possible composition, and in other constellations, the suprasystems could be defined as the International Civil Aviation Organization (ICAO) in which other subsystems, economic and political, interact.

If the market is exposed to stresses that threaten to move certain variables outside the range of stability, or to a situation in which the safety of the system is threatened, adjustment processes keep variables within their ranges of stability despite these stresses. However, when such situations occur, special subsystems such as technological and human barrier function systems are activated to preserve the steady state of the system (Svenson, 1990). Regular inspections of the system and preventative regulations can serve as such barrier functions. According to Svenson and Salo (2003) these adjustment processes rely on negative feedback in various forms: Internal feedback, which keeps its loop within the boundary of the system, and external feedback, from which the system receives input from external subsystems as well as regulating the output. The purpose of these processes is to keep the divergence of the variables within the limits of a steady state. One such adjustment process could be organizational learning, which is often recognized as organizational change, through knowledge improvement and exchange of knowledge according to environmental alteration (Argyris, 1999). However, adjustment processes demand time, energy, money, and above all, material and paucity might determine the operation of the system's goals.

A system approach to safety management

A system approach to safety management is to a large extent evident throughout the international aviation industry. Yet, some problems remain in managing safety as the environment and threats are ever changing. The Canadian Civil Aviation Authorities (CCAA) identified organizational issues as the greatest threat to aviation safety, and suggested that actions by the organization are the required exercise, which will make the system even safer. It was therefore concluded that the most efficient way to make the Canadian aviation system even safer would be to adopt a systems approach to safety management.

The United Kingdom Civil Aviation Authority (UKCAA) have likewise taken a system approach and outlines safety management as a "systematic management of the risks associated with flight operations, related ground operations and aircraft engineering or maintenance activities to achieve high levels of safety performance" (Done, 2002).

In one sense it may be possible to view safety management as an integrated part of overall management. Especially in larger complex organizations such as the aviation industry, where safety management becomes a part of all management in that safety concerns are considered in all aspects of management, in setting goals, planning, and measuring performance. An integrated process established throughout the organization. The CCAA emphasizes that a safety management system philosophy requires responsibility and accountability for safety to be retained within the management structure of the organization (Transport Canada, 2001).

As safety becomes part of the overall management, the process of safety management also becomes part of the organizational culture, a widespread concept throughout the organizational literature, with relation to safety management. A concept referred to as 'safety culture' has been defined as an indicator of safe operations, and is a familiar concept within the nuclear industry. INSAG-4 (as cited in Svenson and Salo, 2003, p. 20) defines safety culture as the "...assembly of characteristics and attitudes in organizations and individuals which established that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance". The safety culture is hence an important contributor to safety operations, both in considering individual's and whole organization's attitudes towards safety.

Regulation strategies

Perhaps a common ultimate strategy for safety management is desired. However, different complex systems are based on different and specialized technologies and activities; therefore, the details of a strategy for managing the safety of that activity must be handled in a very individual manner to reach an optimal level of safety. The strategy chosen will not only depend on the technology and the activity, but also on what risk that activity will bring. Even though the total elimination of risks is desired, "no aircraft could fly, no automobile move, and no ship put out to sea if all hazards had to be eliminated first" (Hammar, 1972).

Rasmussen and Svedung (2000) identified three types of accident categories together with the related risk management strategies. The first category was occupational safety, which focused on frequent, but small-scale accidents. The hazard sources in this category are very complex and the control of safety is focused on the removal of causalities, which is based on empirical epidemiological studies of past accidents. The second category, referred to as protection against medium size, focused on the identification of infrequent accidents, such as aircraft accident. The development of safer systems in this category depends on responses to analysis of the individual, latest major accident. In addition, management is focused evolutionary safety control that is, the removal of causes of particular accidents (Rasmussen and Svedung, 2000). Though the hazards are well defined in these systems, the accident rate in a nuclear power plant, for example, would be so low that, the safety management design could not be based on empirical evidence from accident research (for example, protection against rare, large-scale accidents). Instead it is based on defenses identified by predictive analysis such as probabilistic safety analysis, PSA.

The organization can choose to implement different regulatory strategies depending on the accident category relevant to the specific activity. Durbin, Melber and Blom (2001) outlined six regulatory strategies that are currently being used in the nuclear power industry, where the regulators must assure safety in the face of significant challenges, similar to the aviation industry. The six different strategies that are based on those developed by the authors of the Swedish Nuclear Power Inspectorate (SKI), were identified as the following; prescriptive, case-based, outcome-based, risk-based, process- or system-based and licensee self-assessment.

The present study, aim and outline

The general purpose of the present study was to describe safety management in a context relevant to the aviation industry by using a framework in which theoretical general systems are essential. The present study will discuss a case study of the Swedish Civil Aviation Safety Authority-SCASA (Luftfartsinspektionen), in which a description of the SCASA's role as regulator of the aviation industry will be outlined. To delimit the scope of the present study, with regard to the multifaceted notion of safety management, the present study will focus in particular on safety management in three perspectives; (1) the structure of the organization, in which a general description of systems will be outlined; (2) Internal as well as external threats against the SCASA and against the market; and, (3) information feedback systems, in which internal and external system feedback will be presented, and incident/accident reports and regulatory strategies outlined.

METHOD

Document analysis

In the present study, documents put forward by the aviation industry have been used and analyzed. Mainly four documents have been exploited, (1) the Business Activity Plan (Verksamhetsplanen) 2003-2006, which has given an overview of and insight in to the SCASA's present and future focal areas; (2) a sectors account for the development of the aviation in 2001, which provided a general knowledge across the industry; (3) an analysis report of all occurrence reports in 1999 that have been analysed by the SCASA; and (4) the Accident Prevention Manual developed by the International Civil Aviation Organization in 1984, which outlines concepts, methods, applications and ideas in relation to preventative safety efforts.

Interviews

Participants. Four employees, all men in middle management positions at the SCASA, participated in the study and were interviewed. The participants represented four of the five different sections of the organization: two represented Surveillance located in Sollentuna, Sweden, one represented Regulations (also Operational Approvals), located in Norrköping, Sweden, and the last represented Technical Approvals, also located in Norrköping.

Material. A semi-structured questionnaire was developed and used for the qualitative interviews. Based on the safety management prospective put forward by Svenson and Salo (2003) the questionnaire covered three approaches to safety management. First, the structure of the organization, which concerns the identification of main, statistical, and perceived risks; the organization's definition of safety management; as well as the structures and processes relating to safety management. The second approach concerns threats against the organization and finally and the third approach covers information system feedback. This entailed the examination of internal feedback (i.e., incident and accident reports), external feedback (i.e., the relationship between the SCASA and the market), and finally, of regulatory strategies.

Procedure. A letter was sent to a contact person at the SCASA in order to establish initial contact. This letter defined the essence of the study, and questioned whether employees were willing to be interviewed. An acceptance was later received and the contact person suggested five different employees who were willing to be interviewed. The author later contacted these individuals either by e-mail or by telephone to specifically ask if they were interested and to arrange dates for the interviews. Four of these five individuals confirmed their willingness and interview dates were finalized. The fifth was at that time on vacation and suggested a date three weeks after initial contact was established. This entailed that that the interview would have taken place outside the time span available and therefore he did not participate in the study.

A letter of information was then, also given to the participants at the interview occasion, again to clarify the essence of the study. The interviews were held at four different occasions during which the participants responded to a set of questions in the semi-structured questionnaire, which had a time-span of about an hour and a half. The author asked the questions while a research assistant recorded the responses. Following the interviews, the responses were summarized and sent to each of the participants, enabling them to add information and/or correct the material.

ANALYSIS OF SCASA DOCUMENTS AND RESULTS

The results will firstly be provided in a general description of past as well as present characteristics of the air transportation industry, followed by a brief outline of the SCASA as a regulatory organization, with general proceedings, visions and goals, all based on the document analysis. Finally, based on the interviews the results will be presented in accordance to the three approaches taken to safety management in the semi-structured questionnaire.

The Air Transportation Industry

In its infancy, aviation was merely a vision of humans imitating the soaring patterns of birds. From that vision, Leonardo da Vinci´s pioneering work in the 1400's, on the possibilities of flying developed and laid the foundation for the scientific study of aviation. However, it was not until December 17th 1903 in Kitty Hawk, North Carolina, that American brothers Wilbur and Orville Wright carried through the first test of flying, today considered to be the first successful attempt to fly (Anderson, 1997).

Until World War I, aviation was the domain of the individual and no organized system existed for the exchange of safety information. The War changed this by providing a stimulus for the creation of large-scale aircraft industries. Ever since then, the civil aviation industry has been growing at a rapid rate. Ongoing technological advancement, considerable international network with safety organizations, huge financial budgeting and a development of services have collectively come to define the network of the aviation industry (International Civil Aviation Organization, 1984).

Favorable conditions of the past, when aviation was a blooming business, the present dynamic society brings with it some dramatic changes of the conditions of aviation management and safety. The attacks on New York and Washington September 11, 2001 are still affecting the market and the aviation industry has never faced such financial hardship. More than 250 000 employees around the world have been affected by the downsizing of the airline companies. In addition, the overall travel demand has decreased by 10 percent and the losses for the aviation industry during 2001 have been estimated between 130 and 150 million SEK (Luftfarstverket, 2001).

The world around us continues to face hardship. Not only are the events of September 11 still affecting the aviation industry, the current situation in Iraq presets new threats to the industry. While the actual danger of flying has not increased, an almost world wide fear have developed due to the terrorist attacks. According to J. Söderström (personal communication, June 10, 2003), the reservation statistics for the Commercial Airline Companies fell 50 percent on the very first day of the war. Thought, the reservations are recovering with about the half, weeks after it is still a huge loss for the industry. Despite the turbulence and the reduction of travelers it is not statistically dangerous to fly with large passenger aircrafts. In 1994, 1385 people were killed in 47 accidents around the world during flights. The average in a 10-year period is 720 per year (Brandsjö, 1996). Comparing this with numbers of people killed in traffic, which is estimated to 82.649 in year 2000 (International Road Traffic and Accident Data, 2003).

Terrorist attacks are not the only threat to the aviation industry. Additionally to the situation around the world that constitutes threat to the aviation industry the aviation market has during the last twenty years been characterized by large turbulence and an increase in merging airline companies. This has lead to downsizing processes and outsourcing parts of the organization and recently, to the development of low budget airline companies which have made huge success (Luftfartsverket, 2001)

This development leads to competition among traditional airline companies, and in trying to remain successful, these companies put themselves at risk. In order to keep prices down, resources and personnel must be cut. These changes can often render a company temporarily unstable, and in these circumstances the SCASA must take particularly care to ensure that safety concerns are not compromised- that safety regulations and demands are kept in a stable state.

The Swedish Civil Aviation Safety Authority; The regulatory activity

The SCASA serves as the regulatory authority of the Swedish air transportation. They have a difficult and complex role in limiting the occurrence of incidents and accidents. The investigation of incidents, often instigated by a combination of interrelated factors, is a process of discovery, monitoring and sanctioning- a process inevitably constrained by the relation between regulators and the regulated (Reason, 1997).

SCAA, The Swedish Civil Aviation Authority shall, according to the regulation (1988:78) with instructions from SCAA, "practice inspection over the safety for the commercial aviation". The SCASA as an administrative part of SCAA then carries out these inspections, though with aviation safety issues being an independent division within the SCAA. With words like openness, consequence, objectivity, competition neutrality and quality, the SCASA shall encourage a positive co-operative atmosphere towards the market. (Luftfartsinspektionen, 2003). They envision their safety work within the Swedish aviation industry serving as a model for the rest of the world. The Swedish rules related to the safety of the aircrafts are of a higher standard than the rest of the worlds, nevertheless, Sweden have to accept the some what loser rules related to other nationalities which is to enter the airport.

Fundamental to the SCASA is the Swedish Aviation Law and the Aviation Order that reflects the guidelines developed by the ICAO that explain how the authorities intend to carry out their statutory mandate. Also fundamental, is the European regulations and directives through the Joint Aviation Requirement (JAR) pertain as a result of the Swedish membership of the European Union and the European Aviation Safety Agency (EASA). Additionally, the section for regulations together with these international bodies develops local regulations, Regulations for Civil Aviation (BCL), (see figure 2.). These international bodies further control the overall course of action throughout the organization.

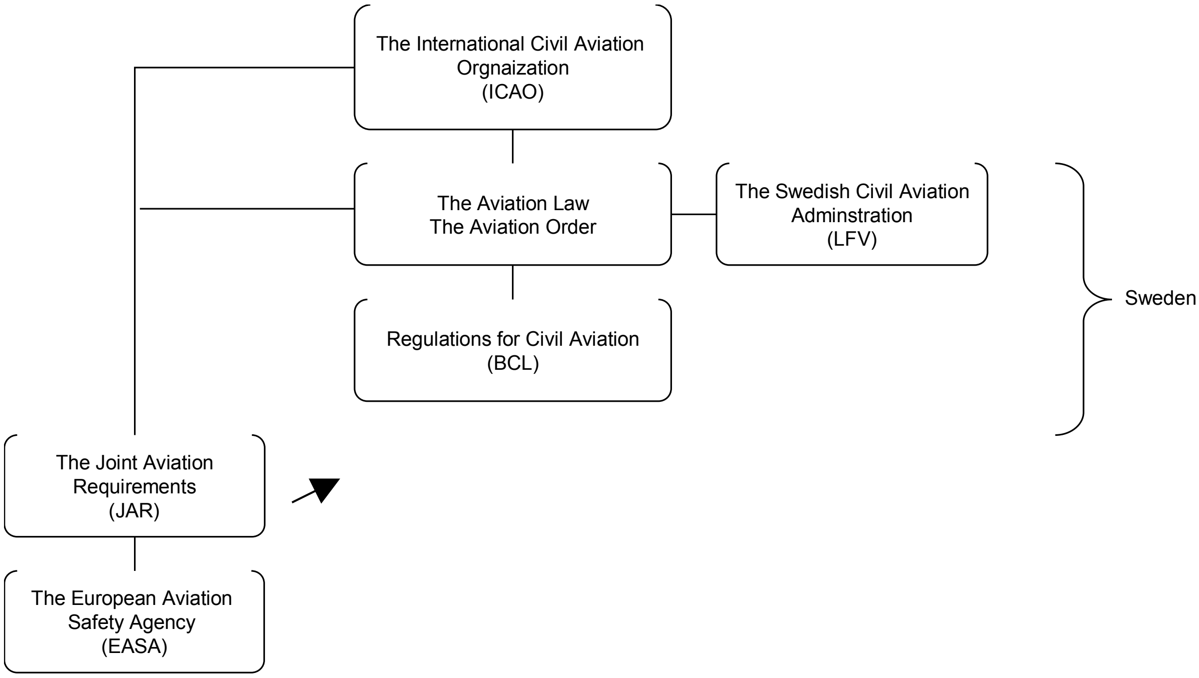


Figure 2: Graphical representation displaying the Swedish Civil Aviation Safety Authority's general proceedings within the organization.

The SCASA's safety strategy and concrete goal stipulates that: (1) the aviation safety standards in Sweden shall be in accordance with other well developed nations; (2) number of accidents per fly-hour and year should been halved during the period 1998-2007; and (3) the protection against criminal actions within civil aviation shall be in accordance with other well developed nations.

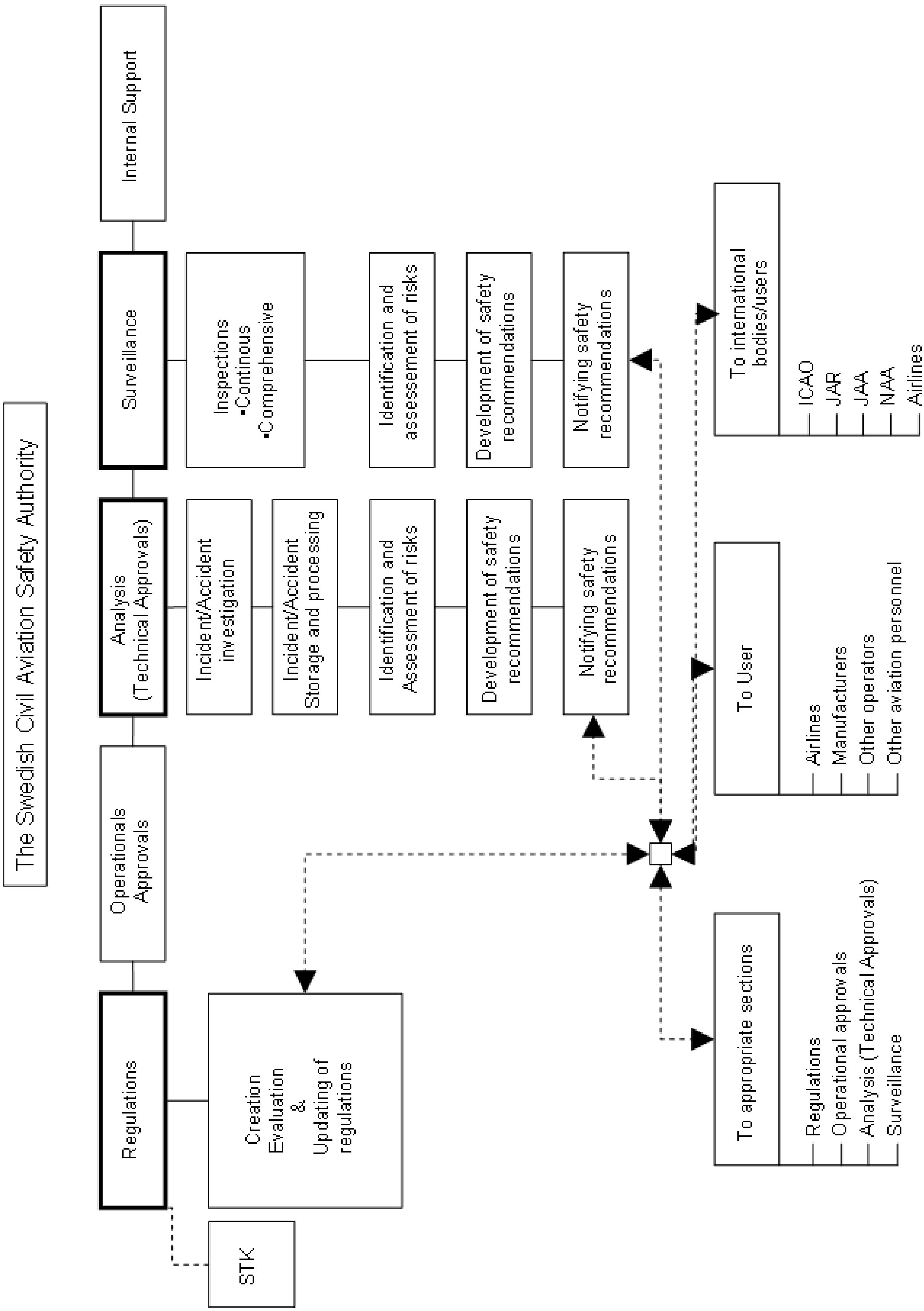
The SCASA has chosen five perspectives, which currently emphasizes their most important areas of focus. The perspectives are: (1) the customer, the aim to create a confiding relationship between the regulated activity and the regulator, (2) the co-workers, this perspective should safeguard and develop the regulator's members knowledge and competence, (3) production, what services and products should be accomplished, (4) economy, opposing how to create the resources that are required and how to full fill the duty as regulator within the financial frame given and (4) internal work methodology, this final perspective outlines how the regulator should work, how they are to create the services demanded by the customers and how they can improve their activity (Luftfartsinspektionen, 2003).

The structure of the Swedish Civil Aviation Safety Authority

The overall observation was that the SCASA as a regulator emphasised a systems approach characterised by a clear structure, commitment and strategies. The directors and middle management are ultimately responsible for safety, as they are responsible for other aspects of the enterprise. This is the logic that underlies recent regulatory initiatives.

The SCASA constitutes five sections, each featuring offices with specialized subject areas. The sections are Operational Approvals, Technical Approvals, Surveillance, Regulations and Internal Support. All sections are located in Norrköping, Sweden, except for Surveillance, which is located in Sollentuna, Stockholm. This structure of the organization is a result of their reorganization, which was finished and implemented in June 2001. A structural representation of the SCASA from a selected safety perspective can be seen in figure 3.

Figure 3 (next page) Structural representation of the SCASA from a selected safety perspective.



The Swedish Civil Aviation Safety Authority
Regulations
Operationals Approvals
Analysis (Technical Approvals)
Surveillance
Internal Support
Creation
Evaluation
&
Updating of regulations
STK
Incident/Accident investigation
Incident/Accident Storage and processing
Identification and Assessment of risks
Development of safety recommendations
Notifying safety recommendations
Inspections
▪Continous
▪Comprehensive
Identification and assessement of risks
Development of safety recommendations
Notifying safety recommendations
To appropriate sections
Regulations
Operational approvals
Analysis (Technical Approvals)
Surveillance
To User
Airlines
Manufacturers
Other operators
Other aviation personnel
To international bodies/users
ICAO
JAR
JAA
NAA
Airlines

The reorganization of the Swedish Aviation Safety Authority

In June 2001, the SCASA was reorganized for the purpose of developing more practical and efficient responsibility areas. As a result of this reorganization, the structure is clearer, and people (both affiliated and non-affiliated with the organization) know to whom they can express questions and concerns. Nevertheless, the reorganization is still new and is not yet stabilized so it can be hard to comment on the future development of the organization.

The implementation of the new organization demands endurance, as well as a continuous inclination toward innovation. The organization has now edified new leadership with a new alignment and increased delegation. The latter demands an increased involvement for all members of the organization and the delegation assumes that the processes are implemented and in use. However, if some members do not implement the new structure, this could threaten the SCASA as was suggested by one interviewee. Because implementation processes have to be evaluated and then perhaps adjusted and re-implemented a lot of effort and energy are often taken away from the main tasks of duty.

According to the majority of people interviewed, allocating time and effort to the reorganization did not affect work where safety was concerned. It was estimated by 3 of the 4 interviewees that between 40 and 60 percent of their time were devoted to the reorganization during the estimated year it took to complete. And according to these 3 participants, this has lead to an increased prioritizing of work, which always has to be done. This prioritizing can result in the small things growing into bigger proportions. For example, the inspections of the airlines' systems that are used to check whether the pilots can do their work, whether they are updated and follow the rules and so forth, have not been inspected for some time. The interviewee suggested this could lead to a lax attitude, "no one ever checks why bother!", even though it is not a current threat. This was, however, not considered by any of the participants as a threat to the SCASA.

It is also considered by one of the participants that communication has been better since the reorganization as they work closer to each other. As well as a better communication, improved accessibility to their chief leaders has developed a change in leadership has also developed. Increased delegation of the staff has resulted in a much more independent work situation. Despite the assertion of improved communication it is believed that increased discussion regarding safety policy is needed. Of course, the organization is said to be on a high safety level already but what do they mean by it, and how are these policies to be interpreted? This is an ongoing issue within the organization.

Prior to the reorganization as well as after the implementation of the reorganization, the SCASA faced a period of continuous resignations, which has resulted in a process by which competence needs to be established to make sure it corresponds to new demands as the industry becomes more and more complex and turbulent. The salaries created by the market and the localization of the SCASA, in Norrköping, makes the SCASA as an unattractive employer. However, when the organization has periods when the workload is increasing remarkably, retired employees return for a period of time to help out.

The reorganization was a risky prospect in that it was possible that not everyone would accept it. If some people felt left behind in the old structure, a situation could develop in which people did not consider themselves part of the organization, and subsequently work upon their own beliefs. To avoid such a situation, the structure has to be implemented in a good way. However, responses are bound to be influenced by the sections in which the participants were operating, and the extent to which those sections were affected by the reorganization.

Threats to safety

It is important to notice that these threats, statistical and perceived threats to the SCASA, may indirectly serve as a threat to the market, at the same time as threats to the market may constitute a threat to the SCASA. The necessary close interaction between the systems creates a difficulty in separating these from each other.

Internal threats to the Swedish Civil Aviation Safety Authority. Numerous of internal factors may erode the safety of an activity. One such factor that was identified by 3 of the 4 interviewed was the process of creating, evaluating and updating regulation. It was regarded that the SCASA constantly found them selves in a position of being behind. The regulations are too few and they do not match the currently fast development in technology. However, the process of regulation writing is a constant one and a complete rule can take up to four years to write and implement. It also creates a hard situation because of the very rapid technological development and difficulty in progress in changes while maintaining the same routines as is characterized in the general of aviation. In addition, one of the interviewed stated that there had not been a single new rule written since the reorganization was implemented. Thus, there is a gap between the rules and the current reality and closing this gap is one of the SCASA's goals.

Another major internal factor, which may erode safety that was also outlined by 3 of the 4, interviewed, was the inspection area. In general there are too few inspections and too few inspectors. The systems approach to SCASA´s inspection philosophy has made it possible to carry out the inspection tasks in regard to its recourses allocated in the expanded and more complex aviation industry. Yet, the ICAO, who along with the JAR has expressed demands on increasing frequencies of inspections, has criticized this approach. This was also noticed by the ICAO who identified 28 remarks in Sweden concerning the area of inspection, considering them having to few inspections and inspectors. On the other hand, some of the interviews indicated that there were no problems regarding the inspection when recourses were considered.

One reason for this might be the difficulties of recruiting personnel, which was a third general internal factor identified especially by one of the participants, which may erode safety. Competence is hard to find within the area, as the requirements demand years of experience and knowledge within the aviation field. Three of the four interviewees stated that threat to the expansion and development of personnel's knowledge and experience constituted a potential threat to the organization as a whole. Another reason recruiting is difficult concerns the geographical location, Norrköping being a small town, and salaries not being the most preferable. As one of the unwritten requirements for employment is the experience of being a pilot along with years in the aviation industry, follows that they are used to a wage level that is about three times the salary of a flight inspector. It is hard to justify that choice of working for a government authority, thought it might provide a higher employment security. This situation different to that of in England, in which being a flight inspector is, regarded as very high status and they have considerably higher salaries. An additional internal threat, which was considered by the SCASA, was the danger of an inhibited openness between them and the airlines.

External threats to the Swedish Civil Aviation Safety Authority. In addition to internal factors, external factors may erode safety as well. The major external threat that was agreed upon by the interviewed was the financial situation. One of the interviewed identified the problem as charging to little money for the services and suggested that in doing so it will provide less opportunity for inspections.

Another major threat that was generally agreed upon by the interviewed concerned the competition that the market is facing, with the ever-growing low budget airline companies. In order to maintain the low prices, the market is being pressured to cut down on recourses, which results in having modest margins. This leads to an increased workload at the SCASA, as they have to increase the inspections in response to the limited recourses, which results in even greater proportions of prioritizing from other assignments.

Internal threats to the market. It was stated by one of the interviewees that the rules applied by the SCASA are a minimal level that has to be followed in order to maintain the activity which the airline companies runs. Hence, it was not noticed by the SCASA that, which according to Svenson and Salo (2003, p.3) could be an internal threat, being a "slow gradual degradation of safety (organization, people, technology) below a just noticeable difference (JND) between the times of observation". In addition, it was stated that if the SCASA demands too strict regulations, the Swedish market would disappear into the international one.

It was noticed by the SCASA that they saw the danger of having a frivolous management, as they are the ones that create the general atmosphere in the organization, and put a top priority on economy and efficiency before safety. In a situation in which the pilot's relationship to the management is disentangled regarding safety-related issues, it may create an internal threat by furthering the risk of the activity. This is according to Svenson and Salo (2003, p.3) another internal factor that may erode the safety of the organization in where "safety goals turn out to be in conflict with other goals and looses in a goal conflict".

External threats to the market. As the world around us is changing with a seemingly increased threat from terrorist attacks one would believe that this must have affected the aviation industry greatly. Indeed, where the security division is concerned, there is a constant mission of finding the right balance between the accessibility and the safety of the aviation, though, one can never guarantee it being completely safe. Measures such as checking a hundred percent of the luggage as well as a hundred percent of the passengers are taken.

Again this has also affected the SCASA's inspections, as they have to increase especially when the aviation industry finds itself in a critical position.

System feedback

Internal feedback. Regarding to the structural characteristics of the SCASA structure in which the interaction and communication between the sections ought to be bound, a functional internal system feedback is essential. It was noted by one of the interviewed that there is a lot of work being repeated as a result of a defective computer system with inferior interaction between the sections. One of the interviewed also pointed out that too much information was circling around, rendering it impossible to read and relate to. He further asserted that the information ought to be more specific and related to the employees subject areas.

The information flow between the sections, especially between Surveillance, located in Sollentuna, and the remaining sections in Norrköping, was regarded by two of the interviewed as problematic. One stated, "it is always hard for the management to lead with distance, it being more practical if they were located here in Norrköping with the rest of the authority". Whereas another, who is stationed at Sollentuna, stated "I think the communication have improved between the sections".

Means of communication. In general, formal meetings and electronic mail were the main means of communication. Managerial body meetings were held every second week, while section and office meetings were held every week. One participant felt that the meetings were held too frequently , and contributed with too much information circling around.

Along with formal meetings, informal meetings such as coffee breaks were also viewed by the majority as being especially important. Casual conferences in the corridor were being estimated to take place three to five times a day. These diminutive conferences were regarded as extremely important to promote information flow, maintenance and increase of competence, as well as the endorsement of a pleasant and social work environment. The reorganization has contributed to improved communication, by placing members of the SCASA closer to one another. The issue of interpreting of certain safety matters is a constant process as rules and policies are always going to be a matter of interpretation, which is going to differ from person to person. It was commonly held that the informal meetings were also regarded important from this point of view, and that it was easier interpret matters collectively.

The SCASA employees have years of experience in the aviation industry, most of them being former active pilots. Subsequently, numerous contacts have been tied together through out the years and informal contacts have come to constitute a large proportion of the means of communication within the SCASA.

External feedback. It was reported that these informal means of communication were also a very important means of external communication between the regulator, SCAA and the airlines. One of the participants working at Surveillance commented on his almost daily contact with the Airline Company, it being the customer of his.
The communication and feedback between the SCASA and SCAA was merely explained as something that is executed on a higher managerial level.

Incident and accident reports

In the Accident Prevention Manual published by ICAO (1984, p.38) it is stated "incident and accident report should not be regarded as a means to an end in themselves but rather as the first of several steps towards accidents prevention". Instead it should be regarded as a feedback system in which a series of one type of incident/accident may indicate a weakness in a special area. Incidents and accidents are a plentiful source of risk information and lessons learned from the investigations of these ought to be incorporated and part of that feedback system.

The Airline Company writes incident reports and then submit them to the SCASA for analysis, which entails classifying the given incident according to different types of occurrences, that is, operational, technical or environmental. A disadvantage of the present category system of occurrence reports is that a system for classifying potential risk for each occurrence, so-called, 'Risk Assessment', has not yet been set (Luftfartsverket, 1999).

Following the classification, recommended measures and a priority list of the risks involved are determined. This ought to entail that the SCASA would recommend measures on the top priority risks. However, the way in which the SCASA is working, which is based on prioritizing and due to the optimization of resources allocated that are based on facts, it signifies that the measures recommended are being weighed against different considerations such as financial and political which entail it not always being the most safe alternative that is being recommended. However, the SCASA states that this is always a balance that has to be maintained in order to keep the organization in a steady state.

In 2002, a total of 2482 reports, concerning all 7 activity areas such as Heavy Jet planes, Light Jet planes, Helicopter and Civil Aviation, were submitted to the SCASA. 2272 of those were identified as disturbances without any damages, 89 were incidents and accidents where damage could have occurred and 121 of them were technical reports (Hummerdal, 2003). During 1997 and 1998, 450 reports concerning only Civil Aviation were analyzed by the SCASA. These reports indicated that the highest frequency of occurrence was "flying without permission". In a report from the Scandinavian Civil Aviation Supervisory Agency (STK), it was stated that overall, more than a hundred departures within the SAS airline occurred with aircrafts that had not fulfilled the demands of airworthiness (S Christianson, personal communication, May 28, 2003). The number of reports has steadily increased during the last years. One should not interpret this increase of reports as a symptom of the deterioration of airline safety, but rather as an indication of honesty and a willingness to admit to error, qualities that reflect a good safety culture.

The aviation industry uses The Aviation Safety Reporting System (ASRS), developed by NASA, which provides a great example of a system that features an open and trustful information subsystem. This information system is characterized by a willingness to report an incident/accident and this tendency towards honesty is evident and remarkably high in comparison to several other countries (Luftfartsverket, 1999).

In May 1994, the government decided that all Swedish authorities should execute risk analysis on a regular basis in order to compute the financial costs of the risk management, limit risks, and prevent incidents and accidents from occurring. The Swedish National Audit Office (Riksrevisionsverket) found that nearly fifty percent of the Swedish authorities could have defective knowledge regarding risks, damages and incidents in the activity. In addition, twenty-five precent state that regular risk analysis has not been carried through on a regular basis (Riksrevisionsverket, 2003).

Measurement of safety

It is highly desirable to monitor the effectiveness of incident/accident prevention efforts as well as the recommendations issued by the SCASA.

The Swedish Civil Aviation Safety Authority's measures. There are three ways in which the SCASA measures their strategic goals as they relate to safety of their production: one is number of regulations issued, another is number of inspections and deviations, and the last is number of occurrence reports and accidents (Luftfartsinspektionen, 2003).

The market's measures. There is basically two ways that the market can measure the safety. One refers to number of accidents, incidents and fatalities, etc. and the other implies accidents rates. The latter being the only source from which, valid comparisons can be drawn. For example, if two types of aircrafts are compared and type A has one million flight hours in one year resulting in one accident, and type B has five million flight hours in one year resulting in seven accidents, the former type of aircraft indicates an accident rate based on flight hours being statistically preferable (International Civil Aviation Organization, 1984).

Regulatory strategies

The regulatory strategies applied and coined in the nuclear power industry could be related to the aviation industry. There are two strategies applied by the SCASA. The first could be described as partly prescriptive; a strategy that provides very detailed requirements that the airlines must follow in conducting their activity. The second is partly based on self-assessments; a strategy which requires the airlines to develop and implement a self-assessment program to identify both good practices and problem areas needing improvement, which the regulator evaluates (Durbin & Melber, 2002).

In a complex system with multiple interactions between the suprasystem and the subsystems as in the aviation industry, the accident category cannot act as the only predictor of chosen regulatory strategy. Other factors such as the characteristics of safety issues, the nature of the relationship between the regulators and the regulated, the public and, political and legal bodies will influence on the choice.

DISCUSSION

The present study has given a narrative of safety management in the Swedish Civil Aviation Safety Authority (Luftfartsinspektionen, SCASA) in which a system approach was essential. The structure of the organization has been illustrated in a structural representation selected from a safety perspective and threats against the regulatory activity identified. Insufficient inspections and incomplete regulations that is in constant need of evaluation and creation, was identified as being the main threats against the SCASA, which may have effect on safety. Financial hardship and a management marked by unbecoming levity in which safety-goals conflict with other goals such as profit and efficiency were identified as being the main threats against the market. Finally, the information system feedback of the SCASA was described. As well as above issues, limitations of the study and methodological issues will be discussed and future research outlined.

The Swedish Civil Aviation Safety Authority, the regulator

The SCASA's general safety strategy and concrete goals stipulated that aviation safety standards in Sweden shall be in accordance with those of other well developed nations and that number of accidents per fly-hour and year should have been halved during the period from 1998-2007. Despite these strategies and goals, the five perspectives that the SCASA currently considers the most important areas of focus do not mention safety. One explanation for this might be that the areas of focus are considered to be related to the SCASA's 'pure' business plan in their work towards their customers. One may argue though, that if the systems approach is to permeate all levels of the organization, safety should defiantly constitute a part of all processes.

The structure of the SCASA

The structure of the SCASA, as put forward in figure 1, reflects the processes of the organization as structures and processes within SCASA seem to be well accommodated to each other. However, there are differing opinions regarding the legibility of the structure at present. Due to the recent implementation of the reorganization it is difficult to lay down whether this is just a matter of getting used to the implementation or if it really was better before the reorganization even though one of the main purposes for the reorganization was to get a more legible structure. Another reason for this might be that the different sections were affected disparate by the reorganization. Some sections were completely reorganized through downsizing its unit from 24 members to 4, which would be a rather great alteration while other sections were not affected at all.

It was noticed by some of the interviewed that one major disadvantage of the structure is the present location of the surveillance section, Sollentuna, located 2 hours from the head office in Norrköping. This could create communication problems and distant management may always be difficult. This was also noticed by some of the interviewed.

Though the distance is large between the surveillance section and the rest of the organization, the present location of the members working in SCASA in Norrköping has been improved, and managers are easier to get in contact with. This is a major advantage of the structure, as communication will thrive if, simply, it is easy to communicate. Communication is likewise most important in controlling those threats against the SCASA and the market, which may erode safety.

Threats to safety

The complex industry of aviation brings with it numerous of factors which may erode safety. The insufficient inspections and incomplete regulations identified as the major threats to the SCASA by the majority of the participants, constitutes an issue of concern. These threats in the end may be the fundamental part of the substance of threats to the market and further to the individual when flying.

If the airlines are to have a good safety record, SCASA must provide great work in following up the incidents and provide great recommendations. In order to provide such work, extensive inspection criteria have to be meet. According to SCASA, they had enough staff and all posts were filled, they still emphasized that with the present workload it is always a matter of prioritizing, as they did not have time for every single case. Is it then really the case that the SCASA is not in need for further resources? Probably, but as it is decided by the management that no more positions should be either created nor filled, the financial situation is probably not allowing it. An organization that is never in need of further resources and always has the time for every single task would probably be a dream scenario- a perfect organization, but does it exist? Nevertheless, it is important to strive for one and to emphasize those little things that the staff does not have time for, as they could be those little things that build up and could constitute that little last bit in the chain of defense of a potential accident.

The present situation seems to be characterized by an increasing workload during certain periods. This increase results in demands for further analysis by the inspections and regulations, which in turn takes prioritizing even further, and it is the demands for further resources, which completes the vicious circle. One explanation of limited resources could be to the reorganization and the great effort and energy it often requires. On the other hand, this seems to have been a problem even before the implementation of the reorganization as the Surveillance section was not to a greater extent affected.

Information system feedback

The information system feedback, which, according to some of the participants was lacking seemed yet to be an example of a communication system that works, but will always be in need for improvements.

One factor, which may indicate good communication, is the increasing number of reports reviewed by SCASA. An organization with a good safety record, meaning few reports, is not necessarily a safe organization, for one could, argue that the more reports the organization is handling the safer the market could be considered. Evident from the increasing number of reports over the last years, SCASA seems to have installed in the market a willingness to report on incidents and accidents. Due to the very notion of the SCASA as a regulator, in motivating appropriate behavior of the market and avoid de-motivation of appropriate behaviors, they seem to have succeeded.

Another factor which, at first hand may indicate a favorable means of communication, is the informal contact between the employees throughout the industry.

As most of the employees at the aviation authorities have been former active pilots with years of experience in the aviation industry, they tend to become friends. While this may first seems to be the making of a healthy work atmosphere, which it also can be, one may argue, however, that this is correspondingly set for use of insidious purposes.

The case study illustrated, to the best of the authors' knowledge, high quality safety management. A management process that evidently considered a system approach which is essential in such complex socio-technical systems such as in aviation. International aviation has taken this approach for some time, as they are aware of the disastrous effects an accident could have. A potential accident in these industries would not only affect the individual but also the subordinate society; therefore, the importance of dynamic interaction among subsystems and suprasystems is essential.

The nature of the risks and the environment will constantly change and so one must remain alert for the changes and take preventative actions. The flexibility of the industry is thus essential, as successful safety management is largely dependent on the industries ability to adapt to a constantly changing environment.

Ultimately, SCASA gives a general impression of being in good relation to its regulated organizations with a clear regulating structure. However, SCASA will have to arrive at an understanding of how its regulatory strategies can and will affect the safety of the regulated, both positively and negatively. Recognition of the SCASA's vision is an endeavor for the future. With improvements of a general system approach they may in time serve as a model for other developed nations and provide an even safer aviation for all.

REFERENCES

Anderson JD (1997) *A history of Aerodynamics*. Cambridge University Press, England.

Argyris C (1999) *On organizational learning* (*2nd ed*.). Blackwell Publishers Inc, Malden USA.

Bertalanffy L (1973) *General system theory*; *Foundations, development and applications*. Braziller corp, New York.

Booth RT and Lee TR (1993) *The role of human factors and safety culture in safety management*. Papers presented at a meeting organized by the engineering manufacturing industries division of the institution of mechanical engineers in association with the hazards forum, and held at the institution of mechanical engineers on 12-13 October 1993, Mechanical Engineering Publications Limited, London.

Brandsjö K (1996) *Katastrofer och räddningsinsatser*. Centraltryckeriet, Borås.

Done J (2002) *Implementation of safety management systems*: *Challenges and Benefits*. Paper presented at the 19th Annual FAA/JAA International Conference June 3-7, Australia, 2002.

Durbin NE, Melber B, Blom I (2002) *Regulatory strategies and safety culture in nuclear power installations*. Paper presented at the SKI workshop on regulation in October 2001, Stockholm.

Durbin NE and Melber B (2002) *Alternative regulatory strategies*: *Commercial nuclear power discussions of issues and comments,* manuscript for SKI. (SKI 14.13 Dnr 011133, January 28, 2002).

Eirevik SE and Gunnarsson T (2003) *Avvikelserapportering och erfarenhetsåtermatning i flygplatsens kvalitetssystem*. Linköpings universitet Examensarbete LITH-ITN-KTS-EX-03/009 – SE, Linköping.

Hammer W (1972) *Handbook of system and product safety*. Prentice-Hall Inc, Engelwood Cliffs, N.J.

Huber GP (1991) Organizational learning: The contributing processes and the literatures. *Organization Science* 2(1):88-112.

Hummerdahl D (2003) *Luftfartsinspektionens databas för hantering av luftfartshändelser*. Luftfartsinspektionen, Norrköping.
International Civil Aviation Organization (1984) *Accident Prevention Manual*. International Civil Aviation Organization, Quebec.

International Road Traffic and Accident data (2003) Available: http://www.oecd.org/EN/documents. Accessed April 7 2003.

Leveson NG (1995) *Safeware system safety and computers*. Addison-Wesley Publishing Company, Massachusetts.

Luftfartsinspektionen (2003) *Verksamhetsplanen för Luftfartsinspektionen*, 2003-2006, Luftfartsinspektionen, Norrköping.

Luftfartsverket (2001) *Flygets utveckling 2001*, *en sektorredovisning*. Luftfartsverket, Norrköping.

Luftfartsverket (1999) *Analys av störningsrapporter 1/1999*. Luftfartsinspektionen Rapport 1999:02/La, Norrköping.

Martin A (2002) *The need for a scientific approach to Safety Management*. Paper presented at the CSNI/SEGHOF Workshop in Paris, France.

Miller JG (1978) *Living Systems*. McGraw-Hill, New York.

Rasmussen J and Svedung I (2000) *Proactive risk management in a dynamic society*. Swedish Rescue Services Agency, Karlstad, Sweden.

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

Riksrevisionsverket (2003) *Riskhantering i statliga myndigheter*. Effektivitetsrevision RRV 2002:25, Riksrevisionsverket, Stockholm.

Ruben BD and Kim JY (1975) *General systems theory and human communication*. Hayden Book Company Inc, New Jersey.

SAS (2002) *The SAS Group Annual Report 2002 & Environmental Report*. SAS
AB Publications, Stockholm.

Sorensen JN (2001) Safety culture: a survey of the state-of-the-art. *Reliability Engineering and System Safety* 76:189-204.

STK (2003) *Quality Manual*. STK Safety and Quality Policy.

Svenson O (1990) The Accident Evolution and Barrier Function (AEB) Model Applied to Incident Analysis in the Processing Industries. *Risk Analysis* 11(3):499-507.

Svenson O (1984) Managing the risks of the automobile: A study of a Swedish car manufacturer. *Management Science* 30(4):486-502.

Svenson O and Salo I (2004) *Safety management*: *an introduction to a frame of reference exemplified with case studies from non-nuclear contexts*, manuscript submitted to SKI.

Transport Canada (2001) *Safety management systems*. TP 13739 E (04/2001). Civil Aviation Publications, Canada.

Chapter 6: On Event Reporting in the Swedish Health Care and Civil Aviation Systems

Ola Svenson
Risk Analysis, Social and Decision Research Unit
Department of Psychology
Stockholm University
S – 106 91 Stockholm, Sweden
osn@psychology.su.se

ABSTRACT

This chapter describes the safety feedback from event reporting systems. The companies who were investigated in more detail (SAS and Danderyd Hospital Company) and also the corresponding safety regulation authorities were quite open about their own internal reporting systems and provided valuable information. The present chapter covers company internal event reporting systems and external reporting systems to the societal authorities
Keywords: Incident reports, aviation, health care, feed back

INTRODUCTION

In the introductory chapter on a system perspective on safety management feedback was identified to be a key function for maintaining and developing system safety. The health care and civil aviation systems have routines for information feedback of deviations and other events concerning the safety of the system to clients (patients and passengers). Some parts of these systems will be described in the following. The descriptions concern primarily clients and not the personnel active in the systems and the text is selective in focusing on themes that may be relevant to safety management in other high-risk activities.

HEALTH CARE

The Swedish Socialstyrelsen (the Swedish National Board of Health and Welfare) regulates, inspects and gives recommendations concerning safety in the whole Swedish health care system. Events and deviations can be classified in one of two categories. The first category includes events required by law to be reported to Socialstyrelsen. The second category consists of events and deviations required to be reported to and analysed by the people within a health care unit who work with safety management.

Reports to Socialstyrelsen

According to legislation (Lex Maria) events concerning patients who have been injured or have become sick as a result of maltreatment or exposure to a risk that was not normal or predicted should be reported to Socialstyrelsen. The reports should be given by competent personnel having a position in the organization permitting comparisons between different events and who take active part in the medical safety and quality assurance work at the site. Every health care unit is required to have personnel actively working with patient safety. They are also responsible for distributing information within and between health care units. It is clear that professionalism not only in the health care work but also in event reporting is a requirement. This secures overview and possibilities for detection of system deficiencies

The person who reports should not be a chief or leading person directly responsible for the personnel associated with the event. The events are reported on forms, one for "serious damage" and one for "risk for serious damage". A report should arrive at Socialstyrelsen not later than two months after the event. It is required that risks or risky behavior that has already been followed by changes of routines are also reported.

Among the events that should be reported to Socialstyrelsen one finds
(1) mistakes of drug administration, prescription or dosage,
(2) omitted or delayed investigation or treatment of a patient,
(3) wrongly executed examination, care or treatment,
(4) incomplete or faulty information to patients or relatives,
(5) insufficient information or information leading to incorrect interpretations of instructions to health care personnel,
(6) incorrect use of or errors in maintenance of medico-technical products or other units, such as, emergency power units,
(7) insufficient work routines, organization of the health care or coordination between different units,
(8) insufficient resources concerning, e.g., competence, staffing, buildings or equipment for safe activity and
(9) deviations that are not in isolation reportable, but repeat themselves and therefore may pose a risk to patients.

Internal reporting in a health care organization

As mentioned above, each health care unit is required to have staff and routines for handling deviations from normal operation. The deviations should be analysed and the results fed back to those who were involved in the deviation and to other people in the unit. In addition, the safety managers should disseminate information about events and incidents reported to Socialstyrelsen.

Deviation and incident reporting in the health cares system: An empirical study

Socialstyrelsen is responsible for regulation and inspection of the health care system. Inspections are initiated by concurrent incident reports or by Socialstyrelsen itself. As a rule, an inspected unit is informed about the inspection in advance, if this is not judged to make a high quality investigation more difficult. Inspectors have degrees in law or university studies of relevance to the health care sector (Socialstyrelsen, 2003).

In 2001, 267 Swedish health care units were inspected and their 4 338 deviation reports were analysed (Socialstyrelsen, 2002). One chief aim of the study was to describe the routines for deviation management internally and externally.

The results showed among other things that
(1) the requirements to report were known by most personnel,
(2) the purposes of reporting was not clear to everybody,
(3) some deviations were not reported because of fear of negative consequences for the actor or because she or he did not want to get a poor reputation.
(4) complaints from patients were not perceived as deviations and therefore not reported,
(5) the local safety staff may miss report serious events internally because they are reported to Socialstyrelsen ,
(6) isolated deviations that lead to immediate actions in response to the particular event may not be reported,
(7) analyses of past events are seldom used in proactive risk analyses,
(8) counteractive measures in response to deviations are seldom followed up and
(9) handling deviation reports is only a small part of the quality work in the average health care unit.

Most of the deviations are reported by nurses. Physicians report much less frequently and they indicate that they use other ways of communicating events. Only about 50% of the serious events are reported from one health care unit to other health care units. This is considered a serious shortcoming of safety management in the health care system.

The branch of Socialstyrelsen located in Örebro publishes “Riskronden”, a journal in which information is provided about recent risk events in the health care system. However, the publication does not aim at providing full coverage of the risk events taking place in Sweden. Riskronden also publishes material, results and conclusions of investigations carried out by The Scientific Council of Socialstyrelsen.

Results of particular relevance for other activities

It is interesting to note the stress on information in health care safety management. When incomplete information has been given to the health care staff in their daily work, this should be reported as well as information that is insufficient or leads to the personnel making incorrect interpretations of instructions. Such regulations are important for those writing instructions about procedures in all activities.

There is also great stress on working conditions with relevance to safety. If the work routines and organizations are insufficient or if there is a lack of competence, staff, localities or equipment, this should be reported. Repeated minor events should also be reported even if they are not in isolation judged to be reportable. This is another indication of how important organizational factors are in safety management of the health care system.

The empirical study revealed that the purpose of reporting was not clear to everybody. If staff and subcontractors do not know about the purposes of reporting or do not agree about the relevance of the purposes, hazard management is at risk. To illustrate, if licensee event reports to a regulating authority are made only for formal reasons, this is a sign of non-optimal safety management.

When immediate action is taken in response to an event, reporting rate may decrease. Even though the positive reinforcement for reporting is strong, some events are not reported because of fear of negative consequences. This finding is highly relevant for any high-risk activity or industry. The problem of low quality of the procedures for following up events and learning from them is fundamental, but unfortunately common also in many other high-risk activities. This problem has been taken seriously by some companies in the aviation industry and this will be presented in the next section.

CIVIL AVIATION

Allwin (See this volume) presented a general overview of safety management in the Swedish civil aviation system. It can be used as a background to the more specific focus of the present contribution.

Reports to Luftfartsinspektionen

Luftfartinspektionen (the Swedish Civil Aviation Administration) is responsible for regulation and inspection of civil aviation systems. Luftfartsinspektionen requires reports covering among others, the following events
(1) accidents,
(2) failures in equipment, materials or other safety related damage that has been detected during a flight operation,
(3) deviations or other errors in normal flight conditions and
(4) deviations from good practise, rules or regulation when in an emergency.

Reports about events during operation should be sent immediately to Luftfartsinspektionen or/and to the nearest air traffic control center. When the event concerns verification for air operation of an aircraft, the local representatives of Luftfartsinpektionen should receive the report. There are several different forms for reporting different kinds of events and incidents (See Luftfartsinspektionen at www.lfs.lfv.se/BASIS/lfvb1/irisext/gallandedok/ddw).

Inspections of Swedish airplanes and flights are carried out by the personnel of Luftfartsinspektionen, but they are quite infrequent in relation to the number of airplanes and flight operations taking place. A pilot can work many years without having been subject to an inspection.

Reports within a company

The Aviation Reporting System (ASRS) (http://asrs.arc.nasa.gov/overview_nf.htm), was created by the US Federal Aviation Administration (FAA) and the National Aeronautics and Space Administration (NASA). It has played an important role for other aviation reporting systems used by different companies and authorities around the world.

Recently, Scandinavian Airline System (SAS) developed the Common Deviation Reporting System (CDRS) enabling a unified event reporting, action and follow up system. The Risk Assessment Method (RAMS) analyses the exposure to unaccepted safety related events in predictions of risks for more serious incidents (Henrik Comstedt, SAS, personal communication).

It is interesting that according to CDRS, risk and seriousness are separated. Risk refers to the likelihood of a major accident if the event recurs. Seriousness refers to the probability that an event evolves into a major accident under the prevailing conditions. To illustrate the risk and seriousness concepts, assume a rejected take off (RTO) due to a main door warning.

Case 1
Short runway, bad breaking action and weather
Risk level: R3 (increased)
Seriousness: B (considerably increased)

Case 2
Long runway, good braking action
Risk level: R3 (increased)
Seriousness: D (not increase)d

The risk remains the same because the event is the same (but the particular conditions are different with case 1 worse than case 2).

Use of systems

In general, the bigger airlines have their own reporting systems containing many more events than required by regulation. To exemplify, SAS handles about 6 000 reports per year in its own reporting system, an increase with the introduction of the CDRS system from 3 600 events per year. Only a fraction of the internally reported event is sent to Luftfartsinspektionen (Henrik Comstedt, SAS, personal communication). The motivation of the aviation personnel to report is high and no negative legal consequences follow the reporting of an event, provided there was no evil purpose behind it.

Results of particular relevance for other activities

The civil aviation system depends on less strict societal safety regulation for reporting and licensing than many (big) airlines themselves foster within their own companies. This is the case for SAS who found that an improved reporting and event management system was paralleled by an increase in reporting frequency. As in other activities, deviations from rules and regulation are reported, but also when "good practise" is not followed in emergencies. This could draw attention to new safety related aspects in other organizations as well.

GENERAL COMMENTS

The two main companies who were investigated in more detail (SAS and Danderyd Hospital Company) were quite open about their own internal reporting systems. This was necessary for the present contribution with its summary of some interesting aspects of safety management that may relevant to other activities as well.

A few aspects of safety management were highlighted in the present contribution. First, (a) motivation to report can be increased if the purposes of reporting are known and shared, (b) if the reporting system including the analysis and feedback of the information is improved this makes management more efficient and can increase reporting frequency, (c) if the risk of negative consequences (fear for consequences in company, legal or social) is removed the probability of reporting can increase. Second, information that is insufficient or may lead to misunderstanding procedures or other activities is important to report. Third, lack of staff competence or shortage of personnel should be reported for improved safety management.

Acknowledgements

I wish to thank Pernilla Allwin and Åsa Jonsson for providing me with facts about risk management in the health and aviation sectors. This chapter was also based on interviews in addition to the references below. The Swedish Nuclear Power Inspectorate provided funds supporting the study.

REFERENCES

Socialstyrelsen (2002) *Avvikelsehantering inom hälso-och sjukvård. /Event report management in health care/* Socialstyrelsen:www.sos.se /FULLTEXT/109/2002-109-3.

Socialstyrelsen (2003) *Så här arbetar vi med tillsynen av hälso- och sjukvården. /This is the way we inspect health care/* Socialstyrelsen: www.sos.se/tillsyn.

Chapter 7: Safety Management of Nuclear Power Plants - Values and Balance of Attention

Carl Rollenhagen
Mälardalens Högskola and SwedPower
Swedpower AB Box 527
S – 162 16 Stockholm, Sweden
Carl.Rollenhagen@swedpower.com

ABSTRACT

This paper suggests a theoretical framework for interpretation of issues associated with safety management of nuclear power plants (NPPs). A model is suggested that differentiates between four focus areas tentatively labelled; (1) Strategic economy issue management; (2) Technology management; (3) Competence and Human Relations management (HRM), and (4) Quality system management. For each of these areas, called *internal* organisational focus topics, sets of matching *external* focus areas are identified. Management of NPPs are analysed as movement in a problem space in which the organisation seeks to optimise and trade off partly conflicting values in search of integration and adaptation to external demands.

Key words: *safety management, nuclear power, safety culture, management groups.*

INTRODUCTION

Management of nuclear power plants

Management of nuclear power plants (NPPs) raises concerns that are (at least to some extent) more demanding than for many other industries. For example, issues associated with information management are of crucial importance because public confidence in nuclear power influences the survival possibilities of the industry. Another strategic issue concerns the high requirements attached to systems for quality management – a subject that needs much effort and attention and also exposes the nuclear sector for extensive regulatory demands. External political uncertainties also present obstacles for the selection of long-term investments strategies. Moreover, and most importantly in this context, the deregulation of the energy market forces a need for more cost-effective production. To be able to direct attention and manage issues such as those mentioned above is not an easy task given various resources constrains. Consequently, management groups are looking for concepts, tools and techniques that can support and optimize safe and efficient operation. Benchmarking, balanced scorecard, process analysis etc are examples of management tools that are assumed to create more efficient and cost-effective organizations. Safety management may benefit from applying such methods, although it should be realized that *safety related issues*, in contrast to issues associated with *financial circumstances*, draw on partly different traditions, methods and management philosophies (although these issues are obviously connected as seen from a safety management perspective).

An important aspect of management (including safety management) is belief systems and values associated with various issues domains, and in particular, to what extent these beliefs and values are made *explicit* in the decision process. Beliefs and values, in turn, are related to various management ideologies, traditions and subcultures. Furthermore, a general criterion for the efficiency of safety management is here believed to be one of *balanced attention*. A balanced value and attention framework implies that safety issues can be perceived from several perspectives (financial, quality-related, technological, human etc) and that beliefs and values associated to these various perspectives are made explicit in view of various resource constrains. Power relations may make this difficult, however, since power may rest on maintaining asymmetric information among actors.

Different professional groups (upper management, operation, maintenance, engineering etc) exhibit a more or less *biased attention* to the boundaries of safe operation, the importance of various issues as contributors to risk, and a possible dynamics of the system. Safety management strategies relying on expert judgments based on information obtained in specific issue domains such as quality, human factors, economy etc has a tendency to sub-optimize overall system performance if not integrated properly (Andersson and Rollenhagen 1993, 2003). One of several consequences of such sub-optimization can be that attention is directed toward issues that have minor safety significance in comparison with other more important issues. Another possible consequence is that an issue is perceived as non-safety significant since it appears to rest in a domain with no obviously perceived safety significance.

A solution to this dilemma may be found in co-operative arrangements and strategies that can exploit and iterate experiences from various subcultures, traditions, value system etc and then resolve issues in a dialectic process in which conflicting value systems, in fact, can be viewed not only as an obstacle but also as an asset and opportunity for learning. The increased interest for dialogue theory (Isaacs 1993, 1999) also exemplifies a strategy that may supports awareness about beliefs and values held by different stakeholders and subcultures in a system. Safety management could benefit from these approaches, for example, by forming so called "system groups" (Andersson and Rollenhagen 2003) that contain representatives from the whole system of interest and use the group setting as a simulation model for exploring dynamics in the system.

Beliefs, values and attitudes are partly generated from the restrictions and opportunities associated with various task domains. Values, therefore, partly reflect what has been adaptive and successful for various stakeholders over time. Cultures may change slowly, however, and actors may have difficulties to assimilate rapid changes with both positive and negative consequences for safety. For example, a very strong financial pressure for adaptation may lead to an unbalanced attention toward financial issues at the expense of safety. Consequently, attempts to measure safety climate/culture should address conflicting value system, the nature of work, and the outside context of an organization and interpret the result in a historical perspective of the organization.

Safety cultures and value systems

The concept of safety culture has been influential in that it directs attention to value systems and attitudes that may support (or be harmful) for efficient safety management. Although there are many specific definitions of the concepts safety culture (which will not be discussed further here), most researchers define the concept in relation to such things as those attitudes, values, and practices etc. that are shared among people (for overviews see Hale and Hovden 1998, Sorensen 2001, Flin et al. 2000 and Guldenmund 2000).

Researchers in the subject of culture argue about, for example: to what degree a culture can be managed; the difference between culture and climate, and other issues of similar kind. There is no doubt, however, that safety culture as a concept has fostered a more elaborated view on safety by attempting to make some subjects explicit that previously were more implicit in kind. In general, it appears that research in safety culture has proceeded towards an enhanced interest for the concept of culture in a more general sense of the word and thereby into literature and research traditions developed outside the safety arena. In particular, it seems that a stronger focus on the concept of *value* has emerged (Stackman et al. 2000).

Nuclear organizations, as other organizations of a certain size and complexity, consist of many overlapping subcultures holding at least partly different belief and values. Subcultures can be differentiated based on many criteria, such as people of a certain age and background, job characteristics etc. Furthermore, people do belong to several subcultures both at work and outside work and the corresponding belief and value systems are therefore, of course, context-dependent. Stackman et al. (2000) suggested that values could be understood in an abstraction hierarchy. At the highest level of abstraction, values such as those described by Schwartz (1994) can be described in abstract and universal terms across different context. For the purpose of investigating more specific work settings, however, value descriptions have to be operationalized and adapted to the particular setting of concern (e.g. work values, family values etc). Stackman et al. also argues for a perspective of values described as sets – different sets of values will "increase and decrease in relative importance for an individual across time and differing context". A perspective based on values and specific context domains (issue domains) found in nuclear power operations could be of benefit not only to obtain a better understanding of safety but also for the understanding of the whole integrated socio-technical function of NPPs. In particular, it could be worthwhile to explore the following questions:

a) What basic "issue domains" are perceived as important in NPP management?

b) What basic beliefs and value systems may be discerned for these domains?

c) To what extent are these sets of values representative of different jobs and functions found in NPPs – for example, how could one characterize the value systems among managers in contrast to persons working in quality functions, engineering departments, human resource functions etc?

d) To what extent do values associated with different focus areas reflect opportunities and obstacles for learning and communication?

e) To what extent do organizational structures found in different NPPs reflect an integration (or separation) of value systems and what does that imply for the safety culture(s) of a plant?

f) How is it possible to create integrated analytical functions and create co-operative arrangements that may support a balanced attention to various focus areas?

If answers can be obtained to the questions above NPPs could benefit both in safety and general efficiency, but to achieve this goal we need not only to understand safety management from a theoretical side but also to develop applied supporting tools. Edgar Schein (2000) has expressed the general subject well when stating that: "Part of the reason organizations do not work well, part of the reason we have wars, and part of the reason we have difficulty reaching consensus on major global problems such as maintaining a healthy environment is that we cannot communicate well across cultural boundaries. We have excellent data that show how differently various groups perceive their environment based on different shared tacit assumptions, but we have very few tools for helping people to improve communication across those boundaries" .

RESEARCH INTO SAFETY CULTURE AND VALUES

Safety culture is sometimes perceived in a normative way and common approaches are to measure a current safety climate conceptualized as "safety culture dimensions" and compare these data with a normative view (what is considered as "god" is, however, often rather implicit common sense assertions). Measurement of safety culture and climate has been conducted in many industrial sectors. For example, in the offshore industry Alexander et al. (1994) used questionnaires and interviews to identify differences in perceived culture among employees in an operating company with that of contractors and also explored differences between offshore and on-shore environments. For the operating company six factors were identified; management commitment, personal need for safety, appreciation of risk; attribution of blame, conflict and control and supportive environment. Differences were found in, for example, in that contractor employees had higher appreciation of risk and higher personal need for safety compared to employees in the operating company. In subsequent research Mearns et al. (1998) found evidence of differences in perception of safety *depending on various subcultures* (Flin et al. 1996). Other dimensions suggested to describe safety culture may be found in, for example, Lee (1995), Donald (1995), Byron and Corbridge (1997) and Cox and Cox (1991).

A rather comprehensive set of safety climate/culture dimensions, partly based on previous literature reviews of research, can be obtained from Cox and Cheyne (2000). The dimensions suggested are: (1) Management commitment (2) Priority of safety (3) Communication (4) Safety Rules (5) Supportive environment (6) Involvement (7) Personal priorities for safety (8) Personal appreciation of risk, and (8) Work environment.

An interesting observation in connection with dimensions such as the one mentioned above is that they appear to associate with somewhat different management ideologies. Beyer (1981) describes ideologies as

"Relatively coherent set of beliefs that bind some people together and that explain their worlds in terms of cause-effect-relations…. ideologies explain the hows and whys of events, and affect predictions and the likelihood of outcomes. Ideologies may specify that some courses of actions are far more likely to bring about desired outcomes that others" (pp 166-167).

If one assumes that safety culture dimensions, such as the one suggested above, are important characteristics of safety culture/climate then we would also need *management ideologies* that can support desired values and attitudes. However since NPP organizations do include partly conflicting ideologies, depending on various issues in focus, this would present obstacles (but also possibilities) for the development of a coherent and unified safety culture (a set of basic shared values). It would therefore be of interest to identify management ideologies and associated value system for various issue domains and to study potential generic conflict and coping patterns.

In the earlier safety culture literature, the concept of value is often mentioned but seldom developed further. Current research exhibits a broader theoretical frame of cultural research than previously. Cox and Cheyne (2000) and their colleges present a "multiple perspective model" of safety culture (see also James and Jones, 1974; Denison, 1996). This multiple perspective model argues for a measurement of organizational culture/climate in terms of several complementary approaches; (1) as objective organizational attributes (manifest in systems, processes, structures, reports etc) (2) as perceptions of the *organization* as a more global entity (for example how the organization "is seen" by external observers), and (3) individual perceptions, or how people in the organization feel and think about safety related issues. Also the work by Caroll (1998) shows evidence of an eclectic research strategy of safety culture. A problem, however, with the adoption of broader cultural research approaches to collect data from many different sources are that they are both time consuming and "politically sensitive" (Grote and Kunszler 2000).

Administration of questionnaires might yield interesting data but gives only part of the story and this approach has also been criticized from methodological grounds as applied in cultural research (Shein 2000). On the other hand, research performed by Grote and Kunsler (2000) has demonstrated that questionnaire approaches provides useful information to asses safety culture-related issues, and it was found to correlate rather well with auditing approaches (expert judgments).

In conclusion, it appears that the current literature suggests that value-related issues should incorporate a broad theoretical base and be investigated with approaches that draw on several methodologies – interviews, questionnaires, focus groups, observation, document studies etc.

When it comes to safety management, the safety culture approach seems to have rather little to say, at least judging from the statistically based research in the safety climate tradition. To identify dimensions such as "safety commitment" does not say much about how this process develops and is maintained in organizations. Complementary approaches should seek for both more elaborated ideas about subcultures and their association to various assumptions and values and also study the social interactions among subcultures. My proposition is to discern a list of basic *issue domains* that represent a guiding and meaningful taxonomy for studies of subcultures and value systems in NPPs. To depart from functional *units*, such as maintenance, operation etc may be one possible start. However, such task domains are by themselves associated with complex subcultures (depending on specific tasks) and, more important, each of these functions cope with several issue domains (economy, quality etc). The remainder of this paper is based on a hypothesis that there is a limited set of basic functional issue domains of NPPs. Some of these issue domains (or focus areas) have a parallel also in separate organizational functions, but at a high level of abstraction these domains are not necessarily associated with specific functional departments but represent general functional issue domain in maintenance, operation, technical support etc.

A MODEL

A first outline of a model is presented below. The model suggests four management topics (or issue domains) that together constitute a problem space in which management has to navigate with the goal of high productivity, while simultaneously maintaining high safety and acceptance from the public sector. One of the management's basic problem is assumed to be one *of maintaining a balanced attention* to the four areas in the model.

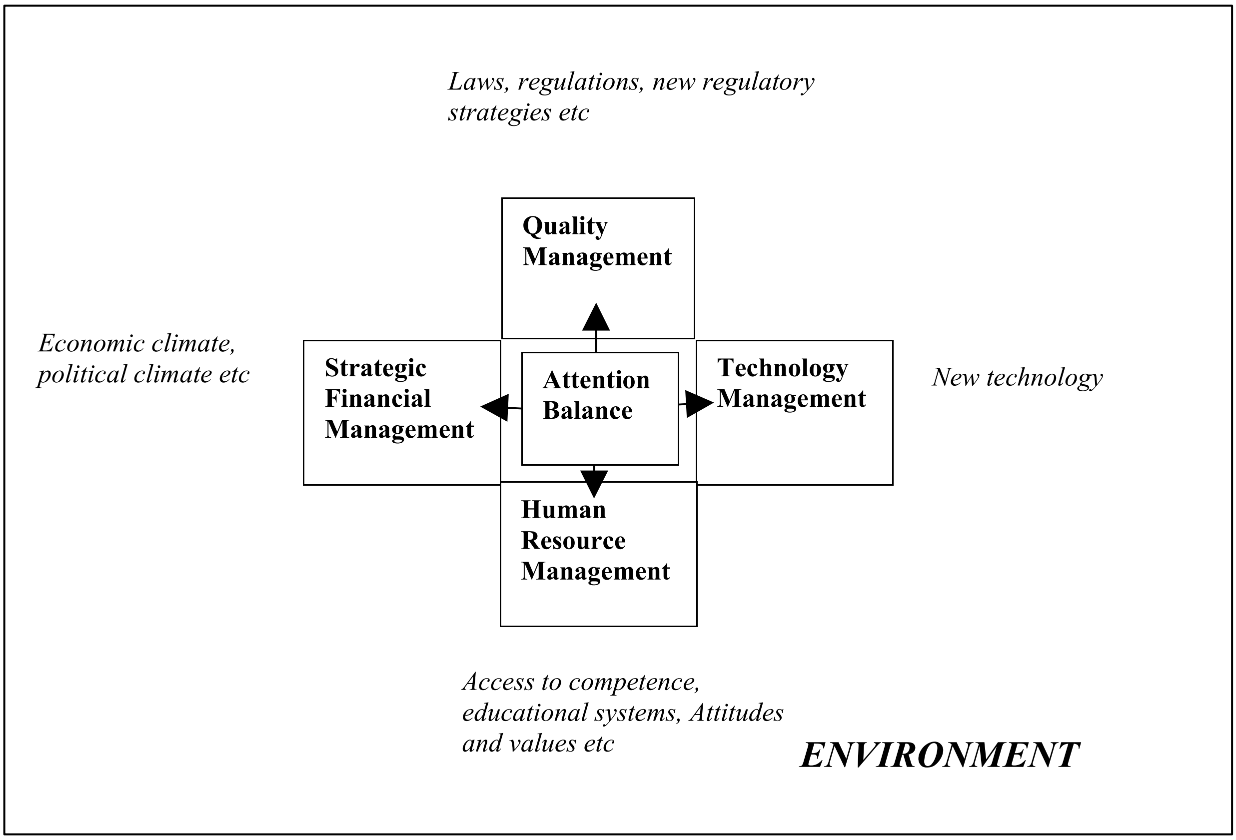


Figure 1 A model describing issue domains of importance in safety management

Quality management: Quality management in this context means the set-up and use of a quality system with associated internal auditing functions. The external mirror image of these functions is comprise of regulatory bodies and related organizational structures, processes and rule systems.

Technology management: By this is meant strategies and issues associated with operative as well as long term maintenance and development of the technological production system. Technological long-term management and quality management are closely related in that norms, standards and regulations present restrictions for the technological change process. Especially in areas, in which new technology is developed, the regulatory aspects sometimes become complicated.

Human resource management: Access, maintenance and development of human resources are crucial for safe operation of NPPs. Knowledge, experiences, attitudes and values held by managers and other personnel, especially seen in a longer time perspective, are associated with a host of external societal factors, such as; general changes in values, access to competence, contractor competence etc.

Financial management: This focus area represents the economic goals of the organization and the associated strategies to handle financial expectations in a deregulated market. Increased demands in this area may lead to changes in focus that, if not monitored and balanced efficiently, may jeopardize safety and in the long run economy also.

A note on safety management strategies

By the concept "safety management strategies" one can refer to various state of affairs. At a molar level, this concept comprises such conceptualizations as provided by, for example, Haddon (1980) in which strategies refer to hazard (i.e. energy) sources, barriers and targets. In the present context, however, the concept of safety strategy is given a more restricted meaning associated to tools and behavior of actors in management groups (i.e. upper management and other management groups related to the various issue domains in the model).

Imagine the model in Figure 1 folded as a cube where each side represents the four management issue areas (quality management etc) and the top surface of the cube represents a safety management arena, such as a management group. Because none of the four issue areas are directly visible from the top, the actors in the safety management group are dependent on their own knowledge of the various areas together with symbolic representations in form of written reports, documents etc. Furthermore, imagine that a decision shall be made and the safety significance of this decision is very uncertain (for instance a decision about a reorganization or changes in resources). Information about the possible safety significance of the decision can be based on several complementary "strategies": (1) The group has access to an *explicit representation (a model)* of the plant, its structures and processes (technological, administrative, human resources etc) and can use this model as decision support; (2) The group has no such risk management support model but the decision process is supported by an adequate personal representation obtained from the four issue areas and decision-making is supported by a dialogue among the members: different possibilities and risks are being "put on the table" for discussion and judgment. (3) The group *has not an adequate representation* of the four issue areas but relies on a strategy where information has previously been provided from the issue areas in form of reports, statements etc – the group in this situation may perceive its main function to formalize a decision which in reality were taken at a "low" postion in the organization. (4) The members of the group, regardless of composition have, prior to the meeting, acquired *personal knowledge* of the fours issue areas by *personal meetings and observation* so that they are well informed about different subcultures, opinions and beliefs.

In the first case (the explicit model) there is opportunity for elaborate discussions and real dynamic simulation – the actors do not necessarily have to share a mental model but must be convinced that the model in use is sufficiently rich and updated to provide support for the decision – they must have confidence in the model.

In the second case, i.e. given an adequate representation of competence from the various areas, there is a base for elaborate discussions. However, as we shall discuss in more depth later, there is also a risk that social influences based on power, hierarchical positions etc bias the decision-making so that issues may not be adequately covered (in terms of finding possible negative consequences of the decision).

In the third case, which is presumably one of the more common, decision-making is just a formalization of a process that was conducted somewhere else. An interesting issue then arises: to what extent, in fact, does the previously conducted "research" represent the full scope of issue domains of significance for safety? Has a balanced attention been achieved? Given a functional formal organization of work domains in NPPs (operation, maintenance, technical support etc) and the related subcultures and values associated with these areas, there is a risk that the presentation given to upper management of the issue may be biased towards some group interest.

The fourth case is an interesting possibility but unfortunately rather uncommon due to various reasons: in that case the actors in the management group has acquired a personal impression of the issue derived from face to face contacts with a personnel in all of the issue domains. Attempt to influence, power structures, and "the rules of the game" may, however, also make this strategy biased towards specific interests with negative consequences for safety.

Some related theoretical orientations

The model in Figure 1 has similarities with the "competing value framework"(CVF) proposed by Quinn and colleagues (Quinn and McGrath, 1985). The CVF was described in terms of a flexibility/control dimension and a dimension called internal/external focus (se Figure 2).

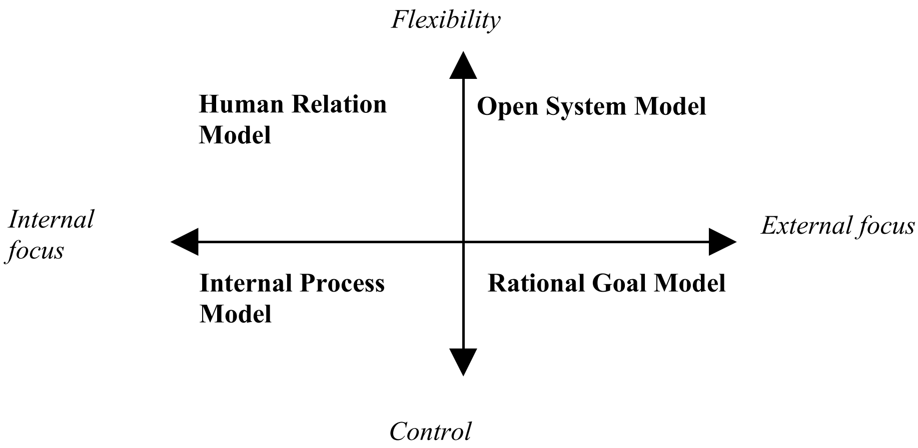


Figure 2. The competing value framework (CVF)

The first dimension models preferences for flexibility/control and the second dimension describes attention to internal vs. external issues. CFV was originally used to classify various management effectiveness criteria and have been used to discuss means-end strategies associated with management *ideological* perspectives (Quinn and Rohrbaugh 1983, Zammuto et al. 2000). These perspectives are of special interest here because they intuitively appear to correspond to a set of value characteristics associated with the four focus areas in Figure 1. The model in Figure 1 also shares obvious similarities with a model suggested by Leavitt (1965) and later extended by Bakka et al. (1999), which distinguish among four central theoretical areas called goal/strategy; structure/strategy; technology/technology management; and HRM.

Oorganizations face inherent dilemmas associated with issue domains similar to the ones presented in Figure 1, and that these issues are central for organizational survival. This may also be found from other sources, such as Parson (1956) and Perrow (1961). To seek balance is an old idea. Disciplines such as human factors/ergonomics have been developed as attempts to *balance attention* among technology and human issues (and associated values) and the whole socio-technical movement can be perceived in a similar vein as an attempt to create a focused balance among competing value systems and associated domains. Below, I will follow ideas presented by Zammuto et al. (2000) connected to the competing value framework. I will also attempt to adapt these ideas to a discussion of safety and management of NPPs and suggest a set of hypotheses about what type of value structures that may associate with the issue areas shown in Figure 1.

Internal Process Model Having an internal orientation and focus on control correspond to desired ends of stability and control where the means are assumed to be information management and communication. Zammuto et al. expresses the characteristics of this ideology as:

"Primary leadership roles associated with the internal process model are monitoring and co-ordination. Structurally, this type of organisation relies on vertical communication and formal rules, policies and procedures for co-ordination and control…This ideology focus on control of internal processes as the means to achieve valued ends. Some common terms to characterise organisations emphasising this managerial ideology is *bureaucratic, rule-bound, by-the-book* and *top-down".*

In Figure 1, the correspondence to the above characteristics of *internal process model* is what is labeled "quality management". Stability and control is the desired ends and the basic tool is a *quality system* that is communicated to all members of the organization. The success of the model relies on the knowledge received by the members of the organization about the rules and formal descriptions that are made explicit in the quality system. Although modern quality systems such as TQM has a much wider scope than the older QA systems, much of the traditions from classical management theory (Fayol 1949), theory of bureaucracy (Weber 1964) and scientific management (Taylor 1911) still appears to influence held values associated with the concept of "quality".

Departing from the research traditions that explore basic value systems such as represented by Schwartz (1996) it is tempting to suggest that professionals dealing with quality issues have a preference for the general categories of values which Schwarz label: *Security, Tradition and Conformity*. Descriptive terms for "*Security*" is "Safety, harmony, and stability of society, or relationships, and of self..”). The class of "*Conformity*" is described as "Restraint of action, inclination, and impulses likely to upset or harm others and violate social expectations or norms.." Finally, Schwartz describe "*Tradition*" as "Respect, commitment, and acceptance of the customs and ideas that traditional culture or religion provide the self".

Applied to a nuclear power perspective, the "quality culture" ideal shares many similarities to a normative view of safety culture in which respect for rule-systems and general cautious attitudes are seen as important key characteristics. Furthermore, the "restraint of action" in Schwartz conception has an obvious analogy in the STAR-concept (Stop, Think, Act, Review) often discussed as a strategy to enhance safety culture in NPPs. Also communication of rules and knowledge of rules are valued in “quality cultures” and “safety cultures” as well as respect for the basic set of safety principles that creates a base for nuclear safety. However, these normative values of; tradition, security, and conformity may be in direct conflict with management values of expansion, innovation, freedom etc.

Human relational model This model corresponds to the flexibility/internal focus in CVF and HRM in Figure 1. Valued outcomes are seen as cohesion and morale and the means are assumed to be training and development of human resources. Leadership roles are associated with mentorship and facilitation. Zammuto et al. expresses the characteristics of this ideology as:

“This managerial ideology focuses on people as the means to achieve desired ends, and words such as family, trusting, empowered and collegial are typically used to characterise organisations with human relations orientation”.

Again, drawing from Schwartz value system characteristics, we would expect this “ideology” to be associated with general value types such as; “benevolence – the preservation and enhancement of the welfare of people…” and “universalism - understanding, appreciation, tolerance and protection for the well-fare of all people and for nature”.

The human relational model, which started with the Hawthorn studies (Roethlisberger and Dickson, 1939/1975) are one of several theoretical orientations that centre on the human side of organizations. The safety culture movement in itself reflects an interest in humans and their values. The decentralized and empowered decision-making that, implicit or explicit, is apparent in the human relation model is, however, not necessarily compatible with the sort of “quality culture” aimed for in the internal process model. Although both models emphasize communication as important, the human relation model also appears to be closer to a value framework stressing independence and freedom and this may run in opposition to the control strategy inherent in internal process model. There is also a conflict in normative propositions of organizational culture (and safety culture) that puts an emphasis on rule conformity in contrast to propositions that stress the importance of a “questioning attitude”. Grote and Kunsler (2000), in their attempt, to analyze safety culture from a socio-technical perspective stress the importance of “control variances at their source” as a desired characteristics of safety culture – high degree of self-regulation is thus seen as a desired factor for safety. But these writers also comment on the observation made by Perrow (1984/1999) and others that tight coupling of complex organizations limits the possibilities for decentralization.

Rational Goal Model The rational goal model is in CVF corresponds to a control/external focus with the basic goals of productivity and efficiency through the means of goal setting and planning. This perspective corresponds to what is called “financial management” in Figure 1. Thus, a major management focus is an efficient organization to adapt to external demands and market conditions. Management ideologies are characterized by clarification of goals. According to Zammuto et al., Terms used for this ideology are goal-oriented, achievers and focused.

In Schwartz terms this orientation may be assumed to correspond to “Power – social status and prestige, control and dominance over people and resources” and “Achievement – personal success through demonstration of competence according to social standards (successful, capable, ambitious, influential”).

Normative “safety culture” assertions borrow *some aspect*s from the above-mentioned ideology in the sense that a clear *powerful and strong* management commitment on safety are often named features that should characterize managers of NPPs. However, since the rational goal model *may* rest on value systems characterized by power, dominance and control, which are mostly associated with financial/productivity issues, there is an inherent difficulty in creating balance and trust when these values are used to support both safety and economical efficiency at the same time.

Open system models The quadrant flexibility/external focus of CFV is named the open system model. Desired outcomes are growth and resource acquisition by means of adaptation and readiness. This characterization corresponds only to some extent with "technology management" in Figure 1. The corresponding features are its focus on innovation and change as well as a leadership stressing informal co-ordination and horizontal communication. In the interpretation of Zammuto et al. concepts such as innovative, aggressive, adaptable and entrepreneurial are words that frequently associate with open system models of this kind. Important general features of open system models are focus on the environment and context as determinants of organizational behavior.

The "technological management issues" in Figure 1, although, in some aspects similar to the open system model in their focus on innovative adaptation (for instance by means of technology). Departing from Schwartz motivational value types, a core value characteristic of technology management is assumed to be "Self-direction" described as "independent thought and action – choosing, creating, exploring (creativity, freedom, independent, curious, choosing own goals).

VALUES IN INTERACTION

Organisational decision-making can be described in many ways. One popular example is the "garbage can model" which perceives decision-making as the management of a constant stream of issues (opportunities, problems, solutions, etc) to be handed on a daily basis (Cohen, March and Olsen 1972, March and Olsen 1976). Decision-making in the organization is, according to the garbage can model far from a rational process; big and small issues are mixed; expert knowledge is not optimized and utilized; persons with limited knowledge in a subject matter make big decisions etc. Due to limitations in information, and other resources many issues have to be put in the "garbage can" with limited attention invested.

The stream of issues that confronts management is of course, in some sense, an obvious observation – priorities have to be made. But priorities have to be balanced so that at least the most crucial subject areas are considered in the decision process. Conflicts of value may arise in this process. March and Simon (1958) argued that management tends to perceive and attribute conflicts in individual terms rather than see them as conflicts among groups. A more fruitful and rational approach would be to increase knowledge and consciousness of the value systems associated with various issue domains.

Although value systems might at first be perceived as highly arbitrary and situation-dependent entities that might escape structural analysis, they appear sufficiently stable for systematic investigation as indicated by some of the research commented on previously. Below, I will elaborate further on this issue. A more complete and empirically based discussion was addressed in the LearnSafe project (see acknowledgements at the end of this chapter).

Since attention on financial issues has increased, the interactions commented on will focus on financial management in relation to the other issue domains. The interactions are presented pair-vice but a more realistic model would, of course, assume more than simple on-to-one interaction possibilities.

Financial management and quality management in interaction

Quality management (in a more traditional sense than TQM) is focused on determining required principles, structures and processes (responsibilities, norms, rules etc), making them explicit and traceable, and a system for control and resolution of observed deviations. Values associated with quality management may be in direct conflict with at least short-term financial goals but also with long-terms financial goals due to several reasons: Quality system are based on the belief that it is important and essential to regulate, describe and control objects so that they remain within desired operational envelopes. Quality systems, thus, impose *restrictions* by stating what should and what should not be the case – they aim for making boundaries visible for actors. Short terms financial values, on the other hand, may sometimes strive for maximum financial profit with the means available or the means potentially available at the lowest possible cost (which, of course, is not necessarily the same as sustained profit in a longer perspective). That organizations may drift away from higher standards of safe performance is commented by, for example, Rasmussen and Svedung, (2000).

A general problem with many quality systems is how actors with multiple goals perceive them. One of the aims of quality systems is to impose restrictions. This implies that quality systems and regulations, in fact, also can slow down safety development. For example, by requiring highly resource-demanding licensee procedures some possibilities for safety development can be delayed. In this context, however, it is of greater importance that quality systems in NPPs present a necessary resistance against unbalanced attention as well as against the application of management ideologies that tend to "forget" safety issues.

Human resource management and financial management in interaction

Human Resource Management (HRM) in terms of focus on teamwork between groups, general training, empowerment etc has been found to correlate with various output measures. For example, Thompson (1996) found that units with progressive human resource practices were units with higher customer commitment, customer satisfaction, profit contribution and lower absenteeism and safety incident rates. Other studies, aimed at investigating the causal direction in longitudinal perspective, present evidence that employee development in fact caused changes in output measures (customer satisfaction) rather than the other way around (Schneider et al. 1996). The reader is referred to Wiley and Scott (2000) for a collection of research data exploring business performance as a function of leadership styles and other HRM-related practices.

How different actors perceive management's values and attitudes towards safety in relation to the safety climate has been explored by, for example, Brown and Holmes (1986) who found tree factors; (1) perception of to what extent managers were concerned with well-being of their subordinates, (2) how active managers were in responding to concerns raised from actors, and (3) direct perception of physical risk. Values that emphasize general well being and concern for people relates to a management ideology rooted in a humanistic orientations that may be in direct conflict with Rational Goal Models with their major focus on efficiency and power. A *balanced attention approach* in NPP-management with respect to HR-management implies sensitivity and need for communication and concern for the importance of the HRM-aspects.

Management of financial resources and personal resources are obviously connected in a multitude of aspects. It is reasonable to assume that different management practices, such as downsizing and outsourcing, may be associated with changes in value systems and thereby in cultures. Little is, however, yet known about how safety might be affected although there is some evidence that downsizing may have contributed to some spectacular accidents such as Bhopal. Perrow (1999) makes some references to this issue, exemplified by the quote: ”Perron and Friedlander, reviewing accidents in the industry from the point of downsizing consequences show how downsizing in terms of increasing worries, work pressures and overload, changes the way employees interact and communicate critical information to each other, and how they can fail, under these pressures, to understand the systems they are trying to control” (Perron and Friedlander 1996).

Financial management and technology management in interaction

Values associated with technology management are both instrumental and terminal: technology may be valued for its own sake and not only as a mean to reach other values. An anecdotal observation of mine is that people who participated in the construction and early operation of NPPs in Sweden did so because they found the industry “exciting”, “new”, “challenging” etc. Many engineers, thus, valued the technology for its own sake – it represented an interesting domain of technology. In those days, the views of upper management (according to interviews) were also much closer to the issue domain of technology management than it is today when financial issues take much more attention. Over time, it appears to have been a gradual departure away from the close association between technology management and financial management with a resulting gap in a unified and shared cognition about NPPs. The subculture of technology management as an issue domain appears to create a new management subculture that departs from the previous more integrated view of financial and technological issues in interaction. This may not be a danger provided that balanced attention can be achieved. The strong force toward attention on financial results has, however, previously been demonstrated as a major factor for some catastrophic events (for an overview see Perrow 1999).

DISCUSSION

This chapter has presented a tentative frame of reference for some issues related to safety management in general and for NPP safety in particular. The general research area of management and organizations is highly diverse and fragmented and is, despite serious attempts and modeling ambitions, only yet tentatively coupled to the sharp technological end of the system in a realistic way. Models such as *SAM* (Murphy and Paté-Cornell 1996, Paté-Cornell 1990, Paté-Cornell and Bea, 1992); *WPAM* (Davoudian, Wu and Apostolakis 1994 a; 1994 b) and *SOCRATES* (Gertman et al. 1998) all represent interesting research approaches as support for safety management. However, these, and other models with similar structural and quantitative flavor may give a false impression of precision and completeness and appear to underestimate important issues associated with, for example, power structures, group interests and conflicting value systems, and dynamic political and economic pressures outside organizations.

The safety culture tradition, based mainly on a cognitive framework and the idea of shared cognitions such as values and beliefs, highlights important aspects of safety management. For this tradition to develop further, it is important to obtain a more elaborate view about subcultures and associated value systems as well as a focus on social structures and influence patterns. In addition, a more *process-oriented* conceptualization about safety management decision-making would be fruitful. Ideas and frameworks departing from a social influence approach as exemplified by Tomicic (2001) appears as a promising point of departure applied to research on safety management. An interesting aspect is Tomicic´s interpretation of decision-making in groups viewed in a rule and game metaphor. The explicit and implicit "rules of the game" guide who are approved to influence decision-making. Taken together the observations made by Tomcic present complications for simplistic control metaphor of safety management due to social and political sources of influence in decision-making: at least one should be sensitive to the limits of the cybernetic control view and not be to idealistic about it.

Power in terms of formal authority and exclusion of different opinions (the consensus mode of agreement) may be a comparatively quick road to take and could, but will not necessarily, increase the speed of implementation. This mode, however, does not guarantee the high quality agreements, which are, required in connection with safety management issues (Janis, 1989). Other research, such as presented by Schweiger et al. (1986, 1989) and Priem et al. (1995), also suggest the view that generation and critical examination of alternatives support high quality decision-making (and therefore presumably also safety awareness).

To conclude, I have suggested a framework based on an idea of balanced attention among four issue areas – (A) financial management (this could also have been labeled "resource management" but I wanted to stress the financial aspect of this issue area in contrast to other resources); (B) quality management; (C) human resource management; and (D) technology management. To maintain a balance among the focus areas, information from all issue domains must be collected transformed and integrated which, then, constitutes the basis for decisions about strategies and actions. In this context, the distinction between information and knowledge is important because of several reasons. It is relatively easy to collect data/information but the analytical task to determine *what* data should be collected and *why* those are of importance for safety is more difficult.

Learning as a consequence of transaction among various value systems can be organized and supported and much more can be done in this direction. But the view of a cognitive shared and general safety culture that comprises a whole organization is presumably a myth and should be viewed more as a "vision" than a realistic goal. It might be better, then, to focus more directly on the specific features of importance in specific subcultures and on the possibility of achieving a reasonable balanced attention among focus on human resources, quality, technology and financial issues, especially in upper management cultures. Values are not easy to perceive and can only be captured indirectly as attitudes, behaviors and artifacts. Refraining from attempts to explore also more basic values, however, means also to refrain from potential knowledge that may contribute greatly to better understanding of the management of NPPs.

Acknowledgements

The author gratefully acknowledges support from the European Commission under Contract No. FIKS-CT-2001-00162 of the Fifth Euratom Framework Programme 1998–2002, Key Action: Nuclear Fission. A preliminary working paper version of this paper was presented in the context of the LearnSafe project (started November 1, 2001, and ran for 30 months). LearnSafe involved 15 partners from five European countries and two international organizations. For additional information see http://www.vtt.fi/virtual/learnsafe/

REFERENCES

Note, the references listed below refer both to references in the text and to other recommended reading.

Alexander M, Cox S and Cheyene A (1994) The concept of safety culture within a UK based organisation engaged in offshore hydrocarbon processing. *Proceedings of the Fourth Annual Conference on Safety and Well-being at Work*. Loughborough University of Technology, UK, November 1-2.

Andersson E R and Rollenhagen C (1993) Om systemgrupper och industriell problemlösning. *Metodrapport. Kungliga Tekniska Högskolan*, ISRN KTH/AFV/FR 93/5-SE, AVF 1993:5, ISSN 1100-5718.

Andersson E R och Rollenhagen C (2003) *Systemgrupper och innovativ problemlösning. Studentlitteratur*, Lund.

Bakka J F, Fivelsdal E and Lindkvist L (1999) *Organisationsteori: struktur, kultur, processer*. Lieber Ekonomi, Malmö.

Beyer J M (1981) Ideologies, values, and decision making in organizations. In P.C. Nystrom and W.H. Starbuck (Eds.), *Handbook of organizational design* (vol.2, pp 166-202). New York: Oxford University Press.

Brown, M J and Holmes H (1986) The use of factor-analytical procedure for assessing the validity of an employee safety climate model. *Accident Analysis and Prevention* 18: 445-470.

Brunsson N (1982) The Irrationality of Action and Action Rationality; Decisions, Ideologies and Organisational Actions. *Journal of Management Studies* 19: 29-44.

Byron N and Corbridge (1997) The Assessment of an Organisation's Health and Safety Climate. *OECD Workshop on Human Performance in Chemical Process Safety*, Munich.

Caroll J (1998) Safety culture as an ongoing process: cultural surveys as opportunities for enquiry and change. *Work and Stress* 12: 255-271.

Cohen M D, March J G & Olsen J P (1972) A garbage can model of organisational choice. *Administrative Science Quarterly* 17:1-25.

Cox S and Cox T (1991) The structure of employee attitudes to safety: A European example. *Work and Stress* 5: 93-106.

Cox S J and Cheyne A J T (2000) Assessing safety culture in offshore environments. *Safety Science* 34: 111-129

Davoudian K, Wu J S and Apostolakis G (1994a) Incorporating organizational factors into risk assessment through the analysis of work processes. *Reliability engineering and System Safety* 45: 85-105.

Davoudian K, Wu J S and Apostolakis G (1994b) The work process analysis model (WPAM). *Reliability engineering and System Safety* 45:107-25.

Den Hertog J F (1978) The role of information and control systems in the process of organisational renewal: Road block or a road bridge? *Accounting, Organisation and Society* 3: 29-46.

Denison D R (1996) What is the difference between organisational culture and organizational climate. A native´s point of view on a decade of paradigm wars? *Academy of Management Review* 21: 619-654.

Donald I (1995) Safety attitudes as a basis for promoting safety culture: an example of an intervention. *Work and Well-being: An Agenda for Europé Conference,* Nottingham, December 1995.

Döös M and Backström T (2003) Constructing workplace safety through control an learning: conflict or compatibility. In Jane Summerton and Boel Berner (eds.). *Constructing Risk and Safety in Technological Practice*. (175-192) Routledge Advances in Sociology. London and New York.

Döös M, Wilhemson L and Backlund. (2001) Kollektivt lärande på individualistiskt vis – ett lärdilemma för praktisk teori. In T Backlund, H. Hansson and C. Thunborg (eds). *Lärdilemma i arbetslivet*, Lund: Studentlitteratur.

Dowell A M. III and Hendershot D C (1997) No Good Deed Goes Unpunished: Case Studies of Incidents and Potential Incidents Caused by Protective Systems. *AIChE 31st Annual Loss Prevention Symposium*, Houston, Texas.

Fayol H (1949) *General and industrial management*. London: Pitman.

Flin R, Mearns K, Fleming M and Gordon R (1996) Risk Perception and Safety in the Offshore Oil and Gas Industry (Offshore Technology Report OTH 94 454). HSE Books, Sudbury.

Flin R, Mearns K, O'Connor P & Bryden R. (2000) Measuring safety climate: Identifying the common features. *Safety Science* Vol. 34 No, 1-3 pp 177-193.

Gertman D I, Hallbert B, Blackman H, Schurman D and Thomson C (1998) Management and organizational factors research: The socio-organisational contribution to risk assessment and the technical evaluation of systems (SOCRATES). In Mosleh, A and Bari, R.A., (Eds.). *Probabilistic Safety Assessment and Management,* Proceedings from PSAM 4, September 1998, New York, Springer.

Ginsberg A, (1994) Minding the Competition: From Mapping to Mastery, *Strategic Management Journal* No. 15:153-174.

Grote G and Kunzler C (2000) Diagnosis of safety culture in safety management audits. *Safety Science* 34:131-150.

Guldemund, R. (2000). The nature of safety culture: A review of theory and research. Safety Science, 34(1-3), 215-257.

Haddon W J Jr (1980) The Basic Strategies for Reducing Damage from Hazards of all kinds. *Hazard Prevention*, Septemper/October.

Hale A R and Hovden J (1998) Management and culture: the third age of safety. A review of approaches to organisational aspects of safety, health and environment. In A. Feyer and A.M Williamson (eds), *Occupational Injury – Risk, Prevention and Intervention* (London, Taylor & Francis Ltd), pp. 129-164.

Hickson D J, Butler, R J, Cray D, Maory G.R and Wilson D C (1986) *Top Decisions: Strategic Decision-Making in Organisations,* Basil Blackwell: Oxford.

Isaacs W (1993) Taking flight: Dialogue, collective thinking, and organisational learning. *Organisational Dynamics*, 21 (3): 24-39.

Isaacs W (1999) *Dialogue and the art of thinking together: A pioneering approach to communication in business and in life*. Garden City, NY: Doubleday.

James L R. and Jones A P (1974) Organisational climate: a review of theory and research. *Psychological Bulletin* 81 (12):1096-1112.

Janis I L (1989) Crucial Decisions. *Leadership in Policymaking and Crisis Management*, The Free Press: New York.

Kahneman D and Tversky A (1982) The simulation heuristic. In D. Kahneman, P. Slovic, and Tversky, A. (Eds.). *Judgement under uncertainty: Heuristics and biases*, (pp. 201-208). New York: Cambridge University Press.

Kahneman D and Tversky A (1973) On the psychology of prediction. *Psychological Review* 80: 237-251.

Kahneman D and Tversky A. (1984) Choices, values and frames. *American Psychologist* 39: 341-340.

La Porte T R and Consolini P M (1991) Working in Practice but not in Theory. *Journal of Public Administration Research and Theory* 1: 19 – 47.

Leavitt H J (1965) Applied organizational change in industry: structural, technological and humanistic approaches. In J. G. March (Ed.) *Handbook of organizations*, Chicago.

Lee T R (1995) The role of attitudes in the safety culture and how to change them. Conference on "*Understanding Risk Perception*" Offshore Management Centre, Robert Gordon University, 2 February, Aberdeen.

March J G & Olsen J P (1976) *Ambiguity and choice in organizations*. Oslo: Universitetsforlaget.

March J G & Simon H A (1958) *Organisations* New York: John Wiley.

Markus M L and Pfeffer (1983) Power and the design of accounting and control systems. *Accounting, Organisation and Society* 8: 205-218.

Marone J and Woodhouse E J (1986) *Averting Catastrophe: Strategies for Regulating Risky Technologies.* Berkely: University of California Press.

Mearns K, Flin R. Gordon R, Flemming (1998) Measuring safety climate on offshore installations. *Work and Stress* 12: 238-254.

Mezirow J (ed.) (1990). Fostering critical reflection in adulthood. San Francisco: Jossey-Bass.

Miller, J., G. (1960) Information overload and psychopathology. *American Journal of Psychiatry* 116: 695-704.

Mintzberg H (1973) *The Nature of Managerial Work*, New York: Harper and Row.

Murphy DM and Paté-Cornell M E (1996) The SAM framework: Modeling the effects of management factors on human behavior in risk analysis. *Risk Analysis* 16:501-515.

Oedewald P and Reiman T (2002) Maintenance core task and maintenance culture. Paper presented at *IEEE Conference on Human Factors and Power Plants*, USA.

Parson T (1956) Sociological approach to the theory of organizations. *Administrative Science Quarterly* 1: 63-86, 225-240.

Paté-Cornell M E (1990) Organizational aspects of engineering system safety: The case of offshore platforms. *Science*, 250:1210-17.

Paté-Cornell M E and Bea R G (1992) Management Errors and System Reliability: A probabilistic approach and application to offshore platforms. *Risk Analysis* 12:1-18.

Perron M J and Friedlander R H (1966) ”The effects of Downsizing on Safety in the CPI/HPI”. Process Safety Progress 15: 18-25. In *Handbook of Organizational culture and climate*. Neal M. Ashkanasy, Celeste P. M. Wilderom and Mark F. Peterson (Eds.), Dage Publications Inc.

Perrow C (1999) *Normal Accidents*. Princeton University Press. Princeton New Jersey.

Perrow C A (1961) The analysis of goals in complex organizations. *American Journal of Sociology* 26:854-866.

Perrow C A (1984) *Normal Accidents*. Living with high risk Technologies. Basic Books: New York.

Priem R Harrison D and Muir N (1995) Structured Conflict and Consensus Outcomes in Group Decision making, *Journal of Management* Vol. 21, No. 4: 691-710.

Quinn R E and Mc Grath M R (1985) The transformation of organizational cultures: A competing values perspective. In P. J. Frost, L.F. Moore, M.R. Louis, C.C. Lundberg, and J. Martin (Eds.). *Organizational culture* (pp. 315-334). Beverly Hills, CA: Sage.

Quinn R E and Rohrbaugh J (1998). A spatial model of effictiveness criteria: Toward a competing values approach to organizational analysis. *Management Science* 29: 363-377.

Rassmussen J and Svedung I (2000) *Proactive Risk Management in a Dynamic Society*. Räddningsverket (Swedish Rescue Service Agency), Karlstad, Sweden.

Reiman T and Norros L (2002) Regulatory Culture: Balancing the Different Demands of Regulatory Practice in the Nuclear Industry. In Hale, A.R., Hopkins, A. & Kirwan, B. (Eds.), *Changing Regulation – Controlling Hazards in Society*. Oxford: Pergamon.

Roberts K H (1993) New Challenges to Understanding Organizations. New York: Mac Millan.

Roethlisberger F J and Dickson W J (1939/1975) Management and the worker: An account of a research program conducted by Western Electronic Company, Hawthorne Works Chicago. Cambridge, MA: Harvard University Press. (Original work published 1939).

Sagan S D (1996) When Redundancy Backfires: Why Organizations Try Harder and Fail More Often, in American Political Science Association Annual Meeting, San Franciso, California.

Schein E H (2000) Sense and Nonsense about Culture and Climate. In Handbook of Organisational Culture and Climate, Neal M. Ashkanasy, Celeste P. M. Wilderom and Mark F. Peterson (Eds.), Sage Publications, Inc.

Schneider B, Brief A P and Guzzo R A (1996) Creating a climate and culture for sustainable organisational change. *Organisational Dynamics* 24(4): 6-19

Schneider S and Anglemar R (1993) Cognition in Organizational Analysis: Who´s minding the Store? *Organization Studies* 14/3: 347-374.

Schwartz S H (1994) Are there universal aspects in the structure and contents of human values? *Journal of Social Issues* 50: 19-45.

Schwartz S H (1996) Value priorities and behavior: Applying a theory of integrated value systems. In C. Seligman, J.M. Olson, and M.P. Zanna (Eds.), *The Ontario Symposium: Vol. 8. The Psychology of values* (pp. 1-24). Mahwah, NJ: Lawrence Erlbaum.

Schweiger D, Sandberg, W and Ragan J (1986) Group Approaches for Improving Strategic Decision-making: A Comparative Analysis of Dialectic Inquiry, Devil's Advocacy, and Consensus, *Academy of Management Journal*, Vol. 29, No. 1: 51-71.

Schweiger D, Sandberg, W and Rechner P (1989) Experimental Effects of Dialectic Inquiry, Devil´s Advocacy, and Consensus Approaches to Strategic Decision making, *Academy of Management Journal*, Vol. 32. No 4: 745-772.

Simon H (1945) Administrative Behavior. New York: MacMillan.

Sitkin S B, Sutcliffe K M and Schroeder R G (1994).Distinguishing control from learning in total quality management: A contingency perspective. *Academy of Management Review*, 19 (3), 537-564.

Sorensen, J.N. (2001). Safety culture: a survey of the state-of-the-art. *Reliability Engineering and System Safety*, 77: 189-204.

Spender J-C (1998) The Dynamics of Individual and Organisational Knowledge, in Eden, C., and Spender, J-C-. (Eds.), *Managerial and Organisational Cognition; Theory, Methods and Research*, Sage.

Stackman R, W Pinder C C and Connor (2000) Values Lost: Redirecting research on values in the workplace. In *Handbook of Organizational Culture and Climate*, Neal M. Ashkanasy, Celeste P. M. Wilderom and Mark F. Peterson (Eds.), Sage Publications, Inc.

Stubbart C (1989) Managerial Cognition: A missing link in Strategic Management Research, *Journal of Management Studies* 26:4, July.

Taylor F W. (1911) *The principles of scientific management*. New York: Harper.

Thompson J W (1996) Employee attitudes, organizational performance, and quality factors underlying success. *Journal of Business and Psychology* 11: 171-191.

Tomicic M (2001) Reaching agreement in a management team: a social influence perspective. Linköping *Studies in Management and Economics, Doctoral Dissertation*, No. 49. (IMIE, No. 50).

Walsh J P (1995) Managerial and Organizational Cognition: Notes from a Trio Down Memory Lane. *Organization Science* Vol 6. No. 3: 280 – 321.

Weber M (1964) *The theory of social and economic organization* (A.M. Henderson & T. Parson, Trans.). New York: Free Press.

Weick K E (1995) *Sensemaking in Organizations*, Sage: California.

Wildavsky A (1995) *But is it true? A Citizen's Guide to Environmental Health and Safety Issues*. Cambridge: Harvard University Press.

Wiley J and Brooks S M (2000) How Workers Describe Top-Performing Units. *In Handbook of Organisational Culture and Climate*, Neal M. Ashkanasy, Celeste P. M. Wilderom and Mark F. Peterson (Eds.), Sage Publications, Inc.

Wilhelmson L (1998) Learning dialogue. Discourse patterns, perspective change and learning in small group conversation. Dissertation (In Swedish with English summary). Arbete och Hälsa 1998:16, Solna, National Institute for Working Life. www.niwl.se/forlag.

Zammuto R F, Gifford B and Goodman E A (2000) Managerial Ideologies, Organization Culture, and the Outcomes of Innovation: A Competing Values Perspective. In *Handbook of Organisational Culture and Climate*, Neal M. Ashkanasy, Celeste P. M. Wilderom and Mark F. Peterson (Eds.), Sage Publications, Inc.(pp. 261-278).

Chapter 8: Analysis of Challenges to Nuclear Power Plant Safety Management: Finland, Sweden, and the European Context

Jari Kettunen, Teemu Reiman and Björn Wahlström
VTT Technical Research Centre of Finland
POB 1301, FI-02044 VTT, Finland
email: name.surname@vtt.fi

ABSTRACT

This chapter provides an overview of the most important safety management challenges within the European nuclear power industry and explores the special characteristics of Finland and Sweden in the European context. The data were gathered as part of the LearnSafe project[1] in 2002 and the SAFIR research programme[2] in 2003-2004. The results suggest, in general, that challenges relative to human resource management and organizational climate and culture are regarded as most important in Europe. The major differences between Finland and Sweden relate to organizational climate and culture-related issues, which are more emphasised in Finland, and to the perceived importance of economic pressures and other external factors, which receive more attention in Sweden. The paper also establishes links between the key findings of the analysis and factors characterising the performance and the operating environment of the Nordic nuclear power plants. Finally the paper gives suggestions and recommendations for further research and action in the context of safety management.

INTRODUCTION

Over the past decade managers of utilities and nuclear power plants (NPPs) have been confronted with a number of new challenges. Especially ageing plants and equipment (OECD/NEA 2000), the ongoing generation turnover (OECD/NEA 2001), and the deregulation of the electricity market (Bier et al. 2001) have been shaping the scope and nature of managerial concerns and responsibilities. The managers have responded in different ways. For example, outsourcing and the use of subcontractors in general have accelerated as a means of optimising the use of resources and introducing cost savings (Kettunen et al. 2004a).

The nuclear power industry as a whole makes a rather unique and consistent community. One factor connecting utilities, licensees, contractors, regulators as well as researchers world-wide is the recognition of the paramount importance of safety. In practice this means that most technical modifications as well as major organisational change initiatives are usually subjected to a rigorous safety analysis before their implementation is approved, and that the relative weight of safety clearly exceeds that of other matters – such as sole technical or economic considerations – in the decision-making process.

There are, however, examples of events in which strive for short-term economic advantage as

[1] Learning Organisations for Nuclear Safety 2001 – 2004. The project was co-ordinated by VTT and received funding from the 5th Euratom Framework Programme with the contract number FIKS-CT-2001-00162.

[2] SAFIR 2003 – 2006 is the Finnish public research programme on nuclear power plant safety. The programme is managed by VTT under the administration of the Ministry of Trade and Industry (KTM). The main funding sources are State Nuclear Waste Management Fund (VYR) and VTT.

well as sheer managerial indifference have gained the upper hand. The criticality accident at JCO nuclear fuel conversion facility in 1999 is a relatively recent, well-documented and extreme case of such behaviour (see e.g. Furuta et al. 2000). The case demonstrated how important it is to identify the critical functions to be managed and to establish appropriate goals, policies and priorities to support the management of potentially conflicting demands and expectations.

Despite the global nature of the industry there are country-specific differences in the status of nuclear power. The size and age of the industry, the nuclear share of electricity generation, and support among various interest groups of the society vary from country to another. For example, while the German federal government persuaded German utilities to commit themselves to a gradual phase out nuclear power (OECD/NEA 2004), the Finnish government as well as the Finnish parliament have both supported the application of a Finnish power company TVO to build new nuclear capacity (www.tvo.fi). Especially in Europe the differences are in this respect large and give raise to an assumption that the NPP managers' problem space may include a particular country-specific element.

In trying to understand managerial challenges several authors have cultivated the concept of competing values that have to be balanced. Some authors speak about the need to manage ambiguity and paradox (Peters & Waterman 1982), or establish balance between chaos and order (Waldrop 1992), while some emphasise the need to identify and separate between important tensions (Cameron & Quinn 1999). The view that organisations position themselves differently in response to their inherent needs has also been integrated into cultural research (Hofstede 1997, Trompenaars & Hampden-Turner 1998). Quinn (1988) has written about managers' need to fulfil many competing expectations and to handle contradictory demands, such as simultaneous requests for flexibility and control. Within the context of nuclear power, for example Rollenhagen (2002) and Wahlström and Rollenhagen (2004) have stressed the importance of securing a proper allocation of management attention over a number of competing focus areas or issue domains.

The question we want to address is as follows: what are those challenges that currently compete for European NPP managers' attention? The main objective of this chapter is to present an overview of the most important management challenges within the European nuclear power industry in the context of safety, to characterise those challenges with respect to generic demands of managerial work, and to highlight major similarities and differences between five European countries. The countries involved in the study are Finland, Sweden, Germany, Spain, and the United Kingdom. A second objective is to describe the situation in Finland and Sweden in more detail and to explore how the managers of Nordic nuclear power plants perceive and emphasise particular problems areas. In addition, the chapter aims to establish links between the key findings of the analysis and factors characterising the performance and the operating environment of the participating Nordic NPPs. Finally the study gives some suggestions and recommendations for further research and action.

METHODS

The major part of the data utilised in this study was collected as part of the LearnSafe project in 2002. The data were generated in response to the question "What are the perceived emerging challenges in the management of nuclear power plants in the context of safety?" using Metaplan sessions and semi-structured interviews.

Metaplan sessions were designed to create an opportunity for the identification and grouping of challenges. During each Metaplan session participants were asked to individually identify and write down on separate sheets of paper four to five key challenges (statements) in response to the research question. The challenges were then collected, attached on the wall of the meeting room, arranged into larger thematic groups by the participants, and weighted within each group on the basis of their perceived relative importance. Metaplan is an active method of data collection during which the researcher acts as a moderator of the process, guides participants through the discussion and documents the results (see also www.metaplan.com for additional information on the method).

A total of 15 Metaplan sessions were conducted with senior and second-in-line (mid-level) NPP managers, of which 14 sessions were held at eight NPPs in five European countries. Usually two Metaplan sessions were held at each plant: one for senior and another for mid-level managers (due to practical reasons there were two exceptions). One additional session was held at the World Association of Nuclear Operators (WANO) in Paris. All sessions were organised by the local LearnSafe partner and carried out using the local language. Statements were afterwards when necessary translated into English by the LearnSafe research team. The organisations involved in the study are listed in Table 1. A more detailed description of the four Nordic NPPs is given in Table 2.

Table 1. Organisations involved in the study.

Organisation	Type of organisation	Country	Data acquisition method
Teollisuuden Voima Oy	Licensee	Finland	1 Metaplan session + interviews
Pohjolan Voima Oy	Utility company	Finland	Interview
Forsmarks Kraftgrupp AB	Licensee	Sweden	2 Metaplan sessions
Ringhals AB	Licensee	Sweden	2 Metaplan sessions
OKG AB	Licensee	Sweden	2 Metaplan sessions
Sydkraft AB	Utility company	Sweden	Interview
Vattenfall AB	Utility company	Sweden	Interview
Grafenrheinfeld NPP (E.ON)	Licensee	Germany	1 Metaplan session
Almaraz NPP	Licensee	Spain	2 Metaplan sessions
Cofrentes NPP	Licensee	Spain	2 Metaplan sessions
UNESA	Utility company	Spain	Interview
Oldbury NPP (BNFL)	Licensee	UK	2 Metaplan sessions
BNFL plc	Utility company	UK	Interview
WANO	International organisation	France	1 Metaplan sessions

Table 2. Details of the four Nordic nuclear power plants involved in the study[3].

Licensee	NPP	Number of units	Present combined effect	Reactors to commercial operation
Teollisuuden Voima Oy (TVO)	Olkiluoto	2	1700 MWe	1978, 1980
Forsmarks Kraftgrupp AB (FKA)	Forsmark	3	3200 MWe	1980, 1981, 1985
Ringhals AB	Ringhals Barsebäck	4 + 1	4300 MWe	1975, 1976, 1981, 1983 Barsebäck 2: 1977
OKG AB	Oskarshamn	3	2300 MWe	1972, 1975, 1985

Semi-structured interviews were used to gather data from ten top utility managers representing Pohjolan Voima Oy (Finland), Sydkraft AB (Sweden), Vattenfall AB (Sweden), UNESA

[3] Note that the figures of Ringhals AB include the second reactor of Barsebäck NPP that was operated by Barsebäck Kraft AB, a wholly owned subsidiary of Ringhals AB. The representatives of Barsebäck NPP took part in the Metaplan sessions held at Ringhals. Note that Barsebäck's second reactor was shut down in May 2005.

(Spain), and BNFL plc (UK). Prior to analysis, data from the interview transcripts were reduced to short summary statements of perceived challenges. Those summary statements were then translated into English and integrated with the statements generated in the Metaplan sessions. The combined number of statements was 593 and those statements were analysed further. Note that the sole Nordic NPP not included in the study was Loviisa NPP (2 X PWR, 1000 MWe). Loviisa power plant is owned by Fortum Oyj.

The data analysis was conducted in four phases using a number of complementary quantitative and qualitative methods. *Phase 1* started with a brainstorming session and definition of a new classification model. The original groups of challenges formulated as part of the Metaplan sessions were heterogeneous, making comparisons between particular plants and countries difficult. Therefore the statements were reclassified using one common model.

The new model was developed by the researchers during the LearnSafe project and it included the following dimensions: (1) Economic and financial, (2) Workforce and competence, (3) Technology, (4) Systems and procedures, and (5) Environment. These dimensions were assumed to cover the major general issue domains of a NPP manager's job. The model can be seen as a modified version of earlier characterisations of factors influencing organisational learning and safety (Baumont et al. 2000, p. 32) and areas of management decision-making (Rollenhagen 2002) in the context of nuclear power. The model is presented in Figure 1.

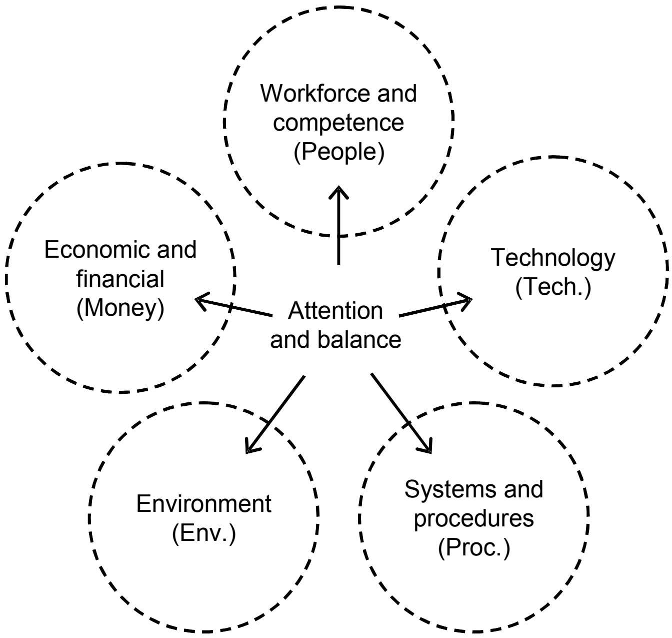


Figure 1. The generic classification model used for the coding of statements.

The five dimensions of the classification model were interpreted as *fuzzy sets*. The use of fuzzy sets can be motivated by the fact that the statements given by the managers in the Metaplan sessions and interviews were representations of their perceptions of difficult challenges facing the participating NPPs. Such statements often relate to each other as well as to various issues domains in different ways and do not therefore easily fit into mutually exclusive categories (a generic problem pertaining to the use of content-driven qualitative analysis methods). By using fuzzy sets particular challenges could be placed on one or several categories at the same time with different weights or degrees of membership. The resulting n-dimensional data space (in this instance $n = 5$) also allowed the use of quantitative clustering techniques as will be explained below. For a good introduction to fuzzy sets and fuzzy logic, see e.g. Kantrowitz et al. (1996).

In *phase 2* the identified challenges were classified. The classifications were performed independently by three researchers representing three different research organisations (VTT Technical Research Centre of Finland, Lancaster University Management School in the UK, and Technical University of Berlin in Germany). The identified challenges were presented in random order, and all references to particular countries, plants and sessions were concealed from the researchers. The researchers were requested to classify the challenges with respect to the dimensions of the common classification model on the basis of their (assessed) degree of membership using a scale of 0 to 100, 0 denoting no membership and 100 very strong membership. Therefore each researcher assigned each challenge with an array of five integers.

In *phase 3* the classified statements were analysed. The classification data was combined and the *average values* of assigned degrees of membership were subjected to a series of cluster analyses. Cluster analysis was regarded as an efficient way of structuring the data (consisting of data points in the 5-dimensional data space). A hierarchical cluster analysis was conducted to determine the optimal number of clusters (see Hair et al. 1998). On the basis of the clustering (agglomeration) coefficient a nine-cluster solution was selected. K-means cluster procedure was used to create nine clusters. These nine new clusters were named by emphasising challenges located close to the cluster centres. The clustering solution was illustrated by means of multidimensional scaling (ALSCAL) and the Euclidean distance model. Associations between the clusters and the selected background variables of Country, Organisation and Management level were studied by means of cross-tabulation and Chi-square tests. The statistical tests were conducted using SPSS.

In *phase 4* data from the Swedish and Finnish NPPs were subjected to further analyses for the purpose of assessing the results of the statistical cluster analysis and identifying the country and plant-specific similarities and differences on a more detailed level. The phase was started with a review of the plant-specific results. Associations between the clusters and the four Nordic plants were studied by means of cross-tabulation and a Chi-square test (which was conducted using Excel). As part of the analysis the original groups of challenges were also contrasted with the statistical 9-cluster solution. In addition, the Finnish and Swedish data in each cluster were compared with each other on the level of individual statements. Moreover, a range of other materials from other research projects and public domains were reviewed and utilised to the appropriate extent. In this way we elaborated our understanding of the operating environment of the four Nordic NPPs and the possible (causal) relationships between selected environmental factors and the identified management challenges.

It must be emphasised here that there is a significant difference between the original groups of challenges concluded in the Metaplan sessions and the 9-cluster solution based on the classification of statements and subsequent statistical analyses. The naming of original groups illustrates how managers categorise plant-specific challenges into larger thematic entities, while the 9-cluster solution provides an overall structure for all 593 classified statements. Since the researchers classified the statements with respect to the five dimensions of the common classification model and since the model itself was introduced by the researchers, the 9-cluster solution summarises the researchers' view of the problem space given the whole empiric dataset.

An overview of the research procedure is given in Figure 2. A brief description of the applied data acquisition methods and phases 1-3 is also provided in Kettunen et al. (2004b).

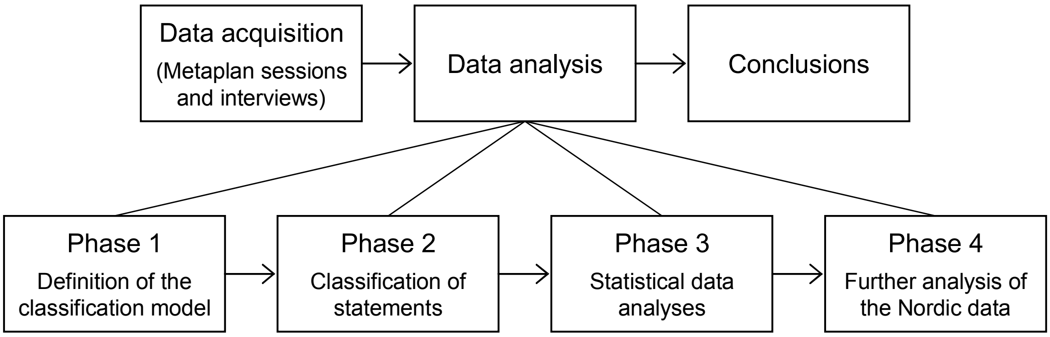


Figure 2. Overview of the research procedure.

ANALYSIS AND RESULTS

The European context

The nine new clusters proposed by the cluster analysis were named as follows: (1) Economic pressures, (2) Human resource (HR) management, (3) Nuclear know-how, (4) Rules and regulation, (5) Focus and priorities, (6) Aging, 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 3 the nine clusters are characterised by examples of typical challenges and statements brought out by the NPP managers and WANO officers taking part in the study. Note that some statements have been reformulated for editorial purposes.

Table 3. Characterisations of the new challenge clusters.

Cluster	**Typical challenges and statements**
Economic pressures	Competition, market conditions (taxes, subsidises, etc.), corporate pressures, cost reductions, and conflicts between costs and safety
HR management	Age distribution of personnel, early retirements, recruitment of new personnel, maintaining competencies
Nuclear know-how	Decreasing number of vendors, competency of contractors and suppliers, and the availability of external services in general
Rules and regulation	New requirements, bureaucracy and paperwork, maintaining an open communication (between the licensee and the regulator), regulatory focus (not always regarded as appropriate or effective)
Focus and priorities	Selection of correct priorities, management focus and commitment, wise use of resources, keeping procedures up to date, and managing organisational change
Ageing, mod. and new technologies	Maintaining the technical condition of the plant, ageing of plant and components, modernisations, taking new technology into use
Public confidence and trust	Societal acceptability of nuclear power, irrationality in anti-nuclear attitudes, distrust in local or regional authorities, hostility in mass media, “an accident anywhere is an accident here”
Climate and culture	Motivation and attitudes, safety culture, need to fight complacency, mental and emotional strain, organisational and human factors in general
Miscellaneous	Balance between safety – plant – people – technology, the development in the nuclear field, control of maintenance, consequences of mergers and acquisitions, decommissioning of plants, etc.

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 the five countries.

The nine clusters are not independent of each other and have interesting connections, which can be found by taking a closer look at the cluster centres (Table 4). The columns of the table represent the nine clusters. The rows represent the five dimensions of the common classification model (see Figure 1). The numbers in cells denote the cluster centres (co-ordinates) with respect to the 5-dimensional data space. It is important to remember that the classification dimensions shall be understood as generic and context-free managerial issue domains, while the clusters identified in the study refer to specific sets of challenges in the given context.

Table 4. Co-ordinates of the nine cluster centres.

Dimension	**Cluster centres**								
	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**
Money	83.5	41.7	37.9	13.8	22.9	48.9	18.2	13.2	57.4
People	23.6	95.7	61.6	23.1	39.9	10.4	17.1	87.2	55.0
Tech.	16.7	14.4	17.9	20.3	19.2	91.4	19.7	10.0	60.9
Proc.	47.4	48.5	43.5	78.0	76.0	43.1	30.1	53.4	56.6
Env.	66.0	42.7	79.8	84.8	29.7	19.9	90.2	17.3	43.8

Table 4 shows how Workforce and competence-related issues (People) seem to break up into three main clusters: HR management (cluster 2), Nuclear know-how (cluster 3), and Climate and culture (cluster 8), of which the first has to do with the challenge of maintaining a sufficient level of competence at the plant, the second refers to the availability and quality of external services, and the third includes motivational challenges and related organisational factors. In a corresponding way challenges linked to Systems and procedures (Proc.) appear to break up in several clusters but especially into Rules and regulation (cluster 4), Focus and priorities (cluster 5), and Climate and culture (cluster 8).

The table also illustrates how important issue domain Environment (Env.) is in the context of nuclear power; four clusters are strongly and two others moderately related to the operating environment of NPPs. On the other hand, Technology (Tech.) seems to be a rather distinctive area with strong links only to two challenge clusters: Aging, modernisation and new technologies (cluster 6) and Miscellaneous (cluster 9). It is interesting to see, however, that challenges relative to Aging, modernisation and new technologies are also moderately connected to financial issues as well as to systems and procedures.

In general, Workforce and competence, Systems and procedures and Environment emerge as dominant managerial issue domains in our analysis: most clusters score high on those dimensions, including the three biggest challenge clusters.

The mutual interconnections between the nine clusters were also studied by means of multidimensional scaling. The analysis was conducted for the distances between the nine cluster centres using SPSS (ALSCAL). The stress factor (badness-of-fit measure) was 0.0567 (moderate/ good) with 10 iterations. The results of the analysis are shown in Figure 3. Note that dimensions 1 and 2 have not been given any particular interpretations.

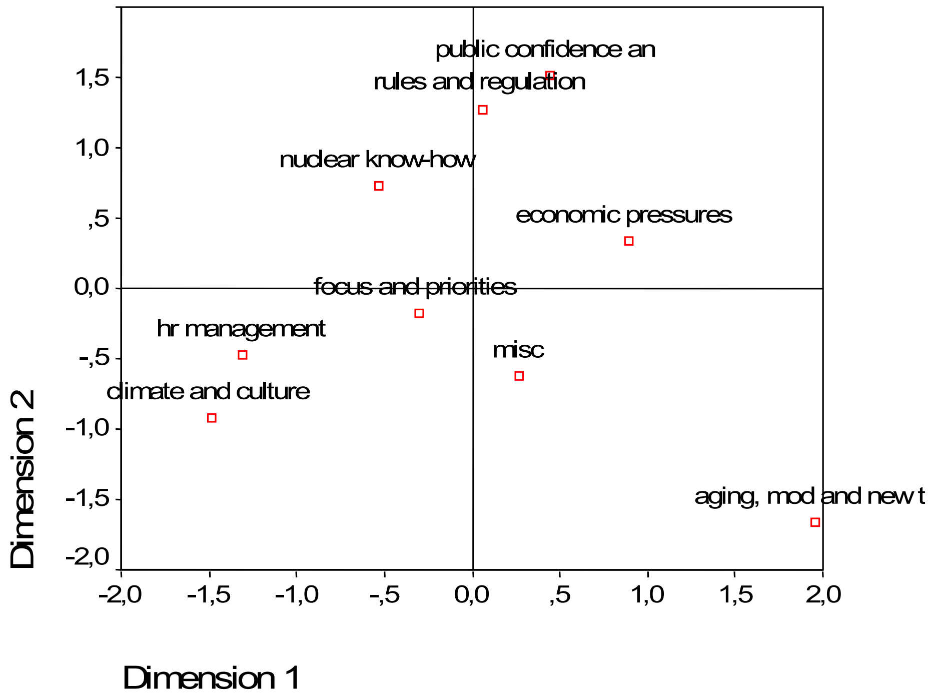


Figure 3. Euclidean distance model of the 9-cluster solution.

In Figure 3 the relative distances between the points on the plane correspond (approximately) to the distances between the cluster centres in the 5-dimensional data space. In this particular case spatial proximity in the Euclidean distance model may be interpreted to represent thematic similarity. Therefore the model suggests, as was expected, that challenges relating to HR management and Climate and culture are qualitatively close to each other. Those challenges are strongly related to workforce and competence-related issues, moderately to management systems and procedures and only slightly or not at all to technology. If a particular challenge also relates to financial matters and environment, we are presumably talking about HR management, otherwise about Climate and culture (see also Table 4).

Perhaps surprisingly, challenges relating to Rules and regulation and Public confidence and trust appear to be closely related, too. There is, however, a common denominator between these two clusters explaining the results: challenges in both clusters are strongly related to external pressures over which NPP managers have little or no control. The special nature of technology-related challenges is also clearly visible in the model. Focus and priorities-related challenges are in the middle, which illustrates their position in the intersection of other problem areas. The same applies, although to a lesser extent, also to Economic pressures.

The interesting question was of course as follows: how do the five countries covered in this study differ from each other? The cross-tabulation of the data with respect to Cluster and Country is shown in Table 5.

The first look at the table reveals that there are many similarities between the five countries. For example, challenges relating to either HR management or Climate and culture were generally emphasised in all countries (the international group being a clear exception), whereas Rules and regulation-related issues were not. In all five countries the largest challenge cluster was either HR management or Climate and culture, or they shared the top position as in Finland. However, the relative importance of Economic pressures was perceived differently in different countries. In Finland financial matters were regarded as insignificant (at least from the safety point of view)[4], while in German and Sweden, as well as amongst the representatives of the international group, their relative importance was at least moderate. And in Sweden Climate and culture-related challenges were far less emphasised than in other countries.

Table 5. Cross-tabulation of Cluster and Country (% within Country)[5].

Challenge clusters	**Fin**	**Swe**	**Ger**	**Sp**	**UK**	**Int**	**All**
Economic pressures	0.0	12.2	15.8	11.2	3.6	18.8	10.3
HR management	21.4	28.9	18.4	18.7	26.2	8.3	22.3
Nuclear know-how	5.4	10.6	10.5	8.0	3.6	4.2	7.8
Rules and regulation	1.8	6.1	5.3	8.0	7.1	2.1	6.1
Focus and priorities	16.1	10.6	7.9	3.2	15.5	14.6	9.6
Ageing, mod. & new tech.	17.9	9.4	13.2	3.2	11.9	8.3	8.8
Public confidence and trust	10.7	10.6	5.3	20.9	1.2	18.8	12.8
Climate and culture	21.4	8.3	15.8	23.5	27.4	6.3	17.4
Miscellaneous	5.4	3.3	7.9	3.2	3.6	18.8	5.1
Total (%)	100.1	100.0	100.1	99.9	100.1	100.2	100.2
Total (*n*)	*56*	*180*	*38*	*187*	*84*	*48*	*593*

The Chi-square test conducted for the data indicated that Cluster and Country were significantly related ($\chi^2 = 127.38$; df = 40; $p < 0.001$). This suggests that despite obvious similarities different challenges tend to be emphasised in different countries. Note, that Table 5 contains the percentages to facilitate comparisons between countries.

In a similar way a comparison was also made between different plants (Organisation) and manager groups (Management level). The Chi-square tests indicated that while Cluster and Organisation were significantly related ($\chi^2 = 181.45$; df = 88; $p < 0.001$)[6], Cluster and Management level were not ($\chi^2 = 24.18$; df = 16; $p \approx 0.086$). These findings suggest that different challenges are emphasised in different organisations, while managers appear to worry about the same things irrespective of their relative rank (top, senior or middle). In the former case notable differences were also identified within single countries, e.g. between two plants in the same country. In the latter case there were only modest (and statistically insignificant) differences in relation to Economic pressures, Focus and priorities, and Public confidence and trust. As was expected, higher rank was related to a greater emphasis on economic issues, while operative (senior and mid-level) managers were more concerned about maintaining a proper focus. Perhaps surprisingly, the operative managers also appeared to be more concerned about the public image of the industry than their senior colleagues.

[4] The table shall be read as follows: none of the challenges identified by the representatives of Olkiluoto NPP in Finland (sample 'Fin') were placed in the 'Economic pressures' cluster in the analysis. This does not necessarily mean, however, that Finnish NPP managers face no economic challenges. The outcome of the analysis is strongly related to the coding of statements, which was conducted by researchers whose interpretation of particular statements may have been different from that of their introducers. Secondly, the international group, in which economic pressures were emphasised, also had a Finnish representation.

[5] 'Int' refers to data gathered at WANO and at a group interview of Finnish and Swedish top utility managers. Data sets 'Fin' (Finland) and 'Swe' (Sweden) contain only senior and mid-level NPP managers' views. This shall be borne in mind when comparing the data sets with each other.

[6] Note that the statements expressed by the top managers of the three Nordic utility companies (Pohjolan Voima Oy, Sydkraft AB and Vattenfall AB) were collected and also presented together. Therefore the number of Organisations in the analysis was 12 (instead 14) and the degrees of freedom 88 (instead of 104).

Finland and Sweden: Further analysis of the data

As a first step towards in analysing the views of the Nordic NPP managers we took a closer look at the plant-level data. The Nordic data consisted of 236 statements, of which 56 were of Finnish and 180 of Swedish origin. The cross-tabulation of Cluster and Organisation is presented in Table 6.

Table 6. Cross-tabulation of statements from the four participating Nordic plants with respect to Cluster and Organisation (% within Organisation).

Challenge clusters	Fin	Swe			V(Swe)	V(N)
	TVO	FKA	RING	OKG		
Economic pressures	0.0	8.1	19.0	9.3	0.49	0.86
HR management	21.4	29.7	28.6	27.9	0.03	0.14
Nuclear know-how	5.4	13.5	9.5	7.0	0.33	0.40
Rules and regulation	1.8	5.4	6.3	7.0	0.13	0.45
Focus and priorities	16.1	6.8	9.5	18.6	0.53	0.43
Ageing, mod. & new tech.	17.9	6.8	6.3	18.6	0.66	0.55
Public confidence and trust	10.7	16.2	9.5	2.3	0.74	0.59
Climate and culture	21.4	10.8	6.3	7.0	0.30	0.61
Miscellaneous	5.4	2.7	4.8	2.3	0.41	0.40
Total (%)	100.1	100.00	99.8	100.0		
Total (*n*)	*56*	*74*	*63*	*43*		

The Chi-square test conducted for the data indicated that in the *Nordic* data Cluster and Organisation were moderately related ($\chi^2 = 41.27$; df = 24; $p \approx 0.017$). This suggests that different challenges tend to be emphasised at the four Nordic plants. Note that Table 6 contains percentages to facilitate comparisons between plants. The coefficient of variation[7] (V(X)) is used to measure relative deviation within the three Swedish plants (V(Swe)) and within all four Nordic plants (V(N)) as regards the relative size of each challenge cluster.

A qualitative analysis of Table 6 suggests that there are, nevertheless, a few similarities between the four Nordic plants. First of all, HR management-related challenges, such as ageing personnel and competence management, were strongly emphasised at all plants. Especially in the three Swedish plants HR management clearly outweighed all other areas of management activity. Secondly, Nuclear know-how, which in our analysis relates to the (long-term) supply of external and industry-specific products and services, was fairly uniformly emphasised in all Nordic plants, though its relative importance was lower than that of HR management.

In case of Focus and priorities, Ageing, modernisation and new technologies and especially Public confidence and trust differences between particular plants are great. In case of these three clusters the relative deviation within the Swedish data (V(Swe)) actually exceeds that of the whole Nordic data set (V(N)). This is an interesting result, but because only one Finnish plant participated no final conclusions can be drawn at this stage.

The most notable difference between TVO and the Swedish NPPs relates to the perceived importance of Climate and culture-related challenges. So, there seems to be a clear country-

[7] The coefficient of variation is the standard deviation divided by the mean, a unitless quantity indicating the variability around the mean in relation to the size of the mean.

related difference. This finding raises further questions about the underlying causes. Another similar area is Rules and regulation, which was smaller in TVO than in the three Swedish plants. When it comes to Economic pressures, financial matters appeared to weigh heavy only for Swedish NPP managers. On the other hand, the three Swedish plants varied in this respect (Table 6).

The results so far seem to suggest that with a few exceptions, country alone cannot explain differences between the three Swedish plants and the Finnish plant.

The second step in analysing how the Nordic NPP managers make sense of their operating environment involved extracting the *original* groups of challenges from the primary data. One Metaplan session and the interview held at the Finnish plant had resulted in 56 statements in nine groups, while the six sessions held at the three Swedish plants produced 180 statements in 33 groups. The original groups of challenges are listed in Table 7. All groups that explicitly refer to workforce, personnel, competence, culture, climate and/ or attitudes have been underlined.

Table 7. Original groups of challenges at four Nordic NPPs.

Plant	**Management level**	
	Senior	**Middle**
Olkiluoto (TVO, Finland)	Plant condition Personnel A new plant Society	The technical condition of the plant Personnel / attitudes, alertness, etc. Personnel / know-how Regulatory role Procedures and practices
Forsmark (FKA, Sweden)	Competency support in the nuclear field Profitability Company culture Confidence	Competency Skilful authority Economy Organisation Technology Politics
Ringhals (RING, Sweden)	Competency Requirements Maintaining technical preconditions Economy Management	Generation change Competency Consequences of change Risk of imbalance between econ. & safety Changed (technical) preconditions Attitudes, politics, policy Modernisation General issues
Oskarshamn (OKG, Sweden)	From old to new technology Competence and competence management Analysis Safety culture Misc	Competence Management /control Rules and demands Plant life management Economy and safety

Table 7 shows that personnel and competence-related issues were present in the primary data and mentioned by both senior and mid-level managers in both countries in all four plants. Various technical challenges and concerns about the regulator's views and activities were explicitly addressed at each plant. On the other hand, certain types of groups were formed only by the Swedish NPP managers. Economy, (the imbalance between) economy and safety, as well as company and safety culture were examples of such groups. So there seems to be a clear difference between the Finnish plant and the Swedish plants concerning the original grouping solutions. The problem was, however, that the picture emerging from Table 7 seemed to be contradictory to the finding that climate and culture-related challenges are more common in Finland than in Sweden (see Tables 5 and 6).

To solve the puzzle we went through all the 236 individual statements for the purpose of establishing the relation between the original groups of challenges and the new clusters. Then, it became apparent that the Finnish NPP managers had identified many HR management as well as Climate and culture-related challenges during the Metaplan sessions, but without explicitly referring to the concepts of 'climate' or 'culture' when grouping them into thematic entities. This explains the seemingly contradictory results in terms of the Finnish data.

A review of the Swedish data yielded interesting results, too. Our first discovery was that seven out of the 15 statements that were mapped to Climate and culture had originally been placed under the title 'Organisation'. Moreover, statements in other groups that may be regarded as thematically related, such as 'Risk of imbalance between economy and safety' and 'Economy and safety', had not been interpreted to be much people-related by the researcher who carried out the coding. Therefore, these statements were sorted into other clusters in the analysis[8]. However, competence-related groups, including 'Generation change', were mostly mapped into HR management, as expected.

The review of the Swedish data did not provide any corresponding simple explanation for the divergent results. However, some coding differences seem to explain a considerable part of the divergence. HR management-related challenges were well represented in the Swedish data. In conclusion, the results of the reanalysis appear to be in line with the results of the statistical cluster analysis, although the fit is far from perfect.

After the review of the original grouping solutions all statements derived from the four Nordic NPPs were sorted within the *new* clusters according to their relative importance, as determined by the participating managers, and analysed on the level of individual statements with respect to their content and main focus areas. The key findings are summarised below.

(1) *Economic pressures*. The Finnish NPP managers did not regard this area as important in the context of safety. The Swedish NPP managers, however, were clearly concerned about the conflict between economy and safety. In particular, they appeared to be worried about the owners' (i.e. top utility managers') interest in and long-term commitment to the industry.

(2) *HR management*. Finnish and Swedish NPP managers shared similar concerns. The challenges imposed by the ongoing generation change and the need to transfer the necessary skills and knowledge to the younger generation dominated their thoughts in this area.

(3) *Nuclear know-how*. Both Finnish and Swedish NPP managers appeared to share the same concern: How to secure an adequate supply of vendors and external services in the future? A reference to business trends was made by one Swedish manager, having supposedly to do with the perceived risk of applying modern management models in the context of nuclear power. The Finnish NPP managers did not refer to this particular issue.

(4) *Rules and regulation*. The Finnish NPP managers did not regard this area as important. The Swedish NPP managers expressed their concern about inadequate and changing regulatory demands, which in their opinion sometimes drifted their resources away from more

[8] The co-ordinates of the centres of the nine new clusters are given in Table 4. Climate and culture (cluster 8) is strongly related to People, moderately to Systems and procedures, and only slightly to three other dimensions of the common classification model. Therefore statements with an explicit reference to financial matters are likely to have been mapped into other clusters.

important things. They were also criticising excessive formalism and bureaucracy for the same reason.

(5) *Focus and priorities*. The challenge of keeping focus on the essential things was emphasised by both Finnish and Swedish NPP managers. The Finnish managers paid also attention to the need to develop procedures and support systems in response to the demands of the changing working life, while their Swedish colleagues brought out the paradox of success and the risk of focusing on only short-term issues. In general, the challenges identified by the Finnish managers appeared to be more specific and concrete, while the concerns referred to by the Swedish managers were typically of more generic nature.

(6) *Ageing, modernisation and new technologies*. Ageing plants and components, modernisation of plant systems and introduction of new technology were explicitly referred to as challenging problem areas by both Finnish and Swedish NPP managers. Those challenges have to do with the overall requirement of maintaining the ‘technical condition’ of the plant. There were no significant thematic differences between the two countries in this area.

(7) *Public confidence and trust*. The Finnish managers were mostly worried about the regulator’s position on validation and licensing-related issues, while the Swedish managers also referred to a number of other external interest groups, including the general public, politicians, suppliers and owners. In consequence, as regards the content of individual statements there was a clear difference between the two countries.

(8) *Climate and culture*. Motivational issues received more attention in Finland than in Sweden. Otherwise the managers of both countries addressed similar type of safety-related topics, such alertness, attitudes, open and questioning climate, and safety consciousness.

The results suggest that the overall picture is complex and that one should not draw far reaching conclusions of the situation without paying careful attention to the multiplicity of the data and alternative explaining models.

DISCUSSION

The European context: HR management challenges rule

The present study has given some interesting findings relevant for the European nuclear industry in general and for Nordic safety management in particular. Overall, it was found that human resource management and organisational climate and culture are the two most challenging areas in the context of safety for NPP managers across Europe. Age distribution of personnel, early retirements, recruitment of new personnel, and maintaining competencies are examples of concurrent HR management-related concerns. Maintaining personnel motivation, building a proper safety culture and fighting complacency, and managing mental and emotional strain are examples challenges that were grouped under the term climate and culture in this study. It may therefore be concluded that organisational and human factors in general constitute a very significant portion of the NPP manager’s ‘problem space’ in Europe.

These findings are well in line with the results and projections of many earlier studies. For example, the study conducted by the Committee for Technical and Economic Studies on Nuclear Energy Development and Fuel Cycle of the OECD Nuclear Energy Agency in 1998 revealed that the number of students graduating at bachelor's and master's level in nuclear science and engineering has been decreasing since 1990 in the OECD member countries (OECD/NEA 2001). This in turn translates into recruitment challenges and greater reliance on the licensees' in-house training programmes. When it comes to climate and culture, and especially personnel motivation, we should not underestimate the potential effects of deregulation and increasing competition. For example, the Nuclear Installations Inspectorate (NII) has identified signs of low morale among the regular employees of UK nuclear sites that have been subjected to various change and development projects to boost efficiency. Since these projects often result in downsizing and an increased use of external contractors, they also create uncertainty about future employment prospects (Bier et al. 2001, HSE).

One interesting finding of the study was that the perceived relative importance of various issue domains is not related to management level, i.e. the manager's formal position in the utility or plant organisation. This may stem from the fact that until recently the top and senior managers have usually been recruited internally within the plant organisation, or at least from within the nuclear power industry.

There were, however, differences also across countries. This seems natural given that the nuclear power programmes of the five European countries are also different in many other ways. But establishing a logical connection between our findings and selected circumstantial factors of the participating countries proved to be a challenging exercise.

For example, personnel-related challenges were given a great deal of attention in Finland despite the fact that the country's nuclear power industry had a steady footing and progressive future plans. At the time of data acquisition in the spring of 2002 the Council of State had already made a positive decision in principle to support TVO's application for a new nuclear power unit (see e.g. www.tvo.fi). Therefore, one could have expected that the challenges of managing the inevitable generation turnover and maintaining good motivation of personnel, as demanding these tasks may be in practice, should have received far less emphasis in Finland than in any other of the four participating countries. Secondly, public confidence and trust together with rules and regulation emerged as least challenging areas of management activity in Germany, although it is a well known fact that lacking public support for the use of nuclear power and amounting political pressures forced the German utilities to conclude a contract with the government on a gradual phasing-out of operating nuclear power plants (OECD/NEA 2004). Moreover, while the British NPP managers together with their Finnish colleagues ranked economic pressures low, the British utility involved in the study has nevertheless been operating unprofitably since the late 1990s and shutting down its elder plants due to increasing operation and maintenance costs and generally unfavourable economic prospects of nuclear power-based electricity generation (BNFL 2003, OECD/NEA 2004).

The above-listed examples clearly show that the relationships between the identified management challenges and various political and economic factors are not straightforward. The lesson learned is that the findings of the analysis shall not be mechanistically linked to, or derived from, any particular simplistic view an societal (e.g. political) processes that have taken place or are underway in the countries covered in this study. The results thus suggest that the NPP managers' problem space is shaped by a number of interacting factors, of which many originate from within the plant organisation. Nevertheless, there are common denominators, such as HR management for example, that conjoin NPP managers in different countries and different plants and which therefore lay a natural foundation for the exchange of ideas, experiences and good practices. Technology is another obvious field for co-operation.

Finland and Sweden: A mixed picture

Ambiguity is perhaps the right word to describe the nature of our findings with regard to the further analysis of the Nordic data. One thing is for sure: HR management-related challenges receive a lot of attention among both Finnish and Swedish NPP managers. In this respect the two Nordic countries are no different from the three other European countries covered in this study. However, presenting a comprehensive, yet concise, overview of the situation in the two Nordic countries is a difficult task. For example, while some of the challenge clusters were differently emphasised in the two countries, they still were similar in terms of their nature and content (e.g. Climate and culture). On the other hand, there were clusters with the same relative importance in both countries, but different contents and focus (e.g. Public confidence and trust). And in general, the differences between particular plants were many times surprisingly large.

A logical starting-point for the search for explaining factors was to take a closer look at the performance data of the four Nordic plants. We first paid attention to load factors, i.e. the ratio between the actual and maximal electrical output of a plant over a specified period of time. The analysis revealed that between 1996 and 2003 the average load factors of the three Swedish NPPs have remained well below those of TVO and that they have also been subject to strong fluctuation. In short, TVO outperforms the three Swedish plants with a wide margin (Figure 4).

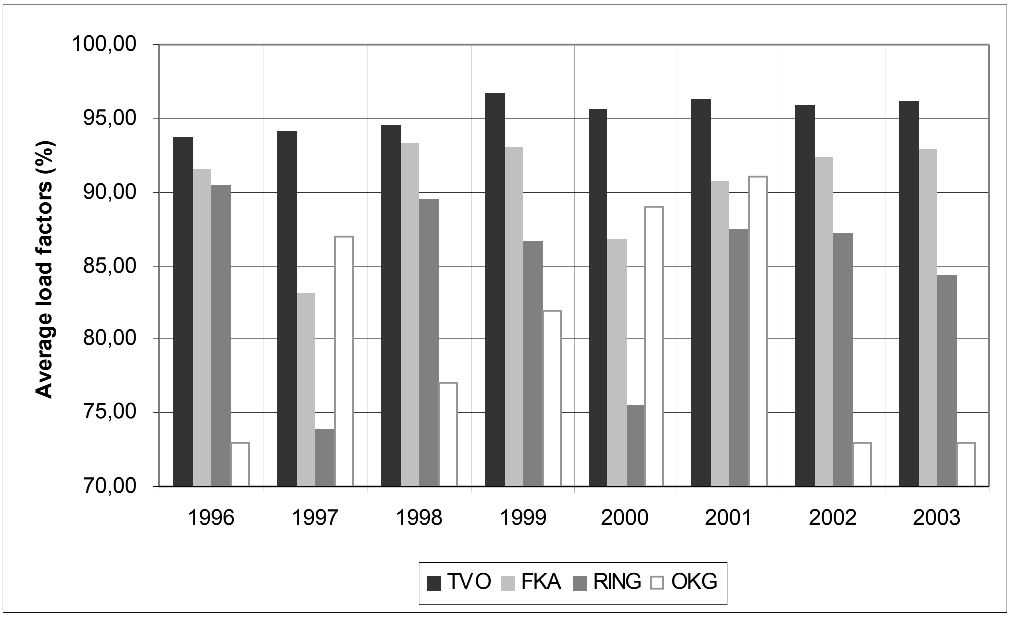


Figure 4. Average load factors (%) of four Nordic nuclear power plants in 1996-2003. Sources: Teollisuuden Voima (TVO), Forsmarks Kraftgrupp (FKA), Ringhals and OKG.

Operating age could in principle partly explain the difference between the Finnish and Swedish plants. Oskarshamn 1 and 2 as well as Ringhals 1 and 2 were brought to service before TVO started generation. Forsmark 1 and 2, however, are of similar design and same age than their Finnish sister reactors Olkiluoto 1 and 2 of TVO (see table 2). Moreover, also TVO has implemented ambitious modifications during the same period of time, including a large modernisation programme that was carried out during the second half of the 1990s. Still its annual load factors have remained at excellent levels.

The picture gets more complicated when the average load factors are contrasted with additional plant performance data, such as reactor and turbine scrams and INES-classified operating events[9]. In 1996-1997 TVO had more scrams per unit than any of the three Swedish plants, and during the years 1998-1999 and 2001-2002 TVO had the second highest scrams per unit rate (KSU). Moreover, between the years 1997 and 2002 TVO had clearly more INES 1 classified events than any of the three Swedish plants with the exception of the year 2000 when TVO's performance in general was very good (STUK, SKI). In other words, TVO's load factors have remained at exceptionally high levels despite relatively frequent reactor and turbine scrams and INES-classified events[10].

The failure statistics may, however, help explaining why technical challenges were actually stressed at TVO. In addition, they help explaining why the representatives of OKG emphasised this area more than their Swedish colleagues: OKG have had more scrams per unit than the two other Swedish plants for a number of years with the exception of year 2002 when FKA 'took the lead' for the first time. The findings suggest, too, that the Finnish regulator, STUK, has been rather flexible towards TVO – otherwise the situation could have been quite different with a series of regulator interventions and forced outages which would have had a significant negative impact on the plant's average load factor. No wonder that rules and regulation were generally regarded as the second least important challenge area at TVO.

A good load factor also translates into high production volumes which contribute to a steady revenue stream. Therefore the load factor may function as a key to understanding the differences in the relative importance of economic pressures between the plants, and especially between TVO, where the relative weight of this area was minimal, and Ringhals, where economic pressures were the second most important area after HR management. In terms of average load factors Ringhals lags far behind TVO. This gap, however, does not provide a satisfying explanation for the findings of the analysis, for the relationship between the annual turnover and the load factor appears to be loose. Instead, the revenue graphs appear to behave smoothly and in accordance with the development of the price of electricity.

Deregulation of the Finnish and Swedish electricity markets in 1995-1996, introduction of a joint Norwegian-Swedish power exchange, Nord Pool ASA, in 1996, as well as heavy rains in Norway in 1996-1997, which filled the country's water reservoirs and thus made the supply of hydroelectric power abundant, eventually led to the decline in the electricity prices in the Nordic interconnected grid. The declining trend continued until the end of the decade, and the prices bottomed in 2000 (Nord Pool). In consequence, the revenues declined, too, and the power companies were forced to introduce cost saving. This must have had at least a modest impact on the NPP managers' work either directly or indirectly.

Despite the existence of a common Nordic electricity market, private households as well as industry in general paid a bit more for their electricity in Finland than in Sweden between 1996 and 2001 (Energy Market Authority, Statistics Sweden, Nord Pool). This has provided the Finnish power companies, including TVO, a sort of economic advantage over their Swedish competitors.[11] This in part may explain the results of the analysis when it comes to

---

[9] INES = the International Nuclear Event Scale, a system for the classification of operating events according to their safety significance. The scale runs from 1 (anomaly) to 7 (major accident). See also: www.iaea.org.

[10] Note that the statistics of the year 2003 have been intentionally omitted from this analysis, because the underlying Metaplan and interview data were collected in 2002.

[11] The four Nordic licensees involved in this study generate electricity for their shareholders at cost. Therefore all assessments on financial results are based on profits before appropriations and taxes as reported by the licensees.

the perceived importance of economic pressures at the four Nordic plants: TVO has managed to pile up money to cover future – planned as well as unplanned – expenditures.

The overall situation in Scandinavia, however, started to change in 2001-2002. The price of electricity bounded ahead, and the price levels in Sweden gradually bypassed Finland in most customer segments. TVO's financial results also eroded, though supposedly due to increasing investments in the planning of the new unit. The Metaplan sessions and interviews were conducted in the midst of this economic change in 2002. It is therefore difficult to estimate to what extent and exactly how those changes are reflected in the primary data.

Overall conclusions and recommendations

The results show how the pressures from the working environment can be perceived in many different ways. Even though the focus of this study was on perceived safety-related challenges, the emerging picture of the managers' problem space encompasses a number of issues (cf. Weick 1995). In terms of the generic managerial issue domains workforce and competence, systems and procedures and environment emerged as dominant in our analysis. In terms of context-specific challenges HR management, climate and culture, and public confidence and trust were mostly emphasised. Safety cannot thus be managed independently of other goals, such as internal efficiency or public image.

Clearly the managers have to cope with and make sense of ambiguous situations and demands (cf. Weick 1995, p 93). Further, the demands extracted in this study could be interpreted as competing goals (Quinn 1988) with seemingly contradictory criteria for performance. The challenge is to pursue all the competing goals simultaneously. Given the fact that human as well as organisational decision-making processes are characterised by 'bounded rationality' and 'satisficing', as stated by March and Simon already in 1958, one may conclude that the task of balancing attention and resources in a proper way is a critical one.

Comparing the challenges across stations and countries proved that the challenges were perceived differently. Some can be attributed to genuine differences in the political climate of the five countries covered in this study. But many others seem to have more to do with the organisational (cf. Schein 1985) than national culture or circumstances. This exercise of comparing the challenges across various stations could be fruitful for the managers in clarifying their cultural biases. Nuclear community is very international and co-operates quite closely. Nevertheless, the differences in the perceived safety challenges are large. It could be hypothesised that these differences in perceptions of the working environment would be even larger in some less international industry.

The role of the regulator is also a question that needs further attention and research in the future. Regulatory practices were raised as a safety concern in a number of plants, even though the regulator is supposed to contribute to the safety of nuclear power. Still, the responsibility for safety is undivided and always resides with the licensee. This raises questions about the role of the regulator in general and methods that could be best suited for this role in particular (cf. Kirwan et al. 2002).

Future research and development work should focus on clarifying the nature of the different challenges extracted in this study, and especially the interface and interaction between the challenges. A related topic for future research and development work concerns applied management models. Are same kind of management initiatives and methods suitable for tackling all the challenges, or does every challenge require a unique approach?

Acknowledgement
This paper builds on the results of the LearnSafe project (Wahlström et al. 2005, www.vtt.fi/virtual/learnsafe/) and the research conducted within the framework of the national SAFIR research programme (Reiman et al. 2004, www.vtt.fi/pro/tutkimus/safir/). The LearnSafe project was initiated in 2001 to study concurrent management challenges and practices in the European nuclear power industry with a special emphasis on management of change and organisational learning. The project was completed in 2004. The SAFIR research programme was initiated in 2003. The programme aims at developing nuclear power safety in various domains, of which one is organisations and safety management. The SAFIR research programme is to be completed in 2006. The contribution of the whole LearnSafe team in providing ideas and input to this paper is gratefully acknowledged. A list of the LearnSafe team members can be found at the LearnSafe project website, which also contains information on the results of the project.

REFERENCES

Baumont G, Wahlström B, Solá R, Williams J, Frischknecht A, Wilpert B, Rollenhagen C (2000) *Organisational factors. Their definition and influence on safety.* VTT Research Notes 2067. Espoo: VTT Technical Research Centre of Finland.

Bier VM, Joosten JK, Glyer JD, Tracey JA, Welch MP (2001) *Effects of deregulation on safety: Implications drawn from the aviation, rail, and United Kingdom nuclear power industries* (NUREG/CR-6735). Washington DC: U.S. Nuclear Regulatory Commission.

BNFL (2003) *BNFL annual report and accounts 2003.* www.bnfl.com.

Cameron K, Quinn R (1999) *Diagnosing and changing organizational culture.* Reading, MA: Addison-Wesley.

Furuta K, Sasou K, Kubota R, Ujita H, Shuto Y, & Yagi E (2000) *Human factor analysis of JCO criticality accident*, Cognition, Technology & Work, 2(4), 182–203.

Hair JF, Anderson RE, Tatham RL, Black WC (1998) *Multivariate data analysis (5th Ed)*. New Jersey: Simon & Schuster.

Hofstede G (1997) *Culture and organizations; software of the mind*. New York: McGraw-Hill.

Kantrowitz M, Horstkotte E, & Joslyn C (1996) *Answers to Frequently Asked Questions about Fuzzy Logic and Expert Systems*. ftp.cs.cmu.edu:/user/ai/pubs/faqs/fuzzy/fuzzy.faq.

Kettunen J, Mikkola M, Reiman T (2004a) *When availability counts – Key concepts, constraints and challenges of outsourcing in the nuclear power industry*. In K.S. Pawar, C.S. Lalwani, & J. Shah (eds.) Proceedings of the 9th International Symposium on Logistics: Logistics and global outsourcing (pp. 552-558). Nottingham: Centre for Concurrent Enterprise, University of Nottingham.

Kettunen J, Jones B, Reiman T (2004b) *Assessing challenges to nuclear power plant management in five European countries: Methods, results and lessons learned*. In C. Spitzer,

U. Schmocker, & V.N. Dang (eds.) Probabilistic Safety Assessment and Management 2004, Volume 3 (pp. 1572-1577). London: Springer.

Kirwan B, Hale AR, Hopkins A (eds.) (2002) *Changing regulation – Controlling risks in society*. Oxford: Pergamon.

March JG, Simon HA (1958) *Organizations*. New York: Wiley.

OECD/NEA (2000) *Nuclear power plant life management in a changing business world*. Workshop proceedings, Washington DC, USA, 26-27 June 2000. Issy-les-Moulineaux: OECD Nuclear Energy Agency.

OECD/NEA (2001) *Assuring future nuclear safety competencies. Specific actions*. Issy-les-Moulineaux: OECD Nuclear Energy Agency.

OECD/NEA (2004) *Nuclear energy data 2004*. Issy-les-Moulineaux: OECD Nuclear Energy Agency.

Peters TJ, Waterman RH (1982) *In search of excellence; lessons from America's best-run companies*. New York: Warner Books.

Quinn RE (1988) *Beyond rational management: Mastering the paradoxes and competing demands of high performance*. San Francisco, CA: Jossey-Bass.

Reiman T, Oedewald P, Kettunen J (2004) *CulMa summary report*. In: H. Räty & E. K. Puska (eds.), SAFIR The Finnish Research Programme on Nuclear Power Plant Safety 2003-2006. Interim report. VTT Research Notes 2272. Espoo: VTT Technical Research Centre of Finland.

Rollenhagen C (2002) *Safety management of nuclear power plants. Values and balance of attention*. A working paper, LearnSafe project. www.vtt.fi/virtual/learnsafe/.

Schein EH (1985) *Organizational culture and leadership.* San Francisco: Jossey-Bass.

Trompenaars F, Hampden-Turner C (1998) *Riding the waves of culture.* New York: McGraw-Hill.

Wahlström B, Kettunen J, Reiman T, Wilpert B, Maimer H, Jung J, Cox S, Jones B, Sola R, Prieto JM, Martinez Arias R & Rollenhagen C (2005) *LearnSafe – Learning organisations for nuclear safety*. VTT Research Notes 2287. Espoo: VTT Technical Research Centre of Finland.

Wahlström B & Rollenhagen C (2004) *Issues of safety culture; reflections from the LearnSafe project*. Forth American Nuclear Society International Topical Meeting on Nuclear Plant Instrumentation, Controls and Human-Machine Interface Technologies (NPIC&HMIT 2004). Columbus, Ohio, September.

Waldrop MM (1992) *Complexity: The emerging science at the edge of order and chaos.* New York: Touchstone.

Weick KE (1995) *Sensemaking in organizations.* Thousand Oaks, CA: Sage.

Websites of referenced utility companies and nuclear power plants

British Nuclear Fuels plc, BNFL: www.bnfl.com
Forsmarks Kraftgrupp AB, FKA, Sweden: www.forsmark.com
OKG AB, Sweden: www.okg.se
Pohjolan Voima Oy, PVO, Finland: www.pvo.fi
Ringhals AB, Sweden: www.ringhals.se
Teollisuuden Voima Oy, TVO, Finland: www.tvo.fi

Websites of other referenced organisations and research projects

Energy Market Authority, Finland: www.energiamarkkinavirasto.fi
HSE Nuclear Safety Directorate, United Kingdom: www.hse.gov.uk/nsd/
International Atomic Energy Agency, IAEA: www.iaea.org
Kärnkraftsäkerhet och Utbildning AB, KSU, Sweden: www.ksu.se
LearnSafe project: www.vtt.fi/virtual/learnsafe/
Metaplan Thomas Schnelle GmbH, Germany: www.metaplan.com
Nord Pool ASA, Norway: www.nordpool.no
Radiation and Nuclear Safety Authority, STUK, Finland: www.stuk.fi
SAFIR research programme: www.vtt.fi/pro/tutkimus/safir/
Statistics Sweden: www.scb.se
Swedish Nuclear Power Inspectorate, SKI: www.ski.se

Chapter 9: Organizational Culture and Social Construction of Safety in Industrial Organizations

Teemu Reiman and Pia Oedewald
VTT Industrial Systems,
P.O.Box 1301, FIN-02044 VTT, Finland
teemu.reiman@vtt.fi, pia.oedewald@vtt.fi

ABSTRACT

In this chapter, we consider organizational culture, safety culture and social construction of safety and efficiency in industrial organizations. We will discuss the way the employees in these organizations construct their work, their organization and its demands. The purpose is to illustrate how subjective conceptions and shared norms influence the technical solutions, strategic decisions and everyday practices, and vice versa. We introduce the concept of organizational core task to denote the motive and demands of activity in complex organizations. The concept offers a means for assessing the unique cultural features of an organization. Practical examples of the use of the concept are given. We conclude that subjective conceptions can lead to objective outcomes by two different mechanisms, through individual situational perceptions of the work and through institutionalisation of cultural conceptions into artefacts. Finally, implications of the cultural approach to safety management are elaborated.

INTRODUCTION

Industrial organizations of modern society have become increasingly complex. In addition to multiple goals (efficiency, safety, credibility, employee well-being), they encompass uncertainties in the data available to the employees, mediated interactions via various tools, multiple interacting parties and tightly coupled and complex technologies. The work is usually highly specialised and potentially hazardous (to the personnel and/or environment). (Vicente 1999 p. 14-17; see also Perrow 1984; Kirwan 2001; Tsoukas & Hatch 2001 p. 988) As stated in the introductory chapter of this book the feedback mechanisms are of crucial importance when managing complex systems. What information is needed in different situations, how it is received and how to deal with contradictory or ambiguous information, are questions that all organizations have to resolve.

The difficulties of managing complex organizations have received a lot of attention in connection with various organizational accidents (e.g. the Challenger space shuttle accident, see Vaughan (1996), Chernobyl nuclear accident or the Piper Alpha offshore platform accident, see Wright (1994) and Paté-Cornell (1993)). In Turner's (1978) terms these have been *disasters*. This means that the accidents have brought the previous approaches and assumptions about safety into question. A disaster is something that was not supposed to take place according to the existing framework of thinking, but it happened nevertheless. The event was thus in contradiction to the basic assumptions (cf. Schein 1985) about safety and the appropriate means for guaranteeing it (Turner 1978; Turner & Pidgeon 1997). Turner (1978) calls the phenomenon of increasing underlying system vulnerability as the disaster *incubation period*. He argues that "within this 'incubation period' a chain of discrepant events, or several chains of discrepant events, develop and accumulate unnoticed." (Turner 1978 p. 86). In this paper, we try to illustrate how a chain of discrepant events can develop and accumulate in the organization. We consider the role of organizational culture in guaranteeing safety and the ways of assessing and steering the prevalent assumptions and conceptions about safety in the organization.

FROM HUMAN ERROR TO SAFETY CULTURE

The attribution of the causes of various accidents that have occurred has changed over time, from technical causes to human and organizational factors. After the Three Mile Island nuclear accident in 1979, the attention concerning nuclear safety first, and gradually industrial safety in general, moved from purely technical issues into social issues and human factors. The cause of the accident was attributed to *human error* (Reason 1990). The remedial actions were mainly formal training and technical enhancements to e.g., the user interfaces. From that point on, human factors studies have strongly concentrated on classifying, predicting and preventing different "human errors" or minimising their consequences. Variability in human performance was considered a negative and potentially dangerous feature.

The aim to control and reduce this variability is common to most human error approaches. The main solution to deal with performance variability is to standardize, instruct and teach about the work tasks. Furthermore, in e.g. nuclear power plants, the guiding design principles of redundancy (multiple backups for the same function) and diversity (variety in the design principle of the safety functions) are applied to manage human error. Work permit procedures, audits and quality assurance are considered as defences against system disturbances (Reason & Hobbs 2003 p. 13).

The term *safety culture* was introduced in 1986 to common usage after the Chernobyl nuclear accident (IAEA 1991). The main reasons for accidents were proposed to be not only technical faults or individual human errors. In addition, management, organization and attitudes also influence safety for better or worse. Organizations (and especially the leaders) form prerequisites or boundaries to human actions in the form of shared attitudes and values. The current safety management theories usually emphasise that organizations should develop a sound "safety culture" in order to guarantee safety and reliability of the organization. A proper safety culture was quickly adopted as a safety requirement by the regulatory authorities, first in the nuclear area and gradually also in other safety-critical domains (e.g. offshore drilling industry, railway industry) in order to prevent accidents of any kind. Safety culture studies and development programs have been conducted in e.g. aviation (McDonald et al. 2000), offshore platforms (Mearns et al. 1998; Cox & Cheyne 2000), chemical industry (Donald & Canter 1994), manufacturing (Williamson et al. 1997; Cheyne et al. 1998) and the transport sector, including railways (Clarke 1998, 1999). For an overview of the development of the safety culture concept, see e.g. Cox and Flin (1998), Guldenmund (2000) and Sorensen (2002).

The concept of safety culture was coined in an attempt to gain an overview and an indicator of the safety level of the organization. The concept tried to grasp the subjective and social factors (such as safety attitudes, management focus) affecting safety. In the literature, the criteria of a good safety culture are considered to be e.g. the following (Grote & Künzler 2000 p. 132, see also Zohar 1980; Reason 1998; IAEA 1991, 1996, 1998; ACSNI 1993; HSE 1997; Lee 1998):

- a safety policy that includes the organization's vision, objectives as well as official criteria and general principles in relation to which the operations are evaluated
- a competent and democratic management practices and a visible commitment of the management to safety
- positive values and attitudes towards safety and a commitment to safety for the part of the staff

- clear definition of responsibilities and obligations, including clear job descriptions and their significance for safety
- operating practices that take safety into account
- a balance between safety and production
- competent staff and good training methods
- good motivation and job satisfaction
- fairness and trust among the staff and management
- quality and up-to-date rules and regulations and good operating and maintenance procedures
- sufficient interpretation and reporting of events and accidents
- good flow of information between the different levels and task areas of the organization
- good design and maintenance of technical equipment
- continuous improvement of operations and safety
- sufficient resources
- working relationships with the authorities

As can be seen from the list, the term safety culture refers to both the larger context and objectives of the organization and the structures and resources (incl. people) needed to fulfil these objectives. The criteria as such, however, do not tell us how a culture that emphasises safety is formed and how it is maintained or changed. Also, the discrepancies or conflicts between the various criteria remain unclarified. The vague definitions and utilizations of the term safety culture have resulted in criticism among academic organizational researchers (e.g., Guldenmund 2000; Pidgeon 1998a; Cox & Flin 1998). Cox and Flin (1998 p. 189) state that "[t]he common presumption appears that the attainment of a good safety culture contributes to, if not represents, the solution to all health and safety-related problems: a philosopher's stone to cure all ills". The concept of safety culture has become a catch-all concept for psychological and human factors issues in complex sociotechnical systems. Previously, the concept of human error had been criticised for exactly the same reason (Jacobs & Haber 1994 p. 76).

The criticism expresses a concern that safety culture is not seen as a contextual phenomenon, but as some kind of a *general ideal model*. Reflections of the ideal model-thinking can be seen in the emphasis on formal safety training and general safety attitudes (e.g., "always put safety first") as a means of fostering a safety culture. This has limitations: "Safety is not a separable form of knowledge. It is not something that is learned as such ... it is an aspect of practice" (Gherardi & Nicolini 2002 p. 216).

One could say that safety is as much an aspect of practice as is any element that makes a skilful worker. But what constitutes a skilful worker in different working environments? For this we cannot apply universal criteria, and the same applies to safety. Thus, it can be claimed that the safety culture concept does not describe the organizational reality sufficiently well. We state that this leads to definitions and measurements that are no longer practically usable or connected to the *daily work* in a particular organization (Reiman & Oedewald 2002, submitted). Organization and work are concepts that can be approached in multiple ways. Safety culture is based on the concept of organizational culture, but it does not make its underlying model of an organization explicit.

THE MODEL OF AN ORGANIZATION

The concept of organizational culture

Starting in the late 1970s, traditional mechanistic management models and organizational theories (see e.g., Thompson 1967; Etzioni 1964; Williamson 1975) were repeatedly found to be inadequate descriptions of reality and to tend to neglect knowledge about human nature. A new concept[1] was needed to describe and explain the individuals' actions and interactions in an organization so that the effectiveness of the organizations could be improved. (Alvesson & Berg 1992; Hawkins 1997) Organizational culture was suggested to be such a concept.

Despite the almost immediate popularity of the organizational culture concept, no widely accepted definition of the concept has emerged (Martin 2002; Schein 1985; Smirhich 1983; Schultz & Hatch 1996). Amongst practitioners, the idea of strengthening "corporate culture" in the name of organizational effectiveness was well received and reinforced by such popular writers as Peters and Waterman (1982) and Deal and Kennedy (1982). Alvesson and Berg (1992), quoting Frost et al. (1985) highlight three issues contributing to the development of the concept of organizational culture: the threat of Japanese competition to US markets (see also Morgan 1986), the social forces that were beginning to emphasize more the issues related to the quality of work, and the widespread dissatisfaction with the knowledge achieved in organizational theory. According to Willmott (1993 p. 515), the "interest in culture as an instrument of competitive advantage has been paralleled and complemented by growing academic attention to the symbolic dimensions of organizational life". Meek (1988) noted that the culture concept was borrowed from the structural-functional paradigm of the anthropological tradition. This paradigm relies heavily on the organism metaphor for the organization and on the social integration and equilibrium as goals of the system (Parsons 1951; Durkheim 1982; Radcliffe-Brown 1958; cf. Schultz & Hatch 1996). These characteristics were also found in most early theories of organizational culture (Baker 1980; Schein 1985; Barney 1986). Alvesson (2002 pp. 43-44) argues that these theories have a bias toward the positive functions of culture in addition to being functionalist, normative and instrumentally biased in thinking about organizational culture. The safety culture concept was derived from this tradition (cf. IAEA 1991).

More interpretative-oriented theories emphasized the symbolic aspects of culture such as stories and rituals, and were interested in the interpretation of events and creation of meaning in the organization (cf. Geertz 1973; see also Frost et al. 1985 p. 17; Turner 1971). The social construction of work and an organization was emphasized. The term "social construction of reality" was introduced by sociologists Peter Berger and Thomas Luckmann (1966). They proposed a theory of society based on the ideas of Alfred Schutz, Karl Marx, Émile Durkheim, and George Herbert Mead. Berger and Luckmann argued that human beings continually and together construct the social world that then becomes the reality to which they respond. According to them, social order is an ongoing human production. The individual is thus in a dialectic (cf. Burr 2003 p. 186) relation to society; simultaneously constructing and being constrained by it. Weick (1988 p. 307) has described the dialectic relation of mental and physical as follows: "enacted [socially constructed] environments contain real objects such as reactors, pipes and valves. The existence of these objects is not questioned, but their significance, meaning, and content is. These objects are inconsequential until they are acted upon and then incorporated retrospectively into events, situations, and explanations."

Smirhich (1983 p. 347) calls the culture "a root metaphor for organization". According to Alvesson and Berg (1992 p. 78) this means that "the cultural dimension can be found in – and not "alongside" – formal organizational structures, administrative systems, technologies, strategies". Alvesson (2002 p. 25) points out that in the idea of culture as a root metaphor, "the social world is seen not as objective, tangible, and measurable but as constructed by people and reproduced by the networks of symbols and meanings that people share and make shared action possible." Schultz (1995 p. 5) writes that the cultural way of studying organizations is to study "the meanings and beliefs which members of organizations assign to

[1] Rather than an entirely new concept it was more a revival of an old concept originally used in the fifties (cf. Jaques 1953; Miller and Rice 1967).

organizational behavior and how these assigned meanings influence the ways in which they behave themselves". Czarniawska-Joerges (1992 p. 124) states that "to understand people's actions, one has to look for the meaning attributed to those actions by the actors themselves, and by the observers". Pidgeon (1997 p. 2) notes that "all organizations operate with such cultural beliefs and norms, which might be formally laid down in rules and procedures, or more tacitly taken for granted and embedded within working practices". We argue that as the complexity of the system increases so does the need for both formal and informal guidelines and decision principles for working at all levels of the organization. These include shared norms and conceptions in addition to written procedures and instructions.

We agree on the importance of acknowledging organizational culture in safety critical organizations. However, the concept of organizational culture as a root metaphor for an organization as a socially emerging phenomenon, does not offer criteria for the assessment of the organization or its specific tasks. The criticism concerning normative organizational culture studies partly stems from the acontextual approach, where values and attitudes are not evaluated against the demands of the work, but by their apparent positiveness (cf. Alvesson 2002 p. 43), such as, valuing openness, being competitive as always good, withholding information, bureaucratic culture (cf. Weeks 2004 p. 37) as inherently bad. Furthermore, in many descriptive organizational culture studies the focus has been on internal integration aspects of the organization such as rituals, myths, stories and ceremonies, not so much on the content of the actual work carried out. Barley and Kunda (2001) argue that since the dawn of systems theory in the end of the sixties "work has slipped increasingly into the background as organizational theory converged on the study of strategies, structures, and environments as its central and defining interests" (Barley & Kunda 2001 p. 76). Barley and Kunda call for a reintegration of studies of work and organizing. We approach this with the concept of organizational core task which is tackled next.

Organizing for the organizational core task

An organization is always a means to some end (cf. MacIntyre 1985 pp. 57-58; Perrow 1986), regardless of how the specific means and ends are socially constructed in a given organization. Reiman and Oedewald (submitted) argue that by defining the organizational core task and the physical environment (e.g. a nuclear power plant) it is possible to conceptualize the social context of the organizational activity more objectively. They have used the concept of *organizational core task* (OCT)[2]. This concept refers to the collective motive of the activity of the organization (Reiman & Oedewald submitted). The OCT is composed of four analytical components: (1) the object of the activity, (2) the objective of the activity, (3) constraints and (4) requirements of the activity. The object of the work (e.g., a power plant, manufacturing plant or offshore platform) and the environment (e.g., deregulated electricity market) set constraints and requirements for the fulfillment of the organizational core task (e.g. generating electricity safely and economically in a particular nuclear reactor at a competitive price). The OCT frames the motive of the activity and the shared constraints and requirements that all the workers have to take into account in all their tasks. (Reiman & Oedewald submitted; Oedewald & Reiman 2003)

OCT is neither an aggregate of all the tasks the organization has to perform nor a single key-task performed by some critical members of the organization. OCT refers to the motive for all activities and this motive should be identical for all organizational levels and tasks. The organizational core task is a theoretical and abstract construct – depicted as a model of constraints and requirements. Organizational culture refers to the organization including its core task as it is currently construed by the personnel, usually more in a narrative (Bruner

[2] For the origins of the core task concept, see Norros and Nuutinen (2002).

1986; Tsoukas & Hatch 2001) - e.g., "our core task is to serve our clients the best we can", "we keep this plant up and running" - than in a propositional form. Organizational culture includes the process of formation and reformation of the conceptions concerning the organizational core task and the means to fulfil it. This process of collective sense-making and (re)interpretation of events is the essence of an organizational culture (Weick 1995). Organizational culture thus also includes the dysfunctional solutions and discrepancies, as well as the attempts to solve or handle them (Oedewald & Reiman 2003 p. 292). Alvesson (2002 p. 164) points out that "the challenge [in cultural research] is to consider the frequently *simultaneous* existence of (a) relative clarity and common orientations associated with a degree of shared meanings across the organization, (b) diversity, conflict and multitude of overlapping group identifications, and (c) ambiguity and fragmentation on different levels". Nevertheless, the central "function" of the organizational culture is to *produce*, *maintain* and *reproduce* shared and accepted *conceptions* (cf. Sandberg 2000 p. 12) of the organizational core task that *work well enough* in the daily tasks and lead to the creation of applicable tools, procedures, and routines (cf. Reiman & Oedewald submitted). Thus, organizational culture is seen as comprising the system, the structure and the structuring in the organization. A more dynamic term describing this could be *organizational culturation.*

Figure 1 illustrates our conceptualization of the social construction of the organizational core task.

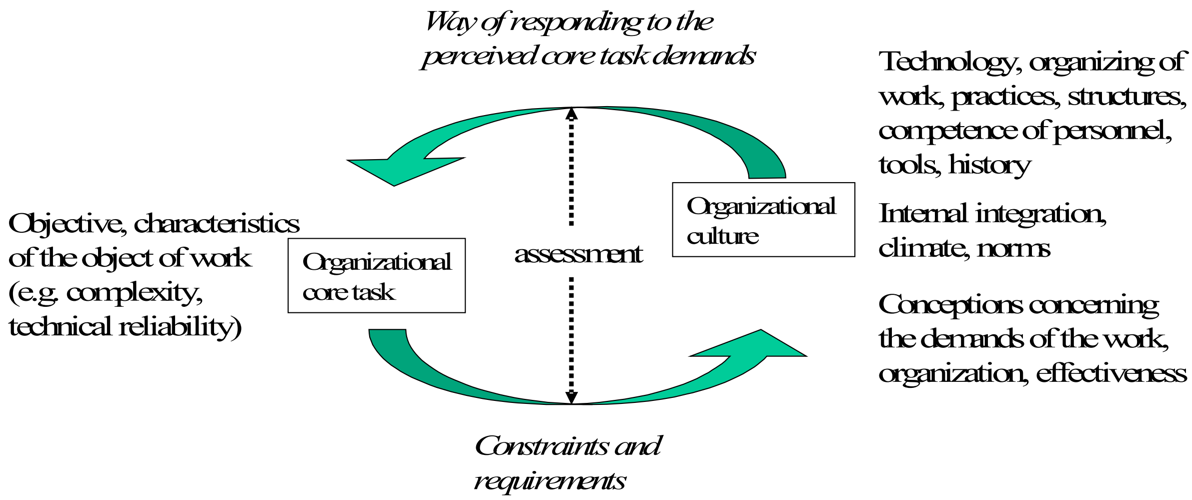


Figure 1. Social construction of the organizational core task. Adapted from Reiman and Oedewald (2002, submitted).

The personnel's conceptions of the core task are historically constructed and rooted in the culture of the organization (Figure. 1). The history of the organization is physically present in the tools, practices and organizational structures. For example, outdated tools can maintain a false image of the present core task (see e.g., Hutchins 1995; Engeström 1999). Thus, changes in the operating environment and the new operational demands caused by the changes do not automatically lead to changes in the personnel's understandings of their core task.

The concept of organizational core task offers a means for assessing the unique cultural features of an organization. The organizational core task sets demands (constraints and requirements) for the activity in the organization. The way of perceiving the criteria shapes the culture of the organization and influences the organization's way of responding to these demands. The organizational practices, values and conceptions can be evaluated against what the organization is trying to accomplish and what demands it has to fulfil in order to survive. The aim of conceptualizing the OCT is not to prescribe the structures (e.g., network organization or matrix organization with particular processes) or practices needed to accomplish the organizational core task. Instead, the aim is to explicate the demands that the organization has to manage in its everyday activities. The demands can be fulfilled organizationally in many different ways. In this sense, the approach is formative rather than normative (see Vicente 1999 p. 110). The organizing of the activity and the activity itself are assessed only on the basis of the requirements that they have to fulfil and the constraints that they have to take into account.

When considering organizational culture, one should take into account that contradictions and different points of view may exist within the organization (Alvesson 2002; Martin 2002). Another premise is that these differences are not a priori "bad". Homogeneity of the culture (widely shared conceptions and assumptions) as such is not always a criterion for good culture. The starting point of all evaluation is the demands of the work, i.e. the core task of the organization. Thus, the demands of the OCT dictate whether certain cultural features (e.g. differences in opinion) are good, bad or insignificant for the effectiveness of the organization (Reiman & Oedewald submitted). For example, in safety critical organizations, different opinions can facilitate discussion and be adaptive in fulfilling the demands of safety and reliability (Reiman et al. 2005).

EXAMPLES OF THE USE OF THE OCT CONCEPT

The organizational core task model offers a way to assess the effectiveness of a particular culture. Existing working practices can be evaluated against the general constraints and requirements. For example, in the maintenance of a nuclear power plant (NPP) one central demand of the core task of the organization was defined as balancing between anticipating the plant condition (and the needed resources) beforehand and reacting efficiently to unforeseen faults in the equipment (Oedewald & Reiman 2003 pp. 286-287). This requires flexible organizing of the work. The need for flexibility was illustrated with examples of coordinating the timetables for jobs that require different areas of expertise and prioritizing the daily tasks in case of a sudden equipment failure. However, the way of organizing activities in an organization studied by Oedewald and Reiman (2003) was highly specialized and distributed according to the technical areas. Due to the specialization the organization provided little help for coordinating the daily activities. Specialization was also highly valued in the culture of the organization. In addition, delays in fault repairs were not monitored at the organizational level, but every foreman had to report the delays in his own area. This resulted in a situation where everyone prioritized tasks that were in their own area of responsibility, even though in theory all technicians should be available to do jobs where most urgently needed.

Nuutinen and Norros (2001; see also Norros & Nuutinen 2002) analyzed how the core task demands are taken into account in sea piloting on archipelago routes. They stated that the core task of piloting has changed gradually (due to e.g. technical changes in the navigation tools), but the actual practices have not. They found that the prevailing way of navigating was "traditional". It was based on an “inside-out view” of the environment even though the current navigation equipment required a “bird's-eye view”. Furthermore, Norros and Nuutinen (2002) stress that effective piloting depends on co-operation. Constructing an ad-hoc piloting team when the pilot boards the ship was defined as one phase of the task. Still, the piloting practice was highly pilot-centred and the captain had only a superficial monitoring role. In the prevailing piloting practice, abundant communication seemed to be interpreted as indicating a lack of competence. (Nuutinen & Norros 2001; Norros & Nuutinen 2002)

Reiman and Norros (2002) utilized core task analysis combined with an assessment of the organizational culture in the Finnish Nuclear Regulatory Authority. They identified three critical demands of the core task of the Authority: achieving and retaining public trust and credibility, maintaining expertise and competence, and using their authority effectively toward the NPPs. The objective of the work was defined as securing safe use of nuclear power in Finland. Instead of critical demands, the authors used the concept of "role" to differentiate between the conflicting requirements of the task of the regulatory authority. According to Reiman and Norros (ibid.), in the authority role the inspectors have to use different indicators and inspections for observations of the status of the plant operation, and practice mediated control through safety regulations and decisions. The public role requires reporting and informing the public openly. It requires successful balancing of fairness and firmness in the relationships with the operating plants, on the one hand, and openness and confidentiality in relationships with the public, on the other hand. The expert role requires dialogue with other experts and self-criticism towards one's own expertise. It also requires acknowledgement of the uncertainty element of all information. (Reiman & Norros 2002)

The main point of the above examples is that by modelling the organizational core task and organizational culture it becomes possible to explain why certain practices and routines are hindering effective activities or can lead to ineffective activities (or accidents) in the future. More importantly, it is also possible to show that certain practices and routines may be either based on a presently inadequate conception of the OCT, or they may in the long run lead to false conceptions. These flawed conceptions and underlying assumptions can lead to creation of artefacts (procedures, practices, rules) that maintain and recreate this imperfect mental representation of the OCT. Thus, organizational procedures and practices are no longer based on an accurate image of the demands of the work. These situations should be avoided.

ORGANIZATIONAL CULTURE, WORK, AND SAFETY

One important requirement of an effective culture in the long term is its ability to reflect on the cultural premises or question its taken-for-granted solutions (cf. IAEA 1991). Especially, definition of company policy and goal setting should involve critical reflection of the organization's role, task and competencies. We consider this from the perspective of the accuracy of the conceptions of the organizational core task prevalent in the given organization. The same kinds of considerations about the ability of the organizations to reflect on their cultural premises and their overall goals have been made in e.g. accident investigations. These investigations have uncovered many organizational (cultural) antecedents of the accidents (Paté-Cornell 1993; Wright 1994; Vaughan 1996; Turner & Pidgeon 1997; Snook 2000).

Snook (2000) analysed the friendly fire incident that took place in Iraq airspace in 1994. Two U.S. Air Force F-15C Eagle fighters accidentally shot down two U.S. Army UH-60 Black Hawk helicopters over the coalition controlled no-fly-zone in Northern Iraq killing twenty six people on board. The F-15s were assigned to sweep the secure zone for enemy aircraft. The fly zone was controlled by U.S. Air Force E-3B Airborne Warning and Control System (AWACS) aircraft, who should have notified the helicopters and the fighters of each other's presence. The AWACS had lost sight of the helicopters shortly after they got airborne and made contact to the AWACS. It was quite common for the AWACS to lose sight of low flying helicopters as they landed or flew behind mountains. The F-15s contacted the AWACS after spotting two helicopters and inquired about friendly craft in the zone. Having forgotten the two helicopters, the AWACS gave negative acknowledgement. The F-15s misidentified the helicopters as enemies and shot them down. The incident can be looked from the point of view of the collision of three subcultures which should have shared the same OCT. Snook writes:

"AWACS, fighter, and helicopter communities were physically and socially isolated from one another. They didn't work together and they didn't play together. Their primary tasks demanded different orientations toward goals, time, and interpersonal relations. … On the one hand, the Air Force operated on a predictable, well-planned, and tightly executed schedule. Detailed mission packages were organized weeks and months in advance. Rigid schedules were published and executed in rolling cycles of linear, preplanned packages. On the other hand, Army aviators reacted to constantly changing local demands. They worked for customers on the ground who rarely knew from one day, or even one moment, to the next, where they needed to be and when." (Snook 2000 pp. 144-150)

These divergent orientations created conflicting priorities and subsequent coordination problems between the communities, and "practical drift" of the practice from the written procedures. Snook concludes his detailed analysis of the incident by proposing that the fundamental question to be considered in an attempt to reduce the chance of future accidents is: "What are the critical design features of a hyper-complex, multilevel, multi-task, organizational system that will increase the likelihood of accomplishing the "total task" consistently?" (Snook 2000 p. 235)

The fact that the demands of the OCT in a complex sociotechnical system are not always obvious to the personnel at every level of the organization or to the outside observer (Oedewald & Reiman 2003; Norros & Nuutinen 2002; Reiman & Oedewald submitted) is a central challenge for the safety and effectiveness of these organizations. Changes in the environment or inside the organization set an additional challenge. Furthermore, the organizational core task is not static. For example, an NPP sets the same technical constraints (e.g., radiation, time lags on feedback) to the activity but the environment might change (e.g., deregulation) and set new demands for organizational efficiency. Another aspect is that the constraints and requirements that stem from the concrete object of the work might also change, for example through the ageing of the technical infrastructure, which generates new phenomena (e.g., corrosion or increase in the frequency of technical faults). Thus, the appropriate means to fulfil the organizational core task also change. In the Snook's example, there were clearly different conceptions of the core task, and it could be argued that also different conceptions existed on what comprises the organization that should have a shared task (army aviators were not considered as belonging to the air force organization).

To conclude, organizational culture is a concept that depicts the systemic and social nature of a corporate life. Culture is the denominator of the various psychological mechanisms (e.g. norm formation, routinization) mediating the work and the organizational life. Thus, its direct impact on the effectiveness or on the safety is difficult to illustrate. This does not mean that culture has no safety or productivity effects. As in the Snook's example, the culture often gradually *drifts* into a wrong direction from the perspective of OCT, which sooner or later manifests itself as misguided actions by the frontline workers or as unfounded management decisions. We have emphasized the need to carefully monitor and manage the social processes where the overall goals, strategies and practices of the organizations are created and subsequently maintained. These processes are the essence of the organizational culture. Organizational culturation also creates and maintains the internal integration among the people that work together. It is clear that problems in the internal integration, e.g. bad climate have negative effects on the organizational outcomes. Still, we argue that the most severe internal problems usually originate from disagreements concerning for example the way of doing one's work, prioritizing tasks, and perceiving the role of one's working group – issues that are related to the core task conception. These conceptions should be assessed against the demands of the particular work.

DISCUSSION

In summary, we propose that subjective conceptions can lead to objective (safety) outcomes by two interrelated mechanisms:

a) Subjective interpretations of e.g. work, risk, or safety can lead to actions that cause accidents, or prevent them from happening. For example, some task is interpreted by the worker as not being very demanding or risky, and thus (s)he does the work less carefully. Prevalent conceptions of the work in the organization influence this perception also. This kind of influence is depicted in e.g. Skjerve and Lauridsen (this volume).
b) Subjective conceptions of the work and the organization can transform into objective facts (cf. Berger & Luckmann 1966) in the organizational culture, thus taken for granted and institutionalized by the community. The "objective facts" manifest themselves in the e.g. work procedures, investment decisions and in the organizational structure. A structure or tools that are originally based on some subjective conception of the demands of the work can maintain an image of the task that is more objective and taken-for-granted than before the institutionalization. This influence has been noted in e.g. various accident investigations, see e.g. Wright (1994).

The main difference between these mechanisms is that the first one has more to do with individual and situational perceptions of the work in a social context. The second refers to taken-for-granted "facts" that become embedded in official routines, tools and organizational structures, where their subjective origin and the associated uncertainties are lost. There is ample evidence of the relation of risk perceptions and attitudes toward safety or risk taking to such objective outcomes as personal injuries (Lee 1998; Mearns et al. 1998; Rundmo 1995, 2000) or safety performance (Zohar 1980; Lee & Harrison 2000). Hutchins (1995) has discussed the role of artifacts in embedding conceptions concerning the work and its demands. Both these mechanisms have an effect on the ability of the organization to correctly perceive the demands of its core task and create the means to fulfil them.

Implications for safety management

By *management* we mean *all the attempts by upper organizational levels to change or maintain the cultural structures and processes of the organization in order to define and achieve the organizational core task*. Adopting this as our standpoint we pick up a couple of themes from the above that have special relevance from the safety management point of view.

The most genuine and far-reaching idea in the safety culture concept is its *preventive* nature (IAEA 1991). With (safety) cultural thinking, you do not wait until the organization is "sick", and then cure it by some form of intervention. Development initiatives can be made without any visible signs of degradation in the safety or effectiveness. The underlying assumption is that it is always possible to enhance the safety, hence the motive for assessing and developing the culture regularly. Minding this, it is even more lamentable that the indicators currently used for safety culture so often come from the number of accidents, and the criteria for good safety culture are the lack of accidents or incidents along a certain time span in the history of the organization. We propose that in high risk industries it is both necessary and possible to analyze the reliability of the organization by assessing the organizational culture.

The focus of safety management as we define it should be on the OCT-related conceptions in the organization. Poor practices and procedures combined with adequate conceptions of the OCT may actually be better than currently functioning procedures and practices combined with deficient or outdated conceptions of the OCT. This can mean a situation where the current practices maintain a false conception of the OCT since they work well enough in the normal daily work, but some critical aspect of the OCT tends to be ignored because it does not manifests itself daily (e.g., bypassing a radiation check at a NPP in a room where there has never been radiation), or its effects are long-term and difficult to perceive (e.g., monitoring the effect of corrosion on equipment), or it becomes relevant only in case of exceptional conditions (e.g., the loss of the external grid at a NPP). Safety management should aim at guaranteeing up-to-date conceptions of the task and the appropriate means to fulfil it.

All organizations change more or less over time and discrepancies between the cultural assumptions and new solutions might arise. Change situations are often to some degree chaotic, unpredictable and are met with resistance in the culture. On the other hand, as stated by Woods and Cook (2002 p. 142), changes in complex systems are "opportunities to learn how the system actually functions". Change can bring implicit norms and working practices previously taken for granted to the surface. For an effective safety management it is also imperative to acknowledge the nature of the organizational culture. In order to maintain internal cohesion, "culture" forms routines, preconceptions and rules of thumb, and hence it inherently resists outside change. Furthermore, inputs from the outside are interpreted within the existing cultural framework of thinking. Organizational culture acts as much as a blindfold as an asset if not reflected upon actively. (Alvesson 2002 p. 119; Kunda 1992; Trice & Beyer 1993) Managers are as much a part of the culture as the workers. Their ability to become aware of and question the cultural assumptions is thus limited. Actually, some characteristics of the culture may better be perceived at "lower" levels of the organization, were e.g., the financial pressures and outside influences do not "distort" the picture as much. Especially in light of the current (perceived) increase in economic pressures it is imperative for managers to better grasp the realities and constraints of work at the shop-floor level. The concepts of OC and OCT can be of help in this.

References

ACSNI (1993) Organising for safety. Health and Safety Commission. Advisory Committee on the Safety of Nuclear Installations (ACSNI). HMSO, London.

Alvesson M (2002) *Understanding organizational culture*. Sage, London.

Alvesson M, Berg PO (1992) *Corporate culture and organizational symbolism*. Walter de Gruyter, Berlin

Baker E (1980) Managing organizational culture. *Management Review* 69: 8-13.

Barley SR, Kunda G (2001) Bringing work back in. *Organization Science* 12: 76-95.

Barling J, Kelloway EK, Iverson RD (2003) Accidental outcomes: Attitudinal consequences of workplace injuries. *Journal of Occupational Health Psychology* 8: 74-85.

Barney J (1986) Organizational culture: Can it be a source of sustained competitive advantage? *Academy of Management Review* 11: 656-665.

Berger PL, Luckmann T (1966) *The social construction of reality: A treatise in the sociology of knowledge***.** Penguin Books, London.

Bruner J (1986) *Actual minds, possible worlds*. Harvard University Press, Cambridge, Massachusetts.

Burr V (2003) *Social constructionism. Second edition***.** Routledge, East Sussex.

Cheyne A, Cox S, Oliver A, Tomás JM (1998) Modelling safety climate in the prediction of levels of safety activity. *Work & Stress* 12: 255-271.

Clarke S (1998) Safety culture on the UK railway network. *Work & Stress* 12: 285–292.

Clarke S (1999) Perceptions of organizational safety: Implications for the development of safety culture*. Journal of Organizational Behavior* 20: 185-198.

Cooper D (1998) *Improving safety culture. A practical guide.* John Wiley & Sons, Chichester.

Cox S, Flin R (1998) Safety culture: Philosopher's stone or man of straw? *Work & Stress* 12: 189–201.

Cox SJ, Cheyne AJT (2000) Assessing safety culture in offshore environments. *Safety Science* 34: 111–129.

Czarniawska-Joerges B (1992) *Exploring complex organizations. A cultural approach.* Sage, Newbury Park, CA.

Deal TE, Kennedy AA (1982) *Corporate cultures*. Addison-Wesley, Reading, MA.

Donald I, Canter D (1994) Employee attitudes and safety in the chemical industry. *Journal of Loss Prevention in the Process Industries* 7: 203-208.

Durkheim E (1982) The rules of sociological method. Free Press, New York. First published in 1895.

Engeström Y (1999) Activity theory and individual and social transformation. Y. Engeström, R. Miettinen, R-L. Punamäki, eds. *Perspectives in Activity Theory*. Cambridge University Press, Cambridge.

Etzioni A (1964) *Modern organizations*. Prentice-Hall, Englewood Cliffs, NJ.

Flin R, Mearns K, O'Connor P, Bryden R (2000) Measuring safety climate: Identifying the common features. *Safety Science* 34: 177–192.

Frost PJ, Moore LF, Louis MR, Lundberg CC, Martin J, eds. (1985) *Reframing organizational culture*. Sage, Newbury Park, CA.

Geertz C (1973) Thick description: Toward an interpretative theory of culture. In Geertz, C. (ed.), *The Interpretation of Cultures*. Basic Books, New York.

Gherardi S, Nicolini D (2002) Learning the trade: A culture of safety in practice. *Organization* 9: 191-223.

Giddens A (1984) The constitution of society: Outline of the theory of structure. University of California Press, Berkeley, CA.

Grote G, Künzler C (2000) Diagnosis of safety culture in safety management audits. *Safety Science* 34: 131–150.

Guldenmund FW (2000) The nature of safety culture: A review of theory and research. *Safety Science* 34: 215–257.

Hawkins P (1997) Organizational culture: Sailing between evangelism and complexity. *Human Relations* 50: 417– 440.

HSE (1997) *Successful health and safety management*. Health and Safety Executive, London, HMSO.

Hutchins E (1995) *Cognition in the wild*. MIT press, Massachusetts.

IAEA, Safety Series No. 75-INSAG-4 (1991) *Safety culture*. International Atomic Energy Agency, Vienna.

IAEA, TECDOC-860 (1996) *ASCOT guidelines. Revised 1996 edition. Guidelines for organizational self-assessment of safety culture and for reviews by the assessment of safety culture in organizations team*. International Atomic Energy Agency, Vienna.

IAEA, Safety Report (1998) *Developing safety culture. Practical suggestions to assist progress*. International Atomic Energy Agency, Vienna.

Isaacs WN (1993) Taking flight: Dialogue, collective thinking, and organizational learning. *Organizational Dynamics*, Winter 1993, 24-39.

Jacobs R, Haber S (1994) Organizational processes and nuclear power plant safety. *Reliability Engineering and Systems Safety* 45: 75–83.

Kirwan B (2001) Coping with accelerating socio-technical systems. *Safety Science* 37: 77-107.

Kunda G (1992) *Engineering culture: Control and commitment in a High-Tech corporation*. Temple University Press, Philadelphia.

Lee T (1998) Assessment of safety culture at a nuclear reprocessing plant. *Work & Stress* 12: 217–237.

Lee T, Harrison K (2000) Assessing safety culture in nuclear power stations. *Safety Science* 34: 61–97.

MacIntyre A (1985) *After virtue. A study in moral theory. Second Edition.* Duckworth, London.

Martin J (2002) *Organizational culture. Mapping the terrain.* Sage, Thousand Oaks.

McDonald N, Corrigan S, Daly C, Cromie S (2000) Safety management systems and safety culture in aircraft maintenance organisations. *Safety Science* 34: 151–176.

Mearns K, Flin R, Gordon R, Fleming M (1998) Measuring safety climate on offshore installations. *Work & Stress* 12: 238–254.

Mearns K, Whitaker SM, Flin R (2003) Safety climate, safety management practice and safety performance in offshore environments. *Safety Science* 41: 641-680.

Meek VL (1988) Organizational culture: Origins and weaknesses. *Organization Studies* 9: 453-473.

Morgan G (1986) *Images of organization.* Sage, Beverly Hill, Ca.

Norros L, Klemola U-M (1999) Methodological considerations in analysing anaesthetists' habits of action in clinical situations. *Ergonomics* 42: 1521-1530.

Norros L, Nuutinen M (2002) The concept of the core-task and the analysis of working practices. N. Borham, R. Samurcay, M. Fischer, eds. *Work Process Knowledge*. Routledge, London.

Nuutinen M, Norros L (2001) *Co-operation on bridge in piloting situations. Analysis of 13 accidents on Finnish fairways*. Paper presented at CSAPC'01 8th Conference on Cognitive Science Approaches to Process Control. 24-26 September 2001, Neubiberg, Germany.

Oedewald P, Reiman T (2003) Core task modelling in cultural assessment – A case study in nuclear power plant maintenance. *Cognition, Technology & Work* 5: 283 – 293.

Ostrom L, Wilhelmsen C, Kaplan B (1993) Assessing safety culture. *Nuclear Safety* 2. April-June.

Parsons T (1951) *The social system.* Routledge & Kegan Paul, London.

Paté-Cornell ME (1993) Learning from the Piper Alpha accident: A post mortem analysis of technical and organizational factors. *Risk Analysis* 13: 215-232.

Perrow C (1984) *Normal accidents: Living with high-risk technologies.* Basic Books, New York.

Perrow C (1986) *Complex organizations. 3rd edition.* Random House, New York.

Peters TJ, Waterman RH (1982) *In search of excellence: Lessons from America's best-run companies.* Harper & Row, New York.

Pidgeon N (1997) The limits to safety? Culture, politics, learning and man-made disasters. *Journal of Contingencies and Crisis Management* 5: 1-14.

Pidgeon N (1998a) Safety culture: Key theoretical issues. *Work & Stress* 12: 202–216.

Pidgeon N (1998b) Risk assessment, risk values and the social science programme: why we do need risk perception research. *Reliability Engineering and System Safety* 59: 5-15.

Radcliffe-Brown AR (1958) *Method in social anthropology.* University of Chicago Press, Chicago.

Reason J (1990) *Human error.* Cambridge University Press, Cambridge.

Reason J (1998) Achieving a safety culture: Theory and practice. *Work & Stress* 12: 293-306.

Reason J, Hobbs A (2003) *Managing maintenance error. A practical guide.* Ashgate, Hampshire.

Reiman T, Norros L (2002) Regulatory culture: Balancing the different demands of regulatory practice in the nuclear industry. In Kirwan, B., Hale, A.R. & Hopkins, A. (eds.), *Changing regulation – Controlling risks in society*. Pergamon, Oxford.

Reiman T, Oedewald P (2002) Contextual Assessment of Organisational Culture – methodological development in two case studies. In: Kyrki-Rajamäki, R. & Puska, E-K. (eds.), *FINNUS. The Finnish Research Programme on Nuclear Power Plant Safety, 1999-2002. Final Report.* VTT Research Notes 2164. Helsinki: Yliopistopaino.

Reiman T, Oedewald P (submitted) Assessment of complex sociotechnical systems – Theoretical issues concerning the use of organizational culture and organizational core task concepts.

Reiman T, Oedewald P, Rollenhagen C (2005) Characteristics of organizational culture at the maintenance units of two Nordic nuclear power plants. *Reliability Engineering and System Safety* 89: 333-347.

Rochlin G I (1999) Safe operation as a social construct. *Ergonomics* 42: 1549-1560.

Rundmo T (1995) Perceived risk, safety status, and job stress among injured and noninjured employees on offshore petroleum installations. *Journal of Safety Research* 26: 87-97.

Rundmo T (2000) Safety climate, attitudes and risk perception in Norsk Hydro. *Safety Science*, 34: 47-59.

Sandberg J (2000) Understanding human competence at work: An interpretative approach. *Academy of Management Journal* 43, 9-25.

Schein EH (1985) *Organizational culture and leadership*. San Francisco: Jossey-Bass.

Schultz M (1995) *On studying organizational cultures. Diagnosis and understanding***.** Berlin: Walter de Gruyter.

Schultz M, Hatch MJ (1996) Living with multiple paradigms: The case of paradigm interplay in organizational culture studies. *Academy of Management Review*, 21: 529-557.

Smircich L (1983) Concepts of culture and organizational analysis. *Administrative Science Quarterly* 28, 339-358.

Snook SA (2000) Friendly fire. The accidental shootdown of U.S. Black Hawks over Northern Iraq. Princeton University Press, New Jersey.

Sorensen JN (2002) Safety Culture: A Survey of the State-of-the-Art. *Reliability Engineering and System Safety* 76, 189-204.

Trice HM, Beyer JM (1993) *The cultures of work organizations*. Englewood Cliffs, NJ: Prentice Hall.

Tsoukas H, Hatch MJ (2001) Complex thinking, complex practice: The case for a narrative approach to organizational complexity. *Human Relations* 54: 979-1014.

Turner BA (1971) *Exploring the industrial subculture.* Macmillan, London.

Turner B (1978) *Man-made disasters*. Wykenham, London.

Turner BA, Pidgeon NF (1997) *Man-made disasters. Second edition*. Butterworth-Heinemann, Oxford.

Vaughan D (1996) *The challenger launch decision*. University of Chicago Press, Chicago.

Vicente K (1999) *Cognitive work analysis. Toward safe, productive, and healthy computer-based work*. Lawrence Erlbaum, London.

Weeks J (2004) *Unpopular culture. The ritual of complaint in a British bank.* University of Chicago Press, Chicago.

Weick KE (1988) Enacted sensemaking in crisis situations. *Journal of Management Studies* 25: 305-317.

Weick KE (1995) *Sensemaking in Organizations*. Sage, Thousand Oaks, CA.

Williamson OE (1975) *Markets and hierarchies: Analyses and anti-trust implications.* Free Press, New York.

Williamson AM, Feyer A-M, Cairns D, Biancotti D (1997) The development of a measure of safety climate: The role of safety perceptions and attitudes. *Safety Science* 25: 15-27.

Willmott H (1993) Strength is ignorance; slavery is freedom: Managing culture in modern organizations. *Journal of Management Studies* 30: 515-552.

Woods DD, Cook RI (2002) Nine steps to move forward from error. *Cognition, Technology & Work* 4: 137-144.

Wright C (1994) A fallible safety system: Institutionalised irrationality in the offshore oil and gas industry. *The Sociological Review* 38: 79-103.

Zohar D (1980) Safety climate in industrial organizations: Theoretical and applied implications. *Journal of Applied Psychology* 65: 96–102.

Chapter 10: Norwegian Petroleum Operations and Regulatory Activities from a System Safety Perspective

Ilkka Salo
Department of Psychology
Lund University
Box 212, 221 00, Lund, Sweden
Ilkka.Salo@psychology.lu.se

ABSTRACT

This chapter treats the former Norwegian Petroleum Directorate NPD in 2003, at that time an organization not yet settled after a period of organizational change. We attempt to model Safety management in NPD according to important themes from the general system theoretic framework presented in this volume. The analysis was based on publicly available documents about NPD. The results include several themes with implications for safety management related to important aspects of the system theoretic framework described by Svenson in a preceding chapter, such as the system structure, safety threats, and information management and feedback.[1] A brief background to the Norwegian petroleum activities from both a historical and a societal perspective is also presented.
Keywords: oil industry, regulator, off-shore oil industry.

INTRODUCTION

Offshore petroleum activity is risky business, and safety is challenged in many ways and at different levels. On a global level, drying oil wells threatens the welfare of societies, with decreasing energy supplies, which in turn threatens the economies. Petroleum activities can also threaten the environment, for example by emissions to the air and seas with both short term and long term consequences for the ecology at different levels. Petroleum production also poses risks for the individual involved in offshore activities. Somebody has to take responsibility of these threats and manage the safety in a way that the threats do not become realities. On a national societal level authorities regulate the safety of companies. The regulatory authority for petroleum activities on the Norwegian continental shelf is the Norwegian Petroleum Directorate-NPD.

There are many possible approaches to safety, both theoretical and practical. Safety culture is one important factor sometimes used as an indicator of safe operations in organizations. In a selective review, Svenson and Salo (2004) disseminated various themes of organizational culture and safety culture. Although the concept safety culture is defined differently in different contexts, it includes some important attributes that are common in many contexts such as shared ideas, values, and behavior (Salo and Svenson, 2002; Jacobs and Haber, 1994). Safety culture may be partly described by how safety is managed in the organization. Svenson and Salo (2004) argued that the efficacy with respect to safety of the prevailing management

[1] An early version of this chapter was previously published as an independent chapter in a SKI report (Svenson, Salo and Allwin, 2005).

policy could be traced back from the consequences of specific activities, to the management of those activities. In a top-down perspective, the effects of an adopted safety policy can be followed through several stages, for example: objectives, planning, orders, implementations, benchmarking, feedback etc. Thus, the study of safety management may be applied both to specific areas and to more general levels (Svenson and Salo, 2003).

Safety management in offshore activities is studied from various perspectives. According to Gordon (1998) highly complex socio-technical systems are dependent on the interaction of technical, human, social, organizational, managerial and environmental factors, which together contribute to catastrophic events. Safety performance, in these terms, is often illustrated in accident analyses such as the Piper Alpha disaster. There are increasing demands to use not only technological factors in the calculations of safety in offshore structures, but also organizational and human factors. People are involved in all life stages of a structure. Robert G. Bea (1998) discusses concepts and engineering approaches to improve reliability of offshore structures including people. He argues that real time safety management, and developments of a Safety Management Assessment System (SMAS) are important issues for safety improvement. One example of a SMAS that has been tested in field was developed to assess mainly marine systems including offshore platforms (Hee, Pickrell, Bea, Roberts, and Williamson, 1999). The assessment process is computerized and models the system on several levels. First, a system is identified by components comprising a given system called *modules* (e.g., operating teams, organizations, procedures, etc.). Each module includes several factors (*for the organization module* e.g., process auditing, safety culture, risk perception, communications etc.), and each factor can be described by several attributes (*for the communications factor* e.g., same language, established forms, feedback, etc.).

The management of safety is related to the organization's safety performance. Mearns, Whitaker, and Flin (2003) studied safety climate, safety management practices, and safety performance in offshore environments. They found associations between safety climate and official accident statistics, and accident reporting frequency. The results showed that proficiency in some safety management practices was associated with lower accident rates and fewer respondents reporting accidents.
In addition, individual leadership and managerial styles have been identified to affect safety management. Results from one study on site managers safety leadership in the offshore and gas industry (O'Dea & Flin, 2001) has shown that although managers are aware of what is the best practices in managing safety, their actions does not necessarily follow their awareness. It seems as if less experience and more directive leadership styles are more associated with overestimation of the own ability to influence the own workforce. The authors suggest improvements in several areas, for example, standardization of safety culture, and harmonization of practices across industries, workforce competency, and involvement in safety activities and decision-making.

Today there seems to exist two general approaches to safety, one technological and one organizational. There are several reasons for making efforts to close the gap between organizational and technological safety. We believe that high reliability organizations will benefit more in the long run from integrated knowledge structures than from separate knowledge structures. One possible key to integration is systems theory.

According to Miller (1978), the highest system level is the suprasystem. Here, the boundaries of the suprasystem are defined by the scope of the study that this chapter is based on: "petroleum activities on the Norwegian continental shelf".

The suprasystem is kept in steady state by subsystems that can be both non-living (e.g., technical systems) and living (e.g., persons, organizations). Except structures, a system consists of processes, information (driven by energy) that can be observed by changes in the structure. Both structures and processes are needed for the explanation of each other. The steady state is described by all including variables within a prescribed range. During normal circumstances, when variables are drifting away from the prescribed steady state, the system counteracts with negative feedback to operate the system back to steady state. Adjustments rely on various information feedback within and between the suprasystem, subsystems, and the environment surrounding the suprasystem (Svenson and Salo, 2003). This gives a general systems framework towards which organizational structures can be modeled.

This purpose of the study underlying this chapter aim to describe safety management in the Norwegian Petroleum Directorate according to specific themes related to the system theoretical framework previously described. These themes are (1) structure of the organization, (2) regulations in relation to safety management, (3) threats to safety, and (4) information management and feedback. Further, we wish that this contribution will expand the perspectives on safety management in general, and point at opportunities for improving safety also in other technological areas. The study was conducted during 2003, a time during which NPD recently had been involved in a process of organizational change and the organizational structures were not fully settled at the time of the investigation. Accordingly, the results in this study reflects a snapshot of a former NPD organization existing during the time this investigation was carried out, not the present NPD organization.

METHOD

Document analysis. The study was based mainly on a selection of publicly available documents from NPD and MPE. The documents were selected to cover a number of important themes of "safety management from a systems perspective" outlined in prior work by Svenson and Salo (e.g.2004, 2005), in a way that allowed the NPD organization to be interpreted and modeled according to those themes. The themes are: (1) structure of the organization, (2) regulations in relation to safety management, (3) threats to safety, and (4) information management and feedback. The analysis was based, mainly, on public documents covering the following areas: (a) NPD´s organization, (b) Service declarations, (c) Collaboration projects, (d) Rules and regulations, mainly the framework regulations and the management regulations, (e) NPD's Annual report 2002, and (f) Facts about Norwegian petroleum activities 2003 from the Oil and Energy Department. Documents *a-c*, are information from NPD available as html documents on the NPD website. Documents *d*, are the collection of NPD regulations for petroleum activities. Documents *e* and *f*, are annual reports from NPD and MPE. Many documents were only available in electronic form from the NPD website following a “paperfree” policy.

ANALYSIS OF NPD DOCUMENTS AND RESULTS

This section starts with a brief background to the Norwegian petroleum activities that we hope will facilitate the identification of NPD as an organization and its relations to other organizational structures. First, a historical review illustrates how a venturesome idea about Norwegian oil production during a few decades grew to a “third in the world” position. Following this, the Norwegian states' organization and participation in petroleum activities will be described. Finally, important objectives and duties of NPD will be presented. In the sections following the background section, documents are analyzed according to the themes of safety management related to the system theoretical framework described in preceding chapters: (1) The structure of NPD´s organization, followed by (2) a discussion about regulations related to safety management, (3) Identified threats, and (4) Information management. Each of the three themes ends with a concluding summary.

Background

A brief history of the Norwegian petroleum activities. The following Norwegian oil history is based mainly on "Fact Sheet 2002 Norwegian Petroleum Activity", published by The Ministry of Petroleum and Energy-MPE (Olje- og energidepartementet, 2002). Today, petroleum operations play a substantial role in Norway's economy, and contribute considerable revenues to the state. Today, Norway ranks as the world's third largest exporter of crude oil after Saudi Arabia and Russia. However, it was not many decades ago people did not think that Norwegian petroleum activities could be a lucrative enterprise. It was not until the discovery of gas at Groningen Netherlands in 1959 geologists started to ponder over petroleum potential beneath the North Sea.

In 1962, the Phillips Petroleum Oil Company was first out to apply for permission to conduct geological surveys. On the 31 May 1963, Norway proclaimed sovereignty over petroleum activities on the NCS (Norwegian Continental Shelf). In a new statute it was determined that the state owns any natural resources on the NCS, and that the Crown alone is authorized to award licenses for exploration and production.
In the same year, companies were granted reconnaissance licenses to perform seismic surveys, but not to drill. In agreements in 1965 by Norway UK, and with Denmark, the North Sea was divided in accordance with the median line. The first offshore licensing round was announced in 1965. The first well was drilled off Norway in the summer of 1966 but it proved to be dry. Since the early 1970s the essential goals for Norwegian oil and gas policies have been National management and control, building a Norwegian oil community and state participation. The Storting (parliament), the government, the ministry, and a new state agency, the Norwegian Petroleum Directorate (NPD), would administer the petroleum operations. The Norwegian Petroleum directorate NPD (Olje Direktoratet) was resolved by the Norwegian parliament in 1972.

Foreign multinational companies initially dominated the off Norway exploration and the development of Norway's first oil and gas fields. A state-owned oil company *Statoil* was created, with initially 50 per cent state participation in each production license. The percentage and forms of state participation have been reorganized a number of times over the years.

The first development off Norway ceased its production in May 1993 (North-East Frigg gas field), and in January 2002 totally 12 fields had been shut (MPE, 2002). Today, the oil production has exceeded the volume of new discoveries for a long time. The same situation is also true for the gas production. A report to the parliament on oil and gas activities outlined two future scenarios, one of short-term decline and one of long-term. The difference between the scenarios was approximated to more than NOK 2 000 billion up to 2050 based on the current oil price (2003:6). A future challenging enterprise for Norwegian petroleum operations.

The Norwegian state organization of petroleum activities. The framework for petroleum operations in Norway is determined by the Norwegian parliament. The parliament approves major development projects or issues of principle. Authority to approve development projects with an estimated cost of less than NOK 10 bn is delegated to the King in Council. The *Ministry of Petroleum and Energy* – MPE (Olje- og energidepartementet) has the overall administrative responsibility for petroleum operations on the NCS. MPE has the responsibility to ensure that operations follow the parliament guidelines.

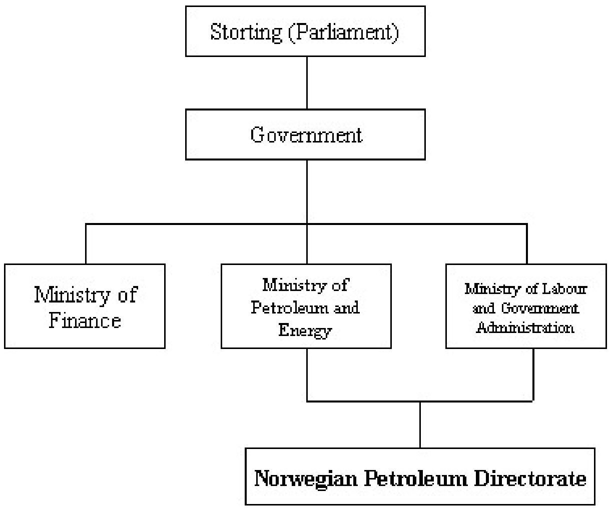


Figure 1: The state organization of petroleum operations (MPE, 2002, p 15).

The MPE is organized in four departments, with each department organized in sections (in parentheses below). The departments cover: *E&P and market* (oil, gas, exploration), *petroleum* (environmental affairs, industry, state participation, economics, petroleum law and legal affairs), *energy and water resources*, and *administration, budgets and accounting* respectively. E&P and market and petroleum departments are responsible for petroleum operations (see figure 1 above).

The overall responsibility for the working environment in the petroleum sector, and for emergency response and safety aspects of the industry, rests within the *Ministry of Labor and Government Administration*. NPD is administratively subordinate to the MPE, but reports to the Ministry of Labour and Government Administration on issues relating to the working environment, safety and emergency response (MPE, 2002, p 16). NPD is located in Stavanger with a regional office in Harstad. The employment figures at the end of 2002 were 346 people, and additional 17 employees were on leave. The percentage of women/men was 44/56. Fifteen employees were hired in permanent positions. Of these, six came from oil-related activities. Thirteen permanent employees have left their positions, four of these as retirees. The percentage female managers were 30% (MPE, 2002).

Norwegian state participation. The Norwegian petroleum resources belong to the Norwegian community and should be managed for best possible benefit both in the present and in the future. It is an important objective that a large part of the profit returns to the state. An instrument for this policy is the *state's direct financial interest* (SDFI), which was created in 1985 when Statoil's license interests on the NCS were split into two financial components, one for the state and one for the company. In state participation after 1993 (after the 14th round) the SDFI receives a holding in each production license that reflects the profitability at the time the license was created. In some licenses, the SDFI holding is 0 %. In 2001, the parliament decided to restructure the participation in the petroleum sector, an enterprise directed towards partial privatization of Statoil. Statoil was in 2001 introduced to international the stock market with 18.2% of the company (MPE, 2002).

Besides Statoil AS there are two other companies created for the SDFI. Petoro AS, who manages the SDFI on behalf of the state, and is the company who owns the SDFI portfolio, and Gassco AS which is a company responsible for transportation of natural gas from the NCS and is wholly state owned. Gassco was created at the time Statoil became partly privatized.

Objectives and duties of the NPD

The Norwegian Petroleum Directorate shall contribute to creating the highest possible values for society from oil and gas activities founded on a sound management of resources, safety and the environment (NPD, 2003:1).

NPD answers mainly to three ministries regarding different matters: (a) resource management and administrative matters (the Ministry of Petroleum and Energy), (b) matters relating to safety and working environment (the Ministry of Labor and Government Administration). (c) NPD also exercises authority on behalf of the Ministry of Finance within the area of CO_2 tax (NPD, 2003:1).

NPD has three primary functions: (a) “to exercise administrative and financial control to ensure that exploration for and production of petroleum are carried out in accordance with legislation, regulations, decisions, licensing terms and so forth”, (b) “to ensure that exploration for and production of petroleum are pursued at all times in accordance with the guidelines laid down by the MPE”, and (c) “ to advise the MPE on issues relating to exploration for and production of submarine natural resources” (MPE, 2002, p 16).

The NPD identifies several important tasks for their activities. It is regarded as important to have "the best possible knowledge" concerning discovered and undiscovered petroleum resources on the Norwegian continental shelf. NPD carries out *supervision* (ie., concept used by NPD for their authoritative activities, e.g., inspection etc) both in order to ensure that the "licensees manage the resources in an efficient and prudent manner", and also by regulatory means, to establish, maintain and further develop a responsible safety level and working environment. It is also regarded as important to influence the industry to develop solutions that are serving the "interests of society as a whole". “NPD provides advice to supervisory ministries and has been delegated the authority to issue regulations and make decisions regarding consents, orders, deviations and approvals pursuant to the regulations (NPD, 2003:1). Environmental issues are considered important, and NPD strives to make Norway leading in this issue. Another important function is to provide the industry, public, and media with non-biased information about petroleum activities (NPD, 2003:1).

The structure of the NPD organization

From January 1, 2001 a prior hierarchical organizational was replaced with a flat organization (see figure 2). The renewal was partly inspired by the Norwegian governments program for renewing, reorganizing and enhancing the efficiency of Norway's public administration (NPD, 2003:2). The characteristics of the new flat organization are shown in Table 2.

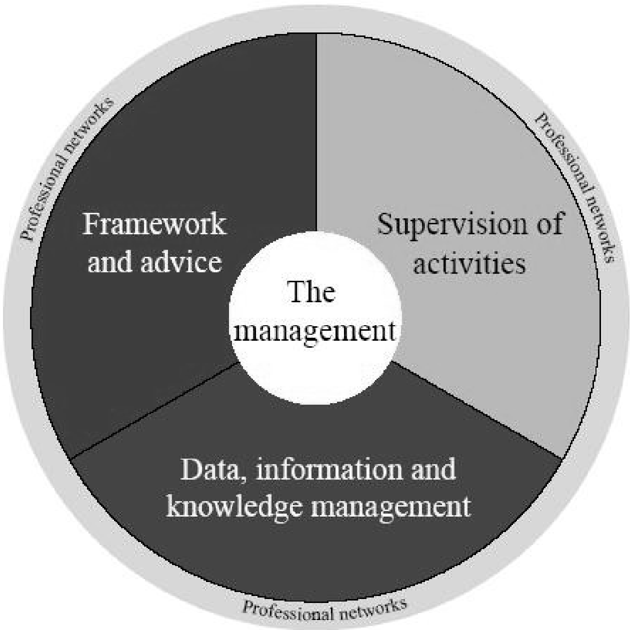


Figure 2: NPD organizational chart (NPD, 2003:2)

Table 2: Themes characterizing the NPD organization (NPD, 2003:2).

The organization
- is flat and based on flexible, multidisciplinary and collaborating teams organized around priority products
- is focused on developing the expertise of NPD staff
- places responsibility for product, quality and process with the teams
- focuses systematically on optimizing and enhancing the efficiency of internal processes
- has few senior managers, who focus primarily on unified strategies, processes and planning
- will be further developed with the aim to base the organization and production of services on the needs of the user
- gives a central place to developing a common culture and values.

The new flat organization is constituted of three "product areas". The product areas are:
(1) *Framework and advice*, "which will develop and propose overall terms for the petroleum sector in cooperation with the authorities, the industry and the unions". They provide decision advice to the Ministries of Petroleum and Energy and Labor and Government Administration.

(2) *Supervision of activities* is responsible for that actors observe and understand the framework conditions for petroleum operations on the Norwegian Continental Shelf (NCS).
(3) *Data, information and knowledge management* takes a national responsibility to provide petroleum sector data to the NPD partners and to the public. They also develop, integrate, and distribute knowledge from the petroleum industry (NPD, 2003:2).

National and international cooperation. NPD has cooperates with several organizations both nationally and internationally. The (national) co-operation is organized in a number of collaboration projects (samarbeidsfora) focusing various areas relevant for the NPD. Table 3 shows collaboration projects that NPD takes part in (2003:4). In addition, NPD is active in international cooperation co-operation with several countries (Angola, Bangladesh, CCOP, Mozambique, Namibia, Nicaragua, Russia, South Africa, Timor-Leste, Vietnam).

Table 3: NPD collaboration projects (according to NPD, 2003:4).

Safety forum (Sikkerhetsforum)	Is the central co-operational arena between parts of the industry and authorities regarding HMS. The safety forum is directed by NPD who also hold the secretarial post. The safety forum includes representatives from: -Norwegian Petroleum Directorate (NPD) (chair and secretariat) -Ministry of Labour and Government Administration (AAD) (observer) -Norwegian Oil and Petrochemical Workers' Union (NOPEF) -Federation of Oil Workers' Trade Union (OFS) -Norwegian Confederation of Trade Unions (LO) -Lederne -LO Industri -Cooperating Organizations (DSO) -The Norwegian Oil Industry Association (OLF) -Norwegian Shipowners' Association -Federation of Norwegian Engineering Industries (TBL)
Co-operation for safety (Samarbeid for Sikkerhet, SfS)	The project was established 2001/2002. The participants from both the employers and employees organizations has a common goal to improve safety related to human actions onboard vessels and installations, and to put the focus on all affecting circumstances. NPD are represented as observers. Among the participant organizations are: Lederne, LO, Norwegian Shipowners' Association, NOPEF, OLF, TBL, and DSO.
CDRS	Is a common database established in September 1999. The database contains drilling information from all wells drilled on the Norwegian Continental Shelf since 1984.
DISKOS	The DISKOS data repository is a data management system that has been designed to store corporate and national data. Thus, data from the Norwegian continental shelf are found in the national petroleum data store in Stavanger.
FORCE	Has the objective to provide structured opportunities for the participants to discuss, with each other and with research and technology providers.
FUN	Is a forum for oil companies and authorities in Norway that focuses on matters related to forecasting and uncertainty evaluation of future oil and gas production. The forum, which was established in May 1997, has 18 member companies including representatives from: BP, Mobil, Norsk Hydro, Saga, Shell, Statoil, and the NPD.
NIGOGA	Is an electronic document containing guidelines for the performance and reporting of organic geochemical analyses of well samples (rocks and fluids) as applied in the Norwegian petroleum industry. Thirty-two laboratories from Europe, USA, and Australia participated in this project.

Service declarations. This section describes the NPD service declarations (serviceerklæringar), which gives a description of what to expect in the interaction between NPD and the licensee. From that perspective, it is illustrative for systems interactions. From a more narrow perspective, service declarations are one part of the information management system. We have chosen to present this section under the heading of NPD's organization, but it could also be part of the information management section presented below. Service declarations are central means for improving the service and the user orientation of the state administration (NPD, 2003:3a). The main purpose of the declarations is to provide the users information about the services provided by NPD. They are based on NPDs opinion about their own tasks and the needs and demands of the users. Important parts of the service declarations are summarized under the six headlines below. The first headline (*Supervision of safety and work environment in petroleum operations*) is central to safety management and will receive extra attention.

Supervision of safety (tryggleik) and work environment in petroleum operations is based on the regulations of health, environment and safety (HES) in the petroleum activities act (the framework regulations) with four regulations**:** the Management Regulations, the Information Duty Regulations, the Facilities Regulations, and the Activities Regulations. NPD together with the Norwegian Pollution Control Authority (SFT) and the Norwegian Board of Health (NBH) issued the acts on 3 September 2001. 60000 hours of supervision (tillsyn) is made per years by the NPD (NPD, 2003:3b).

In revisions and verifications, one group is identified as responsible for the activity that is going to be investigated. (a) Three weeks before the supervision takes place, the activity that is going to be supervised receives a written notice about the activities that will be included in the check-up, and are also asked about documents that will be included in the. (b) The activity of supervision starts with an orientation about the goals and the content. (c) This is normally followed by interviews with representatives for the supervised activity. In addition, verifications of documents and equipment, or gathering of additional information is carried out. (d) The activity supervised is requested to have an observer available during the entire supervision. The results will be announced during a meeting where details of observations will be given and anything still unclear will be solved. (e) Three to five weeks after this, a report will be published. (f) The supervised activity will receive a report together with a reminder about duties and possible sanctions. There is time to complain about the sanctions. (g) When agreement is received, a written announcement that the activity of supervision is finally closed will be sent out.

When the supervisory activity is directed towards incidents, jeopardizing safety and working environment, a very short notice is given. The procedure that follows resembles the one for verifications (above). In cases of police investigations, the NPD will assist with technological or other expertise. This parallel activity should not influence the regular supervision activity.

The operators shall receive consent from the NPD before: (1) Investigations including drilling to a depth of 200m bsl is carried out. (2) Exploration drilling. (3) Manned underwater operations. (4) An installation or parts of it are taken into operation. (5) Rebuilding or modifying installations. (6) Plans to continue operation of an installation exceeding its "lifetime" or other things that are anticipated. (7) Availability of an installation, possible removal of an installation not enclosed by the petroleum law. (8) Removing of or changing the use of a vessel that has a significant safety related function related to the petroleum activities.

The normal handling time is nine weeks. In cases of when the licensee will carry out activities that does not correspond to specified regulations, the licensee must apply for dispense (NPD, 2003:3b). The service declarations on *working hours and settlements about working hours* gives advice on when and how the operators shall manage stay and off-duty periods. This includes, for example, time limits for when NPD shall be contacted about extended work times (NPD, 2003:3c).

The fact pages and announcements about production figures on NPDs homepage. NPD makes efforts in making information available to the users. One important instrument for this activity is the NPD homepage. The homepage will include fact pages with updated information about production licenses (for example, first time registrations), *wells* (for example, bore programs, daily reporting from well activities, other communications between operator/licensee), and *production figures* from NCS (based on monthly reporting from the operating companies. The fact pages make it possible to download data files that can be used in datasheets and other programs for further calculations (NPD, 2003:3d).

(4) *Inquiries about* (public-) *openness*. NPD gives advice about openness to public documents and points to the laws and regulations concerning, for example, *the principle of public access to official records* (offentlighetsprinsippet), and the *the laws that regulate public access to official records* (offentleghetsloven). A public journal is available on the homepage for at least one week, and older journals can be required from the NPD main archive. Inquiries about (public-) insight shall be handled in one to three days and in extra ordinary cases not more than eight days (NPD, 2003:3e).

(5) *The petroleum register* is a register of all production and pipeline licenses. This service declaration gives advice, for example on documents that should be included in transferences, pledges, change of company names etc (NPD, 2003:3f).

(6) The service declaration for the *Library service* gives advice on library resources and how various documents can be acquired externally. The library includes 16 000 books, reports, conference documents, and 300 journals covering various areas relevant for petroleum activities, such as: petroleum geology, geophysics, production of oil and gas, laws, safety, etc. About 50% of the documents are available in English (NPD, 2003:3g).

Summing up the NPD organization from a systems perspective. There are several possible levels of suprasystems according to which petroleum activities can be modeled. Possible suprasystems might be, for example: petroleum activities in the North Sea including other regulators than NPD, European petroleum activities, on-shore activities excluded and relevant regulators, etc. This study aims at describing NPD in relation to petroleum activities on the NCS. The boundaries for the suprasystem are, accordingly, petroleum activities on the NCS. We argue that both the NPD and the Ministry of Petroleum and Energy perspectives are needed to model NPD as one sub system of the suprasystem.

First, the arguments are based on an interpretation that NPD emphasizes a systems perspective when describing the own organization’s interactions with licensees, collaborative projects, and the public (subsystems/structure) and the information exchange needed in the interaction (process). The licensees are easily illustrated as companies acting on the NSC, and constitute one and each an individual subsystem. The collaborative projects were illustrated by an identification of both national and international cooperation projects labeled "fora", and the tasks identifying the interaction with the fora. This is, however, not completely straightforward for a systems analysis. The identified cooperation projects (fora) are not as stable over time as the structures of the collaborating parties (e.g., employees organizations, companies, departments, etc.) included in the projects. From one perspective a forum can be modeled as a process that the parties engage in, from another perspective a forum is a structure, however temporarily manifested, that may have substructures resembling "real" subsystems.

Second, the arguments are based on an interpretation that MPE also emphasizes a system approach to its activities and interactions, and in addition, models enclose NPD in the activities (NPD is organizationally sub ordered MPE). The basic functions of NPD is to exercise authority (regulate) legislated in higher-level organizations (MPE and higher) in one direction, and answer back to the ministries, among them MPE (advice and feedback). It is only in this context that the NPD become identifiable and interpretable from a systems perspective. The regulatory activities are based on the petroleum regulations. However, we have decided to discuss regulations in the context of safety management (below).

Figure 3 models the suprasystem "petroleum activities on the NCS" according to Leveson's (1995) and Miller's (1978) system definitions. It includes two basic subsystems: NPD and the companies. In addition, the subsystem "state and crown" is located above the NPD. The dotted ellipse indicates temporary structures such as cooperative projects. Arrows indicate system input and output, subsystem interaction, and interaction between the suprasystem and the environment.

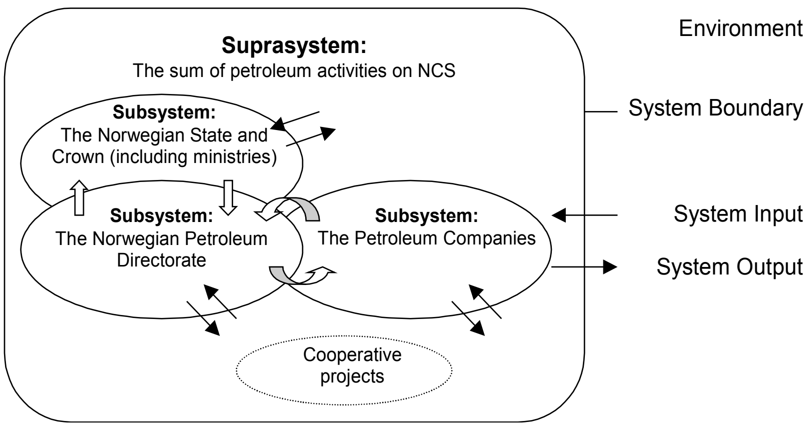


Figure 3: System model of petroleum activities on the NCS according to Leveson's (1995) and Miller's (1978) definitions. Interaction and system input/output are illustrated with arrows.

Petroleum regulations

The following section is based on an English translation of the petroleum regulations (yet available on the NPD site). However, NPD emphasizes that any disputes shall be decided based on the Norwegian text (NPD, 2003:5).

Norwegian petroleum activities are basically regulated through five regulations (in force Jan 1, 2001). The regulations are: (a) Regulations relating to Health, Environment and Safety in the Petroleum Activities (the Framework Regulations), (b) Regulations relating to Management in the Petroleum Activities (the Management Regulations), (c) Regulations relating to Material and Information in the Petroleum Activities (the Information Duty Regulations), (d) Regulations relating to the Design and Outfitting of Facilities etc. in the Petroleum Activities (the Facilities Regulations), and (e) Regulations relating to Conduct of Activities in the Petroleum Activities (the Activities Regulations) (2003:5a).

In addition to the five regulations there are corresponding guidelines, which are not legally binding. They should be considered jointly in context to obtain the best possible understanding of what the authorities wish to achieve through the regulations (2003:5a).

The Norwegian Pollution Control Authority, the Norwegian Social and Health Directorate and the NPD co-operate on joint, total regulations relating to health, environment and safety (HSE) on the NCS (NPD, 2003:5).

What are the regulations telling about safety management? A closer examination of the regulations gives us a hint about how management of safety is regulated in the petroleum regulations. Two of the five regulations are considered as more relevant in this context: (1) the framework regulations (2003:5b), which "provides a framework for coherent and prudent petroleum activities", and (2), the management regulations (2003:5c), which "assembles all overarching requirements as to management in the health, environment and safety sphere" (NPD, 2003:5a). We have selected and focused on 6 themes (1-6, below). The themes are summarizing interpretations derived from the regulations, not explicitly expressed. Reference to chapters and sections in the framework- and the management-regulations respectively, are given in brackets below.

The framework regulations

1. Everybody shall contribute to safety management.

It can be interpreted that safety management according to the framework regulations implies that everybody working at the licensee, contractors or subcontractors shall comply with stated requirements. The employees shall be given opportunity to contribute to working environment and safety, and in the establishment, follow up, and further development of management systems (Ch. II: 5, 6, 13; Ch. IV: 13).

2. The organization and culture is important for safety management and everybody should contribute to its maintenance and development (2003:5b).

It can be interpreted that safety management according to the framework regulations implies that the principles related to risk reduction shall take into account not only technical and operational solutions but also organizational, and that assessments shall be made in all phases of petroleum activities. The operator is responsible for that the own organization complies to the regulations and that NPD can make decisions of changes in the operators organization. The responsible part shall promote the development of a sound health, environment, and safety culture in all aspects of the petroleum activities, and encourage everybody to take part in such activities (Ch. III: 9, 10, 11).

The management regulations
3. Safety barriers are important to safety management.
Safety management implies the establishment of safety barriers. If more than one barrier is needed there must be a sufficient degree of independence between barriers (Ch. I: 1).
4. Important elements of safety management
Steering, decisions, and feedback are important elements of safety management. Safety management is dependent on clear and unambiguous definitions and possibility to assess results according to objectives. The establishment of safety indicators is necessary for safety monitoring. Decision-making shall be well defined in relation to objectives including decision criteria and coordination of decisions (Ch. II: 3, 4, 7, 8).

5. Competence is important for safety management. Safety management requires an assurance that staffing and the competence of personnel correspond to the demands of the activities (Ch. III: 11).
6. Safety management is partly a process of safety improvement that is dependent on feedback
Improvement of safety is part of the safety management, and measuring and follow-up can be viewed as important means for feedback in this process. Individuals shall be encouraged to take part in the process (Ch. V: 22).

Summing up: Regulations and safety management. The NPD framework- and management regulations express several relevant themes for safety management. In this respect, the regulations emphasize not only technological of safety management, but also organizational and individual factors. We get the impression that safety management is a concern for every one involved in petroleum activities, not only managers. Individuals should be encouraged to active participation in the process of safety development, maintenance, and improvement. It seems as if promotion to individual participation in the safety process is one important part of the NPD safety strategies. It was noted that the regulations reflected several themes of positive safety management.

Threats identified by NPD

Offshore petroleum activities involve risks from various perspectives, among them personal, technological, and environmental. (fire, pollution of the air and the seas, diving, vessels, helicopters , weather, wind and climate, etc.) A public NPD document that explicitly identifies internal or external threats to the own organization was not found in the documents analyzed. Instead, documents clearly describe projects directed towards various safety improvements among companies on the NCS. The other way around, if there are documents in which NPD actively focuses on planned or recently started safety projects, the safety problems related to the projects are, if not urgent, so at least important. One such document is

the NPD annual report 2002 (2003:6). The concerns about a future scenario including declining production rate and exploration are highlighted in the annual report. “Incidents which the regulations require to be reported immediately to the NPD remained at roughly the same level in 2002 as the year before” (2003:6). Some incidents had not changed in proportion since the preceding year such as falling objects, which continued to represent the largest single category, and will not be in focus here. Instead, we will analyze a selection of safety-related threats with a more urgent character, and how they are managed by NPD. In the annual report, NPD highlights the needs to take care of a number of identified safety threats. Two lethal accidents shadowed the passed HSE year which otherwise showed no strong changes in any direction.
“One of the fatal accidents falling under the NPD’s regulatory authority occurred on the mobile unit Byford Dolphin on 17 April, where the victim was hit by a falling object. The other took place on Gyda on 1 November, when a man was crushed between two containers during a lifting operation. The immediate causes of these accidents have been clarified, but the NPD felt it was important to identify the deeper reasons and has done much work on these. Its findings have been conveyed to the players concerned” (2003:6).

Almost every threat presented is an internal threat identified in companies. No internal threats originating from NPD's own organization or external threats directed towards NPD were presented in the documents. Table 4 shows a selection of safety threats identified among companies and following actions to manage the threats.

Table 4: Safety threats among companies identified by NPD and actions to manage the threats cited from NPS’s annual report 2002 (NPD, 2003:6).

Identified safety threats	**Descriptions**	**Actions**
Use of overtime	-Experience shows that illegal overtime working can only be combated when all sides collaborate and are actively opposed to such breaches -Attention strengthened by the Byford Dolphin accident	From the beginning of the year NPD increased the resources for inspecting working hours, partly in response to a number of union requests.
Spurious injury statistics	The number of personal injury cases declined significantly from earlier years in 20021. However, the figures may not be directly comparable. This is because checks on personal injury reporting reveal that some companies have changed the criteria governing which injuries are reported	NPD believes that these criteria fail to accord with the regulations. Various follow-up measures are considered.
Gas leaks	The number of gas leaks exceeding 0.1 kilogram per second increased in 2002 from the year before.	Greater attention will accordingly be paid to this problem by the NPD in 2003, in part through more independent investigations of major leaks.
Accidents and near misses related to crane and lifting operations	Special attention was paid to the safety of crane and lifting operations. A number of serious accidents and near misses in this area indicate a need for improvement.	This was confirmed by the checks carried out and will be followed up.
Culture	Unfortunately, both supervision and accident investigations have revealed that the HSE culture is not always what it should be. The need	The NPD is currently pursuing a three-year program aimed at defining a good HSE culture and analyzing the factors that influence it. The new regulations

	for change appears to be existing at every level, from boardroom to shop floor.	address an expectation that the industry will now achieve a cultural boost to counter the negative trend of recent years. Challenging established attitudes and developing a new and more integrated understanding of reality are the aims.

Summing up threats identified by the NPD. NPD identifies several threats to safety and measures to counteract the threats. The threats are discussed against a background of recent incidents, among them the tragic accidents at Byford Dolphin and Gyda, which give additional impetus to immediate countermeasures. The threats in companies are of various kinds and include both organizational and cultural aspects. From a systems perspective both the regulator and the regulated are parts of a safety system in which both parts contributes to safety. Accordingly, it would be appropriate to consider possible threats to the own organization, in this context, threats that can jeopardize the safety system that include both the regulator and the regulated companies. For example, one situation that ought to be considered as an external threat directed towards the Norwegian Petroleum Directorate, is the indications of declining petroleum production over the coming years indicated in the annual report. Norwegian petroleum incomes are linked to the directorate's own budget, and decreasing gains will probably affect the conditions for the regulatory work. This would be relevant in relation to the identified scenarios, partly directed towards decreasing incomes and the consequences of reduced GNP, resulting from different resource management which are described in the text.

Information management

The ability of the organizational system to maintain a steady state is partly dependent on the management of information. Participants' apperception about the speed and accessibility of information, the direction of information flow, and arrangements to discriminate between more and less relevant information are all part of keeping the system on an even keel. The management of information is one of several missions in the creation of a positive safety management. NPD's information management is treated, for example, both in the framework regulations and in the management regulations. A brief summary of important implications of the regulations for information management is found at the end of this section.

Information on the NPD website. The rules and regulations are available on the NPD internet pages only, according to a "paperless principle" (papirløst forhold). The NPD website is a good example of efforts making most public documentation on Norwegian petroleum activities freely available! The website is found at: http://www.npd.no. The homepage (index) is focused around the latest news, and clearly structured headlines direct the reader to hyperlinks covering various aspects of NPD activities. As far as we can see, the NPD site is an example of good web design delivering information both to the public and to actors on the Norwegian petroleum arena. The information is available in appropriate formats. Except the usual html format, the various NPD publications are available downloadable in PDF format. NPD is also responsible for the production and publication of the bibliographic database OIL covering petroleum literature of Nordic origin. All of the references in Oljeindeks/Oil Index from 1974 until today are to be found in the literature reference database OIL which covers approx. 60.000 references, some also including links to the full text documents. OIL is accessible from the NPD site (NPD, 2003:7).

One convenient solution that makes communication easier is the accessibility to important forms used in communication between NPD and the companies. Today, just some of the forms used for reporting to the NPD are published on the site. The plan is to extend this list (NPD, 2003:8). The forms include: (1) Pre-qualification of new companies on the Norwegian continental shelf. (2) Reporting of manned underwater operation. (3) Quarterly reporting of hours worked on installations. (4) Reporting of damage on load bearing structures. (5) Confirmation of alert/report about situation of hazard and accident. (6) Prognosis and results for exploration wells. (7) Registration of wells.

Information management is integrated in the organizational structure. Another important aspect of safety management is to what degree the information system is integrated in the organization. As presented in previous chapters, information management is integrated as one of three product areas in the NPD organizational structure. The product area of *Data, information and knowledge management* takes a national responsibility to provide petroleum sector data to the NPD partners and to the public. They also develop, integrate, and distribute knowledge from the petroleum industry (NPD, 2003:2). In the creation of an organizational model for NPD's activities in which information management include one third of the area it could assume that NPD considers information management to be a very serious matter.

Summing up: Information management. NPD has invested great efforts in becoming a state of the art information manager. We have identified several examples of good information management in NPD. From the perspective of regulations, both framework- and management regulations identifies important aspects of information management. Such aspects relates to: (a) the use of Norwegian as a common language of communication in the petroleum activities, (b) the availability to all safety related documentation of how petroleum activities are carried out, and (c) the identification and use of necessary information to carry out safe operations in petroleum activities, and the establishment of information and communication systems. NPD has a high degree of public accessibility to documentation of various kinds at their website. The NPD has taken several steps towards a "paper free" solution of information management and many documents are today only available in a electronic format at the NPD website. Finally, NPD has integrated information management as one of three product areas in their new organizational model. In doing this, NPD emphasizes the importance and seriousness of information as part of the organizational system. From our point of view system structures for information feedback are existing and emphasized in the NPD organization.

DISCUSSION

The study has presented a number of themes of safety management in the Norwegian Petroleum Directorate. A systems perspective was applied to the themes in appropriate cases. The themes related to the organization in which the structure of the NPD organization was disseminated and modeled from a system perspective. The framework and management regulations were analyzed for content related to safety management. Urgent threats and their remedial actions explicitly expressed by NPD were reviewed. Finally, the NPD information management was focused both from a safety management and from a systems perspective.

The Norwegian Petroleum Directorate: regulation and safety

The NPD's safety strategies become expressed in many of the documents that were analyzed. For example in the regulations, many of them explicitly express a direction toward health, environment, and safety. Information about safety management regarding the own organization and activities are not discussed in the documents that were analyzed in this study. Examples of this will be discussed below.

The structure of NPD

The boundaries of the suprasystem analyzed, are "the sums of petroleum activities on NCS". First, the Norwegian State petroleum activities (including NPD) presented in documents from MPE, did include both structures, and processes representative for a systems approach. Second, the information in the selected NPD documents was too superficial for any deeper analyses of NPD substructures. However, the documents gave more information about system processes in interactions between NPD and other subsystems. We can conclude that both MPE and NPD emphasizes an approach to their activities that allow a systems application on the analyses, but the available NPD documents was not useful for structural analysis of the NPD subsystem. In particular, there was a lack of information about how the teams are organized, how the interaction works within or between substructures, and how boundaries for management are organized at different levels within NPD. One question raised was concerning how collaborative groups consisting of members from different subsystems shall be treated in a systems model. Are they structures (however more temporal in character) or processes? The service declarations together with the regulations tell us what can be expected in an interaction with NPD. Accordingly, these documents are illustrative for systems processes.

Threats to safety

There are numerous threats to safety in offshore petroleum operations. We have focused a number of threats that NPD have prepared actions against. Among the various types of threats, we want to note that some are identified as organizational and cultural in their characters. As with the regulations discussed above, NPD did not express any threats inherent in or directed towards the own organization. Only internal threats in licensees were identified.

Information management and feedback

The Norwegian petroleum activities are geographically separated off-shore and on-shore and there is a need for good information systems. NPD shows many aspects of good information management. We have focused on three aspects, namely, that the need for good information management is expressed in the regulations, accessibility to much information on the NPD website, including important forms for communication between licensees and NPD, and finally, the fact that information management is identifiable as one third of the new NPD organization. The last fact shows that NPD wants to show how seriously they consider the importance of information management. Accordingly, there do exist information feedback systems. In addition, the NPD regulations on that matter emphasize management of information in several ways. One fact that relates to information management in general and to safety management in particular is that NPD emphasizes that organizations and individuals shall be encouraged to participate in safety activities. This is a positive sign for safety management in the way that it may create trust between licensees and NPD. In the long run it may create organizations with safety ideals internalized to a greater extent in the organization.

Acknowledgements

This study that was made possible through support from the Swedish Nuclear Power Inspectorate (SKI) and the Nordic Nuclear Safety Research (NKS). We thank all people who have contributed to this report. Thanks to the Nordic Group, and especially to Ann Britt Skjerve who took part of the review of this report.

REFERENCES

Bea RG (1998) Human and organizational factors: engineering operating safety into offshore structures. *Reliability Engineering and Systems Safety* 61:109-126,

Gordon RP (1998) The contribution of human factors to accidents in the offshore oil industry. *Reliability Engineering and System Safety* 61:95-108.

Jacobs R and Haber S (1994) Organizational processes and nuclear power plant safety. *Reliability Engineering and System Safety* 45:75-83.

Leveson NG (1995) *Safeware system safety and computers*. Addison-Wesley Publishing Company, Massachusetts.

Mearns K, Whitaker SM, Flin R (2003) Safety climate, safety management practice and safety performance in offshore environments. *Safety Science* 41: 641-680.

Miller JG (1978) *Living systems*, McGraw-Hill, New York.

MPE-Ministry of Petroleum and Energy (2002) *Fakta 2003*: *Norsk petroloumvirksomhet*. Olje- og energidepartementet, ISSN-1502-3133.

NPD (2003) Norwegian Petroleum Directorate. *Frontpage*, Available: http://www.npd.no/Norsk/Frontpage.htm, Accessed October20 2003.

NPD (2003:1) Norwegian Petroleum Directorate. *Objective and duties*, Available: http://www.npd.no/English/Om+OD/ODs+organisasjon/Mål+og+oppgaver.htm, Accessed October 20 2003.

NPD (2003:2) Norwegian Petroleum Directorate. *NPD´s organization*, Available:

http://www.npd.no/English/Om+OD/ODs+organisasjon/Organisasjon+med+powerpoint-kart/ods_organisasjon.htm, Accessed October 20 2003.

NPD (2003:3a) Norwegian Petroleum Directorate, *Service declarations*, Available: http://www.npd.no/Norsk/Om+OD/ODs+organisasjon/ODs+serviceerklaeringer/serviceerkl.+coverpage.htm, Accessed November 10 2003.

NPD (2003:3b) Norwegian Petroleum Directorate. *Service declarations*: *Supervision of safety (tryggleik) and work environment in petroleum operations*. Available: http://www.npd.no/Norsk/Om+OD/ODs+organisasjon/ODs+serviceerklaeringer/Service erklaering-tilsyn.htm, Accessed November 10 2003.

NPD (2003:3c) Norwegian Petroleum Directorate. *Service declarations: working hours and settlements about working hours*. Available: http://www.npd.no/Norsk/Om+OD/ODs+organisasjon/ODs+serviceerklaeringer/Serviceerklaring-opphold.htm, Accessed November 10 2003.

NPD (2003:3d) Norwegian Petroleum Directorate. *Service declarations*: *The fact pages and announcements about production figures on NPDs homepage*. Available: http://www.npd.no/Norsk/Om+OD/ODs+organisasjon/ODs+serviceerklaeringer/serviceerklaring-faktainfo.htm, Accessed November 10 2003.

NPD (2003:3e) Norwegian Petroleum Directorate. *Service declarations*: *Inquiries about* (public-) *insight*. Available: http://www.npd.no/Norsk/Om+OD/ODs+organisasjon/ODs+serviceerklaeringer/Serviceerklaring-innsyn.htm, Accessed November 10 2003.

NPD (2003:3f) Norwegian Petroleum Directorate. *Service declarations*: *The petroleum register*. Available: http://www.npd.no/Norsk/Om+OD/ODs+organisasjon/ODs+serviceerklaeringer/Serviceerklaring-petroleumsregister.htm, Accessed November 10 2003.

NPD (2003:3g)Norwegian Petroleum Directorate. *Service declarations*: *Library service*. Available: http://www.npd.no/Norsk/Om+OD/ODs+organisasjon/ODs+serviceerklaeringer/Serviceerkaring-bibliotektjeneste.htm, Accessed November 10, 2003.

NPD (2003:5) Norwegian Petroleum Directorate. *Collaboration projects*. Available: http://www.npd.no/Norsk/Om+OD/Samarbeidsfora/, Accessed November 10 2003.

NPD (2003:5) Norwegian Petroleum Directorate. *Rules and regulations*. Available: http://npd.no/regelverk/r2002/frame_e.htm, Accessed November 10 2003.

NPD (2003:5a) Norwegian Petroleum Directorate. *Rules and regulations*: Foreword HSE (HMS). Available: http://npd.no/regelverk/r2002/Forord_HMS_e.htm, Accessed November 10 2003.

NPD (2003:5b) Norwegian Petroleum Directorate. *Rules and regulations*: *The framework regulations*. Available: http://www.npd.no/regelverk/r2002/Rammeforskriften_e.htm, Accessed November 10 2003.

NPD (2003:5c) Norwegian Petroleum Directorate. *Rules and regulations*: *The management regulations*. Available: http://www.npd.no/regelverk/r2002/Styringsforskriften_e.htm Accessed November 10 2003.

NPD (2003:6) Norwegian Petroleum Directorate. *NPD's Annual report 2002*. Available in pdf format from: http://www.npd.no/English/Frontpage.htm, Accessed November 10 2003.

NPD (2003:7) Norwegian Petroleum Directorate. *The reference database OIL*. Available: http://www.npd.no/English/Produkter+og+tjenester/Referansedatabasen+OIL/The+Reference+database+OIL.htm, Accessed November 10 2003.

NPD (2003:8) Norwegian Petroleum Directorate. *Forms*. Available: http://www.npd.no/English/Produkter+og+tjenester/Skjemaer/Confirmation_+situation_hazard_accident+.htm, Accessed November 10 2003.

O'Dea A and Flin R (2001) Site managers and safety leadership in the offshore oil and gas industry. *Safety Science* 37:39-57.

Salo I and Svenson O (2004) *Organizational culture and safety culture*: *A selective review of the studies in the field*, SKI Report, Swedish Nuclear Power Inspectorate, Stockholm.

Svenson O, Salo I, Allwin P (2005) *On safety management*: *A frame of reference for studies of safety management with examples from non-nuclear contexts of relevance for nuclear safety*. SKI Report, Swedish Nuclear Power Inspectorate, Stockholm.

Svenson O and Salo I (2004) *Safety management*: *an introduction to a frame of reference exemplified with case studies from non-nuclear contexts*, manuscript submitted to SKI, 2004.

Chapter 11: Factors Affecting Employees' Willingness to Use Mindful Safety Practices at Norwegian Petroleum Installations

Ann Britt Skjerve[1] and Øyvind Lauridsen[2]

Institute for Energy Technology,
P.O. Box 173, N-1751, Halden, Norway.
[2] Petroleum Safety Authority Norway,
P.O. Box 599, N-4003 Stavanger, Norway.
E-mail: ann.britt.skjerve@hrp.no

ABSTRACT

Employees at Norwegian petroleum installations may contribute to safety in at least three different ways: 1) by serving as elements in safety barriers, 2) by using mindful safety practices, and 3) by improvising. The purpose of the present study was to *explore* what type of contextual factors that may affect employees' *willingness* to use *mindful safety practices*, i.e. *discrete* general safety promoting work practices that may prevent the initiation of and/or interrupt unwanted *but not explicitly predefined* event sequences. The results obtained may contribute to the knowledge base for development of safety management practices at the installations. The study was based on a sub-set of the data collected in a large-scale questionnaire survey performed by the Norwegian Petroleum Inspectorate in the year of 2001. The number of participants in the data subset was 2829. The outcome of the study suggests that initiatives to increase employees' willingness to use mindful safety practices will be most efficient if directed at the local work environment, i.e. the workgroup and the context in which the workgroup performs its tasks, rather than at the individual employee or at employees at the installations in general. It further suggests that the transfer of employees to new local work environments, and the introduction of changes in their present local work environment might both affect their willingness to use mindful safety practices.

Keywords: employee safety practices, risk-situations, petroleum installations.

INTRODUCTION

During the past decades studies of socio-technical systems' reliability have gone through several evolutions. From the 1950s to around the 1980s, studies primarily focused on the reliability of technical components, and were based on quantitative research approaches (Rognin et al., 2000). Human contributions were considered from the perspective of risk. Humans were perceived to be error prone, and it was generally seen as desirable to minimize and control human performance to

1

2

the extent possible using automation and operating procedures, respectively. To some degree, however, it was recognized that humans' ability to subjectively judge the situation at hand and to decide on adequate responses in real time was sometimes essential for ensuring system safety. During the 1980s, *cognitive ergonomics* provided a new framework for studies directed at human reliability. The new framework implied that human errors were accounted for with reference to their underlying cognitive processes, and it emphasized how combinations of events could influence human cognition (ibid.). Cognitive ergonomics focused on the characteristics of the larger organizational context rather than on human errors as such, which spurred research interest in how organizational factors could facilitate humans' contribution to system reliability. During the 1990s, studies directed at *high reliability organizations* (e.g., LaPorte & Consolini 1991) took a distinctly positive approach to humans as contributors to system safety. They examined how employees in complex high-risk organizations could reduce the likelihood of unwarranted events by organizing their work in particular ways.

The present study takes as its starting point that employees at Norwegian petroleum installations may contribute to system safety in at least three ways (Skjerve et al. 2003; Skjerve et al. 2004):

Employees may serve as elements in *safety barriers*. Safety barriers are key instruments for the achievement of fault tolerance at petroleum installations. They constitute means to prevent a set of *predefined unwarranted events* from occurring and/or means to reduce the consequences of such events (Petroleum Safety Authority Norway, Management Regulations §1, 2001). The unwarranted events that barriers are applied to protect against include e.g. hydrocarbon releases, fires and explosions, helicopter crashes and ship collisions into the platforms. The role of employees as elements in safety barriers is typically guided by dedicated operating procedures, which specify what the employees should monitor for and how they should respond in different situations. This implies that the cognitive activity of the employees tend to be *rule-based*: Employees' activity will be carried out with reference to *external or internalized rules*, it will be *goal-directed* and *structured by feed-forward* (Rasmussen 1986).

Employees may also contribute to system safety by protecting against dangers that have *not* been explicitly predefined as unwarranted events, by using *mindful safety practices* (MSPs) (Skjerve et al. 2003).[3] The term MSPs can be defined as discrete general safety promoting work practices that may prevent the initiation of and/or interrupt unwanted but *not explicitly predefined event sequences.* Mindful safety practices are based on the recognition that *employees' work processes* are associated with generic risks. It is for example foreseeable that an employee at some point in time can come to work in a way that endangers him/her self and/or others, but difficult to foresee exactly how and when this will happen. To protect against this type of risk, a mindful safety practice stating "you should stop a colleague if the colleague's activity may endanger himself/herself or others" can be developed and enforced. A subset of the MSPs that are applied at Norwegian petroleum installations is outlined below:

- If you observe a person in danger, you should warn the person.

[3] The concept *mindful safety practice* was previously referred to as *safety mechanism* (see Skjerve et al., 2003).

– An employee may be allocated the role as watchman (“Hawk's eye”), i.e. to warn his or her colleagues about any potential dangers that may come to inflict their task performance process.
– When faced with safety-critical or potentially safety-critical situations you should “Take Two” (minutes) to think through the situation *before* acting.
– If you realize that your performance may have safety-critical consequences for you or your colleagues, you should stop.

The above type of safety practices is characterised as *mindful* because they serve to increase the employees’ awareness of possible – but not explicitly defined - danger sources. They encourage an employee to review situations from different perspectives (e.g. by making the employee aware that colleagues may not have noted all dangerous aspects in a situation), and to be open to the possible relevance of new information and/or to the need for reinterpretation of old information (e.g., to review the current danger level in a situation). These elements are all attributes of the concept *mindfulness* as suggested by Langer (1989, 61-81). When using MSPs, the activity of the employees *tend* to be *less procedurally guided* than when they serve as elements in safety barriers. In general, a mindful safety practice will *not* specify the exact danger(s) that the employees should guard against, nor what action(s) the employees should take to reduce the danger level (see examples page 152). Using MSPs, the employees have to rely more on their *subjective, real-time evaluation* of the danger associated with the *situation at hand*, and the cognitive activity involved will thus contain large *knowledge-based* components (Rasmussen 1986). MSPs may constitute a formal part of the safety management system, in the sense that using a mindful safety practice, such as e.g., a “Hawk's eye” (see page 153), may formally constitute an element in a safety barrier. However, using a “Hawk's eye” can also be an informal work procedure (see also Aase et al. 2005).

Finally, employees may contribute to system safety by use of *improvisation.* Improvisation can be defined as the activity of fabricating out of what is conveniently on hand (Merriam Webster’s Collegiate Dictionary 1993), and will primarily involve knowledge-based reasoning. Improvisation may be required when dangers occur that deviate radically from what has been anticipated in the safety systems.[4]

The three ways in which employees may contribution to system safety are summarized in Figure 1 on next page.

[4] This corresponds to what is sometimes referred to as ‘beyond design basis’ occurrences.

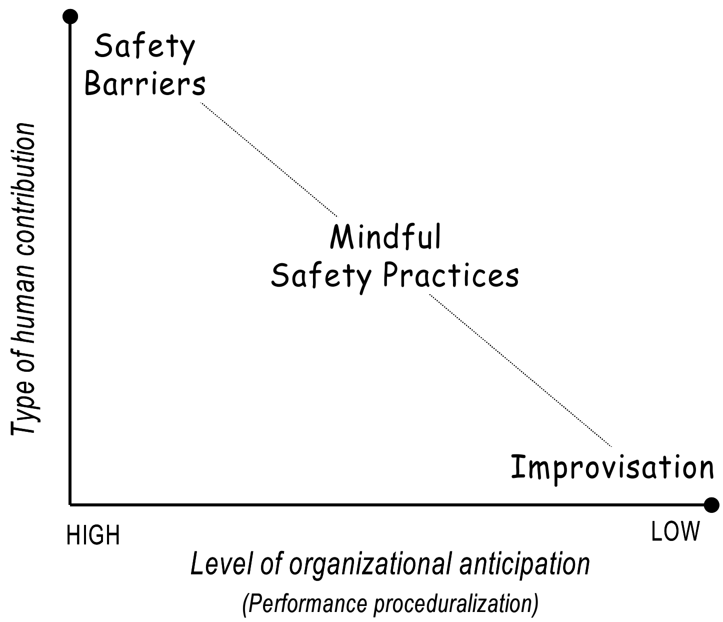


Figure 1. Three ways in which employees may contribute to system safety. The contribution types are depicted with reference to their associated level of organizational anticipation - and thus their level of performance proceduralization.

Humans' contribution to system safety by the application of MSPs seems to have received limited attention in safety studies, even though, e.g. Perrow (1984) convincingly has argued that unforeseen events inevitably will occur from time to time in complex and tightly coupled production systems. Still, studies directed at *high-reliability organizations* (e.g, LaPorte & Consolini 1991), as mentioned above, constitute an exception. This group of studies generally examines what type of work organizations high-reliability organizations, such as nuclear power plants, apply to ensure that critical decisions will be timely and correct (e.g., Bierly & Spender 1995; Rochlin et al. 1998; Sagan 1993; Weick & Sutcliffe 2001). These strategies are referred to as *decision/management redundancy* (Rochlin et al. 1998) or *organizational redundancy* (Rosness et al. 2000). A typical example of a mindful safety practice that has been frequently addressed in the literature is the *four-eye principle* as applied within the domain of aviation. This principle implies that pilot and co-pilot monitor the adequacy of each other's activity and are ready to intervene if they judge it to be necessary (e.g., Hawkins 1987). *Crew resource management training*, which is directed at enhancing the *interpersonal aspects* of operations to reduce the risk of human errors and to mitigate their consequences (Helmreich et al. 1999), may also to some extent be said to focus on the use of MSPs.

Efficient use of MSPs, i.e. use of MSPs in situations were danger is present - and not (excessively) in situations where no danger is present - in ways that lead to risk-reduction, requires that employees are able to correctly distinguish danger situations and adequately warn against these. To fulfil this requirement the employees must be provided with an adequate level of *education and training*. Still, at least two additional factors will moreover influence whether the MSPs will be used efficiently: the employees' *possibilities* for applying MSPs and the employees' *willingness* to apply MSPs. Employees' possibility for applying MSPs will depend on, e.g. the physical layout of the installation (how easy it is for the employees to monitor each other's activity) and on the operational procedures applied (e.g. how much time the employees have available to monitor each other's activity). The employees' willingness to apply MSPs, i.e. the extent to which they actually *will* apply these practices when they have the skills and the opportunity, may depend on a variety of attitudinal and motivational factors, which may be impacted by the characteristics of the employee, the characteristics of the local work environment, and of the overall organization.

RESEARCH QUESTION

The purpose of the present study is to explore what type of contextual factors that may affect employees' *willingness* to apply mindful safety practice at Norwegian petroleum installations. The results may contribute to the knowledge-base for development of safety management practices at the installations.

The study is based on the assumption that the use of MSPs is beneficial to system safety. It is assumed that a higher number of unwarranted events will be prevented if employees intervene in situations where they *judge* that the safety level of the installation and/or of an individual employee is endangered, than if employees do not intervene in these situations. This assumption is not tested in the study.

METHOD

The study is based on data obtained in a questionnaire survey performed by the Norwegian Petroleum Directorate[5] in year 2001 as part of a large-scale study to assess the risk-level at the Norwegian Shelf (Husebø et al. 2002). The population was defined as all staff working on petroleum installations on the Norwegian Shelf. The questionnaire contained five major parts: Part 1 addressed demographic data. Part 2 requested the respondents to evaluate 49 items related to work place safety, and contained four items that directly concerned the use of MSPs. These items were formulated very generally to ensure that they would be equally relevant to employees from all work groups. Three of these items referred to the respondent's use of MSPs:

- Item A: I stop working if I find that continuing could imply a danger to myself or to others.
- Item B: I ask my colleagues to stop working, if I find that they perform their activities in a manner that threatens safety.
- Item C: If I observe dangerous situations, I report on these.

The fourth item referred to the respondent's evaluation of his or her colleagues' application of a particular MSPs:

- Item D: My colleagues will stop me if I work in a risky manner.

[5] Since 2001, the *Norwegian Petroleum Directorate* has since been split in two organizations. The *Petroleum Safety Authority Norway* constitutes the part of the former Norwegian Petroleum Directorate that conducted the questionnaire survey.

For all items in part 2 of the questionnaire, a standard five-point response scale with the following anchoring points was applied: Fully agree, partly agree, neither agree or disagree, partly disagree, and disagree? To reduce the risk that the respondents should develop a particular response strategy, 22 of the 49 items were negatively formulated, i.e. addressing non-desirable safety states. Part 3 of the questionnaire requested the respondents to evaluate the risk for six major accidents. Part 4 contained 31 items that addressed the work environment and the recreational facilities offshore, and finally part 5 contained 17 items that addressed the respondents' state of health (ibid., 25).

The questionnaire was distributed to 64 petroleum installations. Nurses at the installations distributed the questionnaire to all personnel that arrived at the installations in the period 10-21 December 2001. This corresponded to approximately 1/3 of the population. In all 3309 of the 6700 distributed questionnaires were returned. The Norwegian Petroleum Directorate assessed that this corresponded to a response frequency on around 50-55%. This can be seen as satisfactory in a survey with such a large population (Husebø et al. 2002). It should be stressed that the questionnaire was *not* designed with the current research question in mind. Neither the selection of items nor the quite general item formulations were optimal for the present purpose. However, the questionnaire still offered a unique opportunity for exploring the extent to which the issues it covered affected employees' willingness to use MSPs due to its comprehensiveness and wide distribution.

The present study was based on 2928 of the 3309 questionnaires returned (Husebø et al. 2002). The selection implied that only data from respondents, who had specified what work area they belonged to, i.e. *process*, *drilling*, *well service*, *catering*, *construction/modification* or *maintenance*, were included. This selection criterion was applied to obtain as much control as possible with the organizational contexts of the respondents. The attributes of the questionnaire implied that employees' willingness to use MSPs was *indirectly* assessed. The employees' self-reported use of mindful safety practices was interpreted to reflect their actual use of these. Prior to the exploratory analyses, the responses on all negatively formulated items were inverted, so that higher scores always implied the (assumedly) most safety-contributing alternative. In addition, an item analysis was performed on the scores obtained in part 2 of the questionnaire. Table 1 contains the descriptive statistics for items A-D.

Table 1. Extract of the item analysis: Descriptive statistics for the four items on mindful safety practices.

Item	**N**	**Means**	**Min**	**Max**	**Std.dev.**
A: I stop working if I find that continuing could imply a danger to myself or to others.	2898	4,67	1	5	0,76
B: I ask my colleagues to stop working, if I find that they perform their activities in a manner that threatens safety.	2898	4,42	1	5	0,80
C: If I observe dangerous situations, I report on these.	2908	4,62	1	5	0,63
D: My colleagues will stop me if I work in a risky manner.	2901	4,07	1	5	0,93

The item analysis showed that the dataset held a high level of homogeneity (Skjerve 2005). For this reason, it was expected that the correlation coefficients obtained in the analyses would be *low*, and that the demonstrated strength of the relationships between variables thus might not be representative (Hinkle et al. 1988). Based on this finding, it was decided that the present study should focus on *patterns of results*, i.e. on the results obtained with reference to groups of items, rather than on the results obtained with reference to individual items.

RESULTS

Characteristics of the Respondents

The respondents had the following characteristics: 2670 of the 2928 respondents were males, 247 were females (11 did not provide information about their sex). In terms of age distribution, around 67% of the respondents were between 31 and 50 years old, the younger group contained around 14%, and the older group around 19%. Around 52% of the respondents had worked offshore between 11 and more than 20 years, around 39% between 2 and 10 years, and around 9% between 0 and 1 year. Most respondents came from the work areas maintenance, drilling, and process, i.e. 904, 762 and 523, respectively, and least from the work areas well service, construction/modification, and catering, i.e. 205, 215 and 319, respectively. The respondents' characteristics do not seem to deviate markedly from the characteristics of the population on petroleum installations in general.

The Relationship between Employees' Use of Different Mindful Safety Practices

The relationship between employees' willingness to use MSPs was explored by correlating the three items on self-reported use of MSP (see Table 2). It was assumed that higher levels of inter-item correlation would suggest that the employees' willingness to use MSPs in general was related to *similar* contextual factors, whereas lower levels of correlation would suggest that the use of the separate MSPs in general might be associated with *different* contextual factors.

Table 2. Correlations between the three items on self-reported use of MSPs based on the complete dataset (N = 2884, casewise deletion of missing data).

Items	**Item B:** I ask my colleagues to stop working, if I find that they perform their activities in a manner that threatens safety.	**Item C:** If I observe dangerous situations, I report on these.
Item A: I stop working if I find that continuing could imply a danger to myself or to others.	r = .30*	r = .26*
Item B: I ask my colleagues to stop working, if I find that they perform their activities in a manner that threatens safety.		r = .46*

*p < .001

The results showed that a *relatively* stronger relationship existed between employees' willingness to use the MSPs referred to in items B and C, than between any of these and the mindful safety practice referred to in item A. This could suggest that the contextual factors, which affect employees' willingness to use MSPs that involve *other persons* (item B and item C), might at least partly be of a similar kind, while the factors that affect the employees' willingness to use MSPs that only involve the employee's her *own activity* (item A), might differ from these.

The Influence of Contextual Factors on the Use of Mindful Safety Practices

To explore how contextual factors affected employees' willingness to use MSPs, a set of indexes was developed. The indexes were based on general assumptions about the type of factors that might affect the use of MSPs, and naturally constrained by the available data. An index was seen as sufficiently reliable if it demonstrated a *Cronbach's alpha value of 0.7 or more*, as is the conventionally accepted minimum for rating scales (Murphy & Davidshofer 2001). In addition, a set of single items was applied to represent contextual factors for which no reliable indexes could be composed. To support identification of *patterns of results* (see page 157), the contextual factors were classified in three analysis levels: the *individual level* (factors associated with the individual employee), the *group level* (factors associated with the local work environment in which the employee performs his or her tasks), and the *organizational level* (factors associated with the overall work environment at the installation). Table 3 provides an overview of the indexes and single items applied in the exploratory analyses.

Table 3. Overview of the indexes and single items applied in the analysis.

Name	**Content of the items**	**Cronbach's Alpha**
Individual Level		
Age	• Age?	
Overall health state	• In general, how would you characterize your state of health?	
Perceived personal capability to deal with safety-related issues	*Index, composed of the following items:* • Some times I feel under pressure to work in a manner that threatens safety. • From the perspective of personal career, it is a disadvantage to be too concerned with HSE.[6] • Communication between me and my colleagues often fails in such a manner that dangerous situations may arise. • Preferably I do not discuss issues related to HSE with my immediate leader. • I doubt if I will be able to perform my emergency tasks in a crisis situation. • I am uncertain about my role in the emergency management organization.	.91
Time in job position offshore	• Time in job position whole or part time off shore (specify the number in years)	

[6] The acronym *HSE* refers to *Health, Safety, Environment*.

Name	Content of the items	Cronbach's Alpha
Group Level		
Task performance environment	*Index, composed of the following items:* • I have received sufficient safety education and training. • The HSE procedures adequately cover my tasks. • Safety has first priority when I perform my job. • My colleagues are very engaged in HSE. • The safety delegates do a good job.	.71
Managers' attitude to HSE	*Index, composed of the following items:* • Suggestions and comments from safety delegates are being seriously dealt with by the management. • My leader appreciates that I call attention to issues of importance to HSE. • The company in which I work takes HSE seriously. • My leader is engaged in the HSE work at the installation.	.77
Psychological work environment	This index was calculated based on a subset of the items contained in part 4 of the questionnaire. The items applied requested the employees to evaluate different aspects of the work environment offshore: a) Possibility for planning own work, b) Possibility for gaining in professional skills, c) Relationship with colleagues, d) Relationship with the immediate leader, e) The manner in which the respondent's work is appreciated, and f) The work environment in totality.	.82
Colleagues' use of mindful safety practices	• My colleagues will stop me if I work in a risky manner.	
Organizational Level		
Overall work environment	*Index, composed of the following items:* • You can easily be perceived as quarrelsome if you call attention to dangerous conditions. • In practice, considerations for production are prioritised over considerations for HSE. • Insufficient maintenance has lead to poorer safety. • Often parallel work operations lead to dangerous situations. • Insufficient co-operation between operator[7] and contracting firms often leads to dangerous situations. • Reports about accidents or dangerous situations often become "trimmed"/"touched up."	.75
Perceived risk level	This index was calculated based on part 3 of the questionnaire, which asked the respondents to rate the degree to which they felt personally endangered by different possible incident/accident events offshore. The events comprised: a) Helicopter crash into the platform, b) Gas	.87

[7] In the present context, the concept 'operator' refers to the company that owns/runs the installation.

Name	Content of the items	Cronbach's Alpha
	leakages, c) Fire, d) Blow out, e) Releases of poisonous gasses/materials/chemicals, f) Collisions with skips or other objects in the sea, g) Sabotage/Terror, h) Breakdown in the installation's bearing constructions or loss of its ability to float, i) Serious work accidents.	
Physical work environment	This index was calculated based on a subset of the items contained in part 4 of the questionnaire. The items applied requested the employees to evaluate different aspects of the work environment offshore: a) Noise, b) Temperature, c) Vibrations, d) Hygiene/cleaning/tidiness, e) Lightning conditions, f) Air quality, g) Protections against the weather, h) Handling of chemicals, i) Heavy lifts, j) Repetitive work, k) Work in inadequate positions, l) Workload, m) Work tempo, n) Shift-work schedule, o) Workplace design.	.89
Spare-time and rest facilities	This index was calculated based on a subset of the items contained in part 4 of the questionnaire. The items applied requested the employees to evaluate different aspects of the work environment offshore in terms of the quality of spare time and rest periods: a) Noise, b) Temperature, c) Vibrations, d) Hygiene/cleaning/tidiness, e) Lighting conditions, f) Air quality, g) Food/Drink quality, h) cabin standard, i) Training facilities, and j) Additional recreational possibilities.	.87

In general, the distribution of scores on the indexes was skewed to the left, as was the case for the overall dataset. However, the index "Perceived personal capability to deal with safety-related issues" demonstrated a bimodal distribution and for that reason its scores were split in two across the mean before correlations were performed. The scores on the indexes were calculated by taking the average of the scores obtained on individual items contained in the separate indexes.

The relationship between employees' willingness to use MSPs and the defined contextual factors was explored using correlations.

Table 4. Correlations between the three items on self-reported use of MSPs and the defined contextual factors (N = 2379, casewise deletion of missing data).

	Item A: I stop working if I find that continuing could imply a danger to myself or to others.	**Item B:** I ask my colleagues to stop working, if I find that they perform their activities in a manner that threatens safety.	**Item C:** If I observe dangerous situations, I report on these.
Individual Level			
Age	r = .05*	r = .10 ***	r = .13***
Overall health state	r = .02	r = .08***	r = .06**
Perceived personal capability to deal with safety-related issues (above the mean: 3,4076)[8]	r = .21***	r = .29**	r = .32**
Perceived personal capability to deal with safety-related issues (below the mean: 3,4076)[9]	r = -.24***	r = -.34**	r = -.33**
Time in job position offshore	r = .03	r = .11***	r = .08***
Group Level			
Task performance environment	r = .30**	r = .44**	r = .45**
Managers' attitude to HSE	r = .23**	r = .38**	r = .39**
Psychological work environment	r = .12***	r = .23**	r = .22**
Colleagues' use of mindful safety practices	r = .26**	r = .40**	r = .33**
Organizational Level			
Overall work environment	r = .07**	r = .06**	r = .06**
Perceived risk level	r = .06**	r = .12***	r = .08***
Physical work environment	r = .08**	r = .17***	r = .18***
Spare time and rest facilities	r = .12***	r = .16***	r = .14***

*p < .05, **p < .01. ***p < .001

The analyses revealed that the relationship between the employees' willingness to use MSPs and the contextual factors at the *individual* and *organizational* levels was low. For contextual factors at the *group level*, the relationship was *relatively* stronger, except for the index *psychological work environment.* Even though correlations say nothing about the direction of a relationship, it seems reasonable to interpret these results to imply that *group level* factors more markedly affect employees' willingness to use MSPs than individual and organizational level factors. The results suggest that initiatives to promote the use of MSPs would be most efficient if directed at the group level, i.e. the local work environment in which the employees' perform their tasks. A closer inspection of the results further revealed that the relationship between group level factors and the use of MSPs was *relatively* stronger with respect to items B and C, than with respect to

[8] N = 1511, casewise deletion of missing data.

[9] N = 1273, casewise deletion of missing data.

item A. This could indicate that employees' willingness to use MSPs, which involve other persons (see page 158), is more sensitive to group level factors, than their willingness to use MSPs, which only involve the employee him or her self.

To further explore the extent to which group level factors contributed to explain employees' willingness to use MSPs, separate multiple regression analyses were performed on the three items on self-reported use of mindful safety practices (see Tables 5-7). The index "Perceived personal capability to deal with safety-related issues" was excluded from these analyses due to its bimodal distribution.

Table 5. Multiple regression analysis on item A: "I stop working if I find that continuing could imply a danger to myself or to others."

Regression Summary for Dependent Variable: Item A. N=2433. R= .33. R^2= .11 Adjusted R^2= .11 F(10,2422)=30.07 p<0.0000. Std. Error of estimate: .72.						
	Beta	**Std.Err. of Beta**	**B**	**Std.Err. of B**	**t(2422)**	**p-level**
Intercept			3.08	0.16	19.37	0.000
Colleagues' use of mindful safety practices	0.16	0.02	0.13	0.02	6.87	0.000
Spare-time and rest facilities	0.06	0.03	0.07	0.03	2.21	0.027
Physical work environment	-0.11	0.03	-0.15	0.04	-3.73	0.000
Managers' attitude to HSE	0.07	0.03	0.07	0.03	2.30	0.022
Task performance environment	0.20	0.03	0.26	0.04	7.00	0.000

Table 6. Multiple regression analysis on item B: "I ask my colleagues to stop working, if I find that they perform their activities in a manner that threatens safety."

Regression Summary for Dependent Variable: Item B. N=2431 R= .50 R^2= .25. Adjusted R^2= .24 F(10,2420)=78.75 p<0.0000 Std.Error of estimate: .68						
	Beta	**Std.Err. of Beta**	**B**	**Std.Err. of B**	**t(2420)**	**p-level**
Intercept			1.60	0.15	10.73	0.0000
Age	0.06	0.02	0.04	0.01	3.04	0.0024
Colleagues' use of mindful safety practices	0.22	0.02	0.19	0.02	10.26	0.0000
Physical work environment	-0.08	0.03	-0.10	0.04	-2.83	0.0047
Managers' attitude to HSE	0.12	0.03	0.13	0.03	4.58	0.0000
Task performance environment	0.27	0.03	0.37	0.04	10.37	0.0000

Table 7. Multiple regression analysis on item C: "If I observe dangerous situations, I report on these."

Regression Summary for Dependent Variable: Item C. N=2435. R= .48 R^2= .23. Adjusted R^2= .23 F(10,2424)=71.85 p<0.0000 Std. Error of estimate: .55						
	Beta	**Std.Err. of Beta**	**B**	**Std.Err. of B**	**t(2424)**	**p-level**
Intercept			2.49	0.12	20.63	0.0000
Age	0.07	0.02	0.05	0.01	3.97	0.0001
Colleagues' use of mindful safety practices	0.12	0.02	0.08	0.01	5.44	0.0000
Managers' attitude to HSE	0.15	0.03	0.13	0.02	5.61	0.0000
Task performance environment	0.31	0.03	0.34	0.03	11.94	0.0000

The multiple regression analyses only explained a limited part of the variation obtained. This was not unexpected, given the high level of homogeneity in the dataset (see page 156). For items A, B and C, the amount of variation explained was 11%, 24%, and 23%, respectively. Still, in all three multiple regression analyses, the group-level factor *task performance environment* contributed most to explain the variation (see beta-score in Tables 5-7). The two group-level factors *colleagues' use of mindful safety practices* and *managers' attitude to HSE* also contributed to explain *relatively* large proportions of the variation. Overall, the outcomes of these analyses, suggested that group-level factors more markedly influenced employees' willingness to use MSPs, than factors at the individual and organizational level. The *relative* difference between the amounts of variation explained for item A and for items B and C again suggested that MSPs, which involve other persons, could be influenced by different factors than the use of MSPs, which only involve the particular employee him or herself.

To explore the extent to which employees' willingness to use MSPs differed between the six work areas covered by the questionnaire (see page 157), separate *Kruskal-Wallis One-Way ANOVA by Ranks test and Median test* were performed on the three items on self-reported use of MSPs (see Table 8). Non-parametric statistics was applied, as Levene's test revealed that the requirement for homogeneity between the groups was not always fulfilled, and as the six datasets differed in size.

Table 8. Separate *Kruskal-Wallis One-Way ANOVA by Ranks test and Median test* on the three items on self-reported use of MSPs. The table reports significant post-hoc comparisons of mean ranks.

Item	The MSP was applied significantly more in the work area:	Than in the work area:	Result (Kruskal-Wallis test)
A: I stop working if I find that continuing could imply a danger to myself or to others.	*Process* - *Drilling* *Maintenance* - *Construction/Mod.*	Well service Catering - Well service Catering -	$p = 0.01$ $p = 0.00$ $p = 0.01$ $p = 0.00$ $p = 0.00$ $p = 0.02$
B: I ask my colleagues to stop working, if I find that they perform their activities in a manner that threatens safety.	*Drilling* -	*Catering* *Maintenance*	$p = 0.00$ $p = 0.02$
C: If I observe dangerous situations, I report on these.	*Process* - *Drilling*	*Well service* *Maintenance* *Well service*	$p = 0.00$ $p = 0.02$ $p = 0.03$

The above results suggested the presence of at least one pattern: When significant differences were found they tended to involve the work areas *process* or *drilling* (no significant results involved both of these work areas) and to show that the use of MSPs was significantly higher in these work areas than in the work areas with which they were compared. Both the work areas *process* and *drilling* contain staff members, which typically work on a particular installation for a longer period of time, as compared to staff in the other work areas.[10] For this reason, *process* and *drilling* staff members might be expected to hold a relatively *higher level of familiarity with their local work environment*, than staff members from other work areas.

The joint outcome of the analyses directed at the six work areas may tentatively suggest that higher levels of familiarity with the local work environment contribute to increase employees' willingness to use MSPs. This interpretation does, however, imply the assumption that HSE in the local work environments in general is being dealt with adequately - otherwise, increased familiarity would be assumed to reduce employees' willingness to use MSPs.

DISCUSSION

The outcomes of the exploratory analyses lead to three suggestions concerning the influence of contextual factors on employees' *willingness* to use MSPs at Norwegian petroleum installations:

1. The factors that influence employees' willingness to use MSPs may differ depending on whether the *object* of a practice is the employee him or herself or other persons.
2. Employees' willingness to use MSPs is generally more affected by factors at the *group level,* i.e. factors in the local work environment, than by factors at the individual and organizational level.

[10] Excluding *catering* (see Skjerve 2005).

3. The results indicate that higher levels of *familiarity with the local work environment* might promote the use of MSPs - *at Norwegian petroleum installations*. This hypothesis should be addressed in future studies.

The analyses suggested that even through employees' willingness to use MSPs in general was more influenced by contextual factors associated with the group level, this influence was more pronounced with respect to the use of MSPs directed at *other persons*, than with respect to the use of MSPs directed at the *employee him or herself*. It seems likely that employees' willingness to use MSPs, which involve themselves only, might better be accounted for by individual-level factors that are not contained in the present study, such as e.g. risk acceptance and stress management capacity.

Still, the overall outcome of the exploratory analyses suggested that employees' willingness to use MSPs in *general* was more influenced by contextual factors at the group level, than by contextual factors at the individual and organizational level. The relatively stronger influence of group level factors may indicate that *group norms* affect employees' willingness to use MSPs. Group norms can be defined as "…rules or standards established by group members to denote what is acceptable and unacceptable behaviour" (Glendon & McKenna 1995, 171). It has long been recognized that group members may exert *strong* influences upon the way in which an individual group member acts (Sherif 1936; Asch 1958). Group norms, as such, were first described in the classic studies of assembly-line workers in the Hawthorne Western Electric Factory, which demonstrated that factory workers developed informal norms for how much group members should produce, as well as various sanctions (e.g., name calling) to be directed at group members that breached the norms (Roethlisberger & Dickson 1939). The implications that follow from group norms have often been addressed from the perspective of their potential *negative* effects. Studies have, e.g., reported that groups often make riskier decisions than separate individuals (e.g. Wallach et al. 1962), a phenomenon, which is generally referred to as *the risky shift* (Kogan & Wallach 1964). Group norms may, however, also have positive effects on employees' willingness to contribute to safety in an operational environment, as demonstrated in various studies on high-reliability organizations (e.g. Bierly & Spender 1995; Rochlin et al. 1998). An employee may learn what constitutes adequate safety-related behaviour through training and education, but observations of how colleagues deal with safety-related issues may have a strong effect on the work practices that the employee will adapt. Donald and Canter (1993, as referred in Glendon & McKenna, 1995) identified three overall types of contextual factors that were suggested to affect employees' attitudes towards health and safety:

- Organizational rules, i.e., perceptions of others' attitudes, especially workmates, supervisors, higher management and safety representatives.
- Safety-object attitudes, i.e., the attitudes towards e.g., checking of equipment and making suggestions for how safety can be improved.
- Behaviour in respect of safety, hereunder with respect to (potentially) safety-critical situations.

These factors seem to correspond well with the contextual factors that were suggested to influence employees' willingness to use MSPs in the present study.

Accepting the suggestion that group norms may markedly influence employees' willingness to use MSPs will imply the assumption that *an employee's willingness to use MSPs may change if he or she is transferred into a different work group*. Only if an employee's willingness to use MSPs was based on *internalised* attitudes and motivation, i.e. if the employee used MSPs because he or she found that this was the *right thing to do* regardless of what others believed, the employee could be expected to be equally willing to apply MSPs regardless of the particular work environment. It would furthermore be assumed that the introduction of changes in the local work environment might reduce employees' willingness to use MSPs temporarily: When changes are introduced, group norms concerning when and how MSPs should be used in the transformed work environment might have to develop, and/or older norms adapted to the changed operational context.

Based on the results obtained in the present study, it further seem that assessments of group-level factors might provide good indications on the extent to which employees are willing to use MSPs. It might be reasonable to develop a specific measure based on a more thorough analysis of the factors that influence employees' willingness to use MSPs, and to use this measure as a *safety indicator* in surveys of the safety level at petroleum installations.

Regardless of the seemingly meaningfulness and coherence of the results obtained, it is, however, important to stress that the results should be considered with care. First, there is a risk that the respondents may systematically differ from employees that did not respond to the questionnaire, as the response rate only reached 50-55% (see page 156). Second, the respondents' level of *self-reported* use of MSPs might not necessarily reflect their *actual* use of MSPs. The respondents' scores may most likely be biased by various heuristics,[11] in particular by the *availability heuristic* (Tversky & Kahneman 1973), which implies that the frequency of an event is assessed by thinking of examples based on how quickly associated examples come to mind. Thus, it may be easier for respondents to recall instances where they have applied MSPs, since these may have been experienced as more sensational and dramatic, than instances where no MSPs have been applied. Third, the factors associated with the individual level were in most analyses covered by 1-item variables only, whereas factors at the group and organizational levels comprised more indexes. This may have reduced the possibility for uncovering relationships between the use of MSPs and individual-level factors. Fourth, the identification and definition of the contextual factors contained in the present study (see page 158), was based on the subjective judgements of authors and in addition constrained by the items contained in the questionnaire. This was true also with respect to localisation of the various factors at the three analysis levels: individual, group, and organization, and with respect to the outlining of characteristic associated with the work areas drilling and well service. Other researchers might have identified other contextual factors and/or located the factors differently in terms of analysis level and/or outlined other work area characteristics, which could have implied that other results/interpretations had been obtained.

Still, the results obtained are coherent, and the results seem not implausible, as they correspond to the results obtained in earlier studies.

---

[11] A heuristic is a rule of thumbs, which can be applied to a variety of problems, and which usually (but not always) will yield a correct solution.

CONCLUSIONS

The purpose of the present study was to explore what type of contextual factors that might affect employees' *willingness* to use MSPs at Norwegian petroleum installations. The results obtained were intended to contribute to the knowledge base for development of safety management practices at the installations.

The main conclusions in terms of safety management practices that follow from the study can be summarized as follows:

1. Management initiatives to increase employees' willingness to use MSPs will be most efficient if directed at the local work environment of the employees, rather than at the employees' individually or in general at the employees that work on the installation.

   This finding was further suggested to point out two particular issues that could be of importance for safety management:

   → Employee's willingness to use MSPs might change when they are transferred to a different 'local work environment.'

   → Employee's willingness to use MSPs might change when changes are introduced in their local work environment.

   It was further suggested that a specific measure, which taps on the contextual factors that influence employees' willingness to use MSPs, should be develop and used as a *safety indicator* in surveys of the safety level at petroleum installations. This type of indicator could be assumed to contribute to assessments of the overall safety level at an installation.

2. The hypothesis that employees' willingness to use MSPs *at Norwegian petroleum installations* might possibly be influenced by their level of familiarity with the local work environment: Employees, who hold a higher level of familiarity with the local work environment, seem to be more willing to use MSPs, than employees, who hold a lower level of familiarity with the above. This hypothesis should be tested in future studies.

The methodological approach applied in the present exploratory study holds various limitations, and even though the results obtained seem to correspond to earlier findings, the suggestions made in point 1 and 2 should be exposed to further tests.

Acknowledgements

This paper is based on work funded by the Research Council of Norway through the research project "HSE Petroleum: Change – Organization – Technology." Thanks to the Nordic Group, and especially to Ola Svenson and Teemu Reiman for reviewing this chapter.

REFERENCES

Asch S E (1958) Effects of group pressure upon the modification and distortion of judgements. In: EE Maccoby et al. (eds). *Readings in Social Psychology*. Holt, Rinehart and Winston, New York, pp. 174-183.

Bierly III PE, Spender JC (1995) Culture and High Reliability Organizations: The Case of the Nuclear Submarine. *Journal of Management* 21:639-656.

Glendon I and McKenna EE (1995) *Human Safety and Risk Management*. Chapman & Hall. London.

Hawkins FJ (1987) *Human factors in flight*. Gower Technical Press. Hawkins, Aldershot.
Helmreich RL, Merritt AC, Wilhelm JA (1999) The evolution of Crew Resource Management training in commercial aviation. *International Journal of Aviation Psychology,* 9:19-32.

Hinkle DH, Wiersma W and Jurs SG (1988) *Applied statistics for the behavioural sciences*. Fourth edition. Houhton Mifflin Company, Boston.

Husebø T, Ravnås E, Lauritsen Ø, Lootz E, Haga HB, Haugstøyl M, Kvitrud A, Vinnem JE, Tveit O, Aven T, Haukelid K and Ringstad AJ (2002). *Utvikling i risikonivå - norsk sokkel. Fase 2 rapport.* Norwegian Petroleum Directorate, Stavanger.

Kogan N and Wallach MA (1964) *Risk-Taking: A Study in Cognition and Personality.* Holt, Rinehart and Winston, New York.

Langer EJ (1989) *Mindfulness*. Perseus Books, Da Capo Press. Cambridge MA.

LaPorte TR and Consolini PM (1991) Working in practice but not in theory: Theoretical challenges of "High-Reliability Organisations." *Journal of Public Administration Research and Theory* 1:19-47.

Merriam Webster's Collegiate Dictionary (1993) 10th edition, Merriam-Webster, Springfield.

Murphy KR and Davidshofer CO (2001) *Psychological testing: principles and applications.* 5th edition, Prentice Hall, Upper Saddle River, NJ. Massachusetts.

Norwegian Petroleum Safety Authority (2001) *Regulations Relating to Management in the Petroleum Activities (Management Regulations).* Issued by the Norwegian Petroleum Directorate 3 September 2001.

Perrow C (1984) *Normal Accidents. Living with high-risk technologies.* Basic Books, New York.

Rasmussen J (1986) *Information Processing and Human-Machine Interaction. An Approach to Cognitive Engineering.* Series Volume 12. North-Holland series in System Science and Engineering. North-Holland, New York.

Rochlin GI, LaPorte T, Roberts KH (1987) The self-designing high-reliability organization:

Aircraft carrier flight operations at sea. *Naval War College Review* 40:76-90. Available at: http://www.nwc.navy.mil/press/reveiw/1998/summer/art7su98.htm (as of 1st January 2005)

Roethlisberger FJ and Dickson WJ (1939). *Management and the Worker*. Harvard University Press, Cambridge MA.

Rognin L, Salembier P, Zouinar M (2000) Cooperation, reliability of socio-technical systems and allocation of function. *Int. J. Human-Computer Studies,* 52:357-379.

Rosness R, Håkonsen G, Steiro T, Tinmannsvik RK (2000) *The vulnerable robustness of High Reliability Organisations: A case study report from an offshore oil production platform.* Paper presented at the 18th ESReDA seminar Risk Management and Human Reliability in Social Context. June 15-16, 2000, Karlstad.

Sagan SD (1993) *The limits of safety: organizations, accidents, and nuclear weapons*. Princeton University Press, Princeton NJ.

Sherif M (1936) *The Psychology of Social Norms.* Harper and Row, New York.

Skjerve ABM (2005) *Employees' Willingness to Use Mindful Safety Practices at Norwegian Petroleum Installations - an Empirical Study.* Work report project "HSE Petroleum: Change – Organization – Technology" IFE/HR/E– 2005/014.

Skjerve ABM, Rosness R, Aase K, Bye A (2003) *Mennesket som sikkerhetsbarriere i en organisatorisk kontekst*, Institute for Energy Technology, IFE/HR/E-2003/023, Halden.

Skjerve ABM, Rosness R, Aase K, Hauge S, Hovden J (2004) Human and Organizational Contributions to Safety Defences in Offshore Oil Production. In C. Spitzer et al (eds). *Probabilistic Safety Assessment and Management*. vol. 4, Springer-Verlag, Gateshead, pp 2060-2066.

Statsoft (2001) *Statistica '01* Edition, Kernel release 6.1, StatSoft Inc., Tulsa, OK.

Tversky A and Kahneman D (1973) Availability: A heuristic for judging frequency and probability. *Cognitive Psychology,* 5:207-232.

Wallach MA, Kogan N, Bem DJ (1962) Group influences on individual risk taking. *Journal of Abnormal Social Psychology*, 65:65-75.

Weick KE and Sutcliffe KM (2001) *Managing the Unexpected. Assuring High Performance in an Age of Complexity*. University of Michigan Business School Management School. Michigan: Jossey-Bass.

Aase, K., Skjerve, A. B. M., Rosness, R. (2005) Why Good Luck has a Reason: Mindful Practices in Offshore Oil and Gas Drilling. In: (Eds.) Gherardi, S., Nicolini, D., *The Passion for Learning and Knowing.* Proceedings of the 6th International Conference on Organizational Learning and Knowledge, vol. 1., University of Trento e-books, Trento, 193-210.

Chapter 12: Challenges to Safety Management when Incorporating Integrated Operations Solutions in the Oil Industry

Svein Nilsen
Institute for Energy Technology
P.O. Box 173
NO - 1751 Halden, Norway
Svein.Nilsen@hrp.no

ABSTRACT

Safety Management is a particularly challenging task when organization structures are being changed. An example from within the oil industry is taken to illustrate the kind of problems one might be forced to consider in such a situation. The specific problem area addressed is taken from the oil drilling domain characterized by large amounts of highly uncertain or inaccurate information. As an example, the drilling of a well bore is based on assumptions about the formation and often on high uncertainty where adequate contingency planning should be undertaken. The oil industry is making efforts to improve their planning in this respect and to increase the exploitation of previously established knowledge. Success in this respect demands appropriate collective safety thinking within the multi-disciplinary groups responsible for the planning. A large portion of the required knowledge is tacit which calls for communication channels among the staff to be kept open. Major re-organizations may disrupt already established communication channels. One important observation is that requirements for good safety management very much coincide with requirements for good knowledge management.

Keywords: Safety management, knowledge management, integrated operations, re-organizations.

INTRODUCTION

This chapter takes as its starting point the conceptual framework presented in the introductory part of this book. Within this framework, any socio-technical system is decomposable hierarchically into smaller and smaller parts until a level of detail is reached where interesting aspects of the complete system can be described or analyzed. Such an interesting aspect is safety. In order for the system to be considered safe, the system and its subcomponents needs to be in some state of balance. Such a state of balance will call for a given feedback on its present state so that undesired behavior can be compensated for by the internal mechanisms of the system or one of its subcomponents. This paradigm is often referred to as 'systems thinking'. Examples are taken from drilling of oil production wells and particular challenge emerges when the system is going through a transformation process, such as a re-organization.

During a period of re-organization, the individuals and the organizational units may be experiencing that previously purposeful behavior is not purposeful anymore and that safety may not be provided for in a controlled manner. Even more seriously, sub-systems (including the staff) may not be aware that their role has changed and that they in effect are jeopardizing safety because of their negligence of their new roles. This is part of defining, maintaining and disseminating safety relevant knowledge, which is not only the responsibility of each individual in the organization but the management even more. We maintain that management of safety relevant knowledge should be seen as part of the general knowledge management solutions implemented within the organization. Safety relevant knowledge is both basic knowledge about the events that may lead to dangerous situations as well as knowledge about how the corresponding risks are being monitored by the organization and the responsibilities in case an incident should happen (emergency preparedness).

The oil industry is currently in a state of transformation caused by the necessity to produce oil more efficiently. The background for this effort is that oil reserves on the Norwegian Continental Shelf are starting to exsiccate and unless something is done there will be no commercially exploitable oil fields left after 2020. New technology and methods are constantly being proposed as partial solutions to more cost effective oil production methods. Per Ivar Karstad, who is a project leader of the Statoil activity to define an improved process for increased oil recovery (SIOR-Integrated Operations) name some of the means to reach this goal (presented at the POSC Special Interest Groups Meeting in Houston, May 13, 2005)

- Develop and implement permanent ocean bottom seismic equipment
- Develop reliable down hole sensors (HPHT) for pressure, temperature and multiphase flow
- Establish standards and protocols for data transmission to be able to integrate software applications
- Develop tools, methodology and work processes for real-time reservoir and production optimization
- Develop tools and methodology for condition based maintenance
- Improve work- and decision- processes related to onshore operations centers
- Improve ICT infrastructure with respect to reliability and security

As can be seen from this list, there are a number of potential technical and organizational changes that may disturb the state of equilibrium that should be one of the characteristics of safe oil production. Some oil companies has proposed knowledge management systems that aim to mitigate consequences of potential knowledge flow disruptions, typically socio-technical system that support knowledge management and decision support in integrated operation settings. In the following we will take as an example the planning and implementation of oil drilling operations. Knowledge management is essential in the development of any drilling plan and will influence the technical solution eventually chosen and the contingency plans worked out. Later on, we will illustrate how the development of a drilling plan needs to consider a considerable amount of uncertain information, both with respect to the interpretation of the data available during the planning process (e.g. seismic data) and with respect to the effectiveness of the drilling solution decided on. Experiences from the past may be helpful in accomplishing the planning.

Certainly, it is not feasible to consider all relevant experiences of the past. Nevertheless, a certain amount of knowledge should always be acquired and the aim will often be to increase that amount beyond the current level. This by itself should promote the level of safety because the technical drilling solution worked out would be based on a more comprehensive set of background information. Still, this is only true if the quality of the information can be kept at the same level and if the work processes offer the same opportunities for challenging the information acquired by the socio-technical system. It is obvious that codified knowledge presumes pieces of tacit or undocumented knowledge essential to the correct understanding of the document. Generally, the interpretation of the human consumer of codified knowledge is a result of previous personal experiences and a theoretical understanding of the domain in question. Often, this interpretation must at some stage rely on person-to-person contact. Only person-to-person contacts will assert the application of the knowledge is done in a befitting manner.

Thus, challenging the experience might rely on the easy access to human resources, so that tacit knowledge relating to the documented experience may be acquired. Re-organization may estrange such resources from the people implementing the planning and may thus result in knowledge not being challenged as it should. Using the terminology from the 'system thinking' paradigm, one might say that the feedback to each individual subsystem must be adapted to internal self-adjustment mechanisms of that system.

OIL DRILLING AS SEEN FROM A "SYSTEM THINKING" PERSPECTIVE

The Oil industry is characterized by decision making involving safety, high costs and high potential revenues. Often, one needs to find a balancing point of costs against the possibility to earn money and dangers involved in bringing the oil up to the surface level. It is not always easy to calculate the economic and environmental hazards in a drilling operation since the geological conditions may not always be accurate to the point needed for such evaluations. In particular this is true when drilling the so-called "wildcats". Wildcats are exploration wells drilled primarily for the purpose of evaluating potentials for taking out oil from a given oil field. Thus, in this situation knowledge of the geologic formation to be drilled through is less than later on.

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

Partly due to the fact that the formation pressure cannot be controlled only with the drill fluid weight for the total length of the drill hole, the drilling is done in stages i.e. the pressure from the formation does not increase corresponding to the pressure exerted by the drill fluid (e.g.

there may be discontinuities in the pressure when entering new geological layers). When one stage has been completed, a casing (a steel pipe) is brought down the hole and attached to the wall of the formation using cement.

These are all safety relevant risks. However, there are other risks that primarily relate to the margin of profit. Even though these financial risks are no direct threat to safety, they are important because they may be antagonistic to the risks concerning safety. In the long run it is unacceptable to use resources to minimize risks to the extent that the revenues of the enterprises dwindle down to nothing. On the other hand the enterprise cannot completely disregard risks because this might easily lead to accidents that would cost the enterprise dearly. So somewhere in between there is a balancing point where both risks and revenues are kept at an acceptable level.

If a rock has enough *porosity and permeability* to flow oil or gas, then it is a potential reservoir. Most rocks, in particular sandstones and conglomerates contain pore space. If enough pores are present, the pores are large enough, and they are interconnected so that fluids flow through them (i.e., the rock is permeable) in the direction of the drainage point of the reservoir, then the rock is a potential petroleum reservoir. Thus both porosity and permeability are important parameters, but a petroleum reservoir also needs to contain hydrocarbons to a certain percentage. In most rocks, the pores are filled entirely with a salty solution called formation water, but in a few cases some oil or gas is present as well.

A rule of thumb is that 40% or more of the pore fluids must be hydrocarbons (i.e., the *water saturation* is less than 60%). If the water content is greater, then oil tends to stay behind and the reservoir produces only water. These types of reservoirs are said to be "*wet*". If the water saturation is less, then the reservoir may be "productive". Again, before starting to drill, all these parameters are not known with absolute certainty. If uncertainty is above a certain level it might be advisable to compensate for this by increased down hole instrumentation. Increased down hole instrumentation might influence safety in both directions. The handling of the instrumentation complicates the drilling operation and may as such have a negative impact on safety. On the other hand, the presence of extra instrumentation may enable drilling crew to detect incipient and unwanted conditions at a much earlier time.

In order to be able to control the financial risks various efficiency promoting measures are being applied. One of these is the so-called Key Performance Indicators. These indicators attempt to measure the performance efficiency of the various organizational units. Unfortunately, simple efficiency related measures may in certain cases lead to sub-optimization. Obviously, this is not in the interest of the organization, but it is an effect of the management failing to create a work climate that favors cooperation on a sufficiently wide level. There may also be differences in time scope of the various aspired effects that distort a proper view on the balance between safety/costs/revenues.

It is likely that any set of work processes intended to implement drilling will have some strong points and some weak points. In the following we will present one approach much favored in the oil drilling business, at least traditionally. This approach enables the organization to handle the complexity of all decisions to be taken during the planning of the well drilling operation. One weak point in this approach is that some communication lines are favored while others are not used as often. Oil drilling has often been divided into two different main disciplines:

- Evaluation of the oil reservoir and its drainage (Petroleum Technology – PETEK)
- Planning of the drilling operation and the casing and completion of the well (B&B[1])

There is a tendency that communication between people working within organizational units attributed to the two disciplines is scarce. The *Key Performance Indicator* of the PETEK unit will aim at targeting the best reservoirs and to find the optimal drainage points. In order to achieve this, PETEK will have viewpoints on where the well bore should be located and how the drilling string should be instrumented.

The B&B unit will typically have another set of *Key Performance Indicators* expressing how fast the drilling can be done – e.g. rate of penetration (ROP). Obviously, the named *Key Performance Indicator* is antagonistic to the *Key Performance Indicators* of the PETEK unit. Thus, the typical type of communication between the two units will be to establish a compromise where the drilling will not be unacceptably complicated and at the same time the chances for finding the optimal drainage point are fair. Expressing this in terms of the framework presented in the introductory part of this book, this may be as in Figure1:

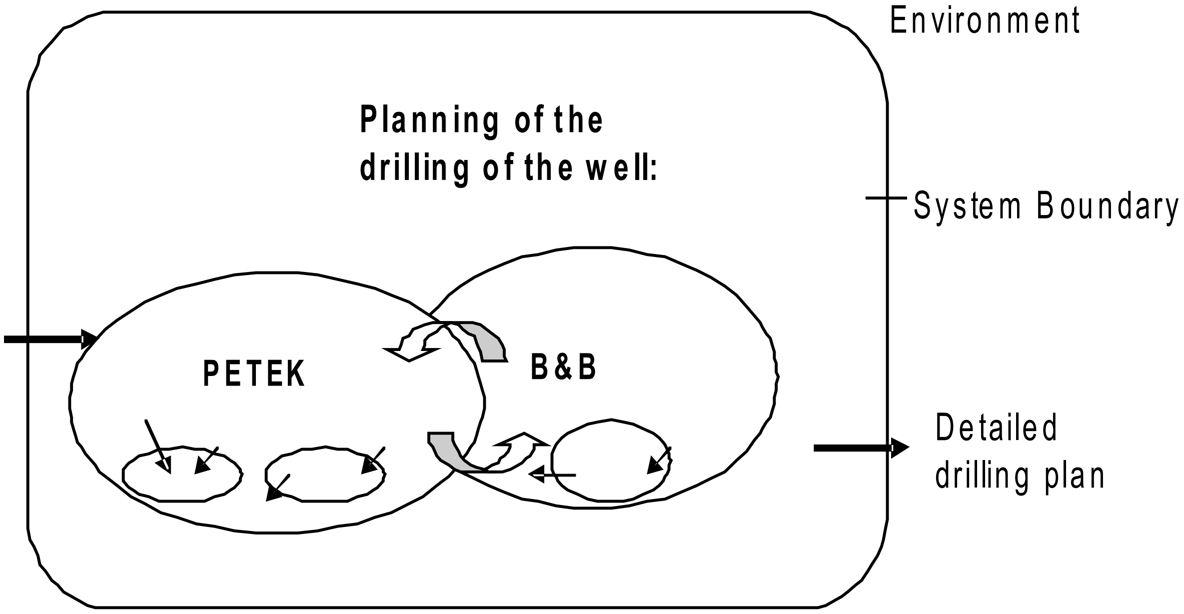


Figure 1 Sub-systems of the planning of oil drilling operations.

Experience has shown that the existing structure depicted in Figure 1 has been successful in implementing several planning processes (even though there have been failures also). The suprasystem ("planning of the drilling of the well") has been kept in a steady state taking into account some of the variables that may affect the outcome of the process. One is inclined to believe that the shaping of this arrangement has been a historic process where the organizations have learned from their own successes and failures and thus over time have become able to improve planning performance. In other words, the system's structures and processes have been changing, and the system has been moving towards new steady states.

Miller states that "A system is adjusted to its suprasystem only if it has an internal purpose or external goal which is consistent with the norm established by the suprasystem (Miller, 1978,

[1] B&B is an acronym representing the Norwegian term "Boring og Brønn" which in English translation reads "Drilling and well".

p.40). The dialectic process going on between the PETEK and B&B units might result in a solution that gives the best possible chances for a safe and at the same time cost effective well operation. Still, for this to happen, the dialectic process must be flexible. There must be ample opportunities for information to be fed back so that the activities of the PETEK and B&B units have the possibility to improve its performance with respect to producing good drilling plans. The dialectic process between PETEK and B&B creates feedback to each unit and such communication must take place until most relevant alternatives for solutions have been brought into the open. Another important feedback is the one that comes from past experiences. Whenever a plan has been implemented, a report must be made that is the documentation on the goodness of the plan originally conceived.

Both these types of feedback are needed to maintain the system as stable as possible (i.e. finding a drilling solution with the best possible chances of succeeding). The dialectic processes between the units is instrumental in identifying as many distinguishing conditions of the formation to be penetrated. The poorer this understanding, the greater chances of applying irrelevant experiences of the past.

Looking back to the introductory chapter, the following remarks can be made with respect to safety management and its application in the oil business.

(a) External feedback in terms of *limiting conditions* exists in terms of regulations required by the authorities. Still, these are not the only limiting conditions observed by the organization.

(b) Also the *costs of behaviour in violation of the safety limits* are influencing the safety management of the organization. Various sets of safety limits may apply; some are easier to compromise than others. The limiting conditions mentioned under a) are only rarely neglected. On the other hand, if safety limits are only commendable, it is possible that in certain cases safety may be down prioritized as compared to short-term profitability.

(c) Using safety limits as a *parameter of competition* is negligible in the oil industry. The general audience is not occupied with the safety levels of a given oil producer and the customer is first and foremost focused on the price of the oil.

(d) The influence of the industry's lobbying is unknown to the author of this paper.

(e) Ethical considerations are presumably observed to a high degree. However, as the margins of profitability narrows this may be compensated through decreasing expenses for safety. Any organization aspiring high safety standards must act to counter this threat to safety.

ORGANIZATIONAL CHANGES PERTAINING TO INTEGRATED OPERATIONS AND THEIR INFLUENCE ON SAFETY

We have seen that the planning of a drilling operation is highly complex and that a lot of strategic decisions need to be taken by a number of people involving several disciplines. Several types of experts need to cooperate to make a high-quality drilling plan, including geologists, geophysicists, petrophysicists, drilling engineers, reservoir geologists etc. For such a large group of people, the challenges to proper knowledge management are substantial. Unless due consideration is taken with respect to satisfactory management of safety relevant knowledge, safety may be jeopardized. Berry and McCormick give an account of a drilling operation where the importance of combining several disciplines in order to have maximum control of the risks and the safety is underlined (Berry and McCormick. 2003).

The drilling operation described in this chapter took place in the winter of 2001-2002, when BP drilled the Havsule exploration well using a dynamically positioned semi submersible. The objective was to test several potentially hydrocarbon-bearing seismic features in the Tertiary and Upper Cretaceous, and gather sufficient data to enable complete verification of the prospect. This is one type of drilling operation where the risks are the greatest. Because of the uncertainties of the project BP assembled a team of formation-pressure and well bore-stability specialists who were involved in all phases of the well operation from the start of planning, throughout the drilling of the well and in the post-well evaluation. This seems to be a trend in the oil industry nowadays.

Since the drilling itself was monitored by a set of MWD (Measurement While Drilling) real-time data points, a data acquisition team was set up to ensure that all needs were met and contingencies planned for. Since the drilling itself most often is implemented by a drilling contractor and a set of service providers at least one senior person from each relevant service provider was included in the data acquisition team (as an example all decisions with respect to drilling fluid are looked after by a dedicated service provider). Typically, it was important to design measurement points that most effectively could check if the predicted pore pressure corresponded to the actual pore pressure.

The experiences from the Havsule well stress the importance of adopting a multi-disciplinary approach to compensate for subsurface uncertainties.

This is just one example of the many complex operations that are planned and implemented routinely on the Norwegian Continental Shaft. They are all unique since the formations are not identical across reservoir targets. In this way, the conditions are radically different from the traditional industrial plant where the production process follows the same path as long as it is kept within design conditions. In the oil industry, it seems to be an absolute necessity to be constantly worried about safety, or else disastrous well blow-outs may follow. In spite of this, people in the business speak about problems occasionally seen and which may result in drilling plans that are of less quality than they should have been. The problems include the following:

- Planning teams are in a few cases dominated by opinionated people who tend to disregard advices or facts that come from less dominating people in the team.

- It is sometimes impractical to use previous knowledge in the planning of a new well. Part of this problem is that knowledge is not readily available. One spokesperson states that up to 60% of the time could be used looking for relevant information.
- Inconveniences in using IT tools that could have been more useful if more integrated in the work processes.

Knowledge management projects in the oil industry will typically attempt to remedy such problems. Some projects may start out with a workflow modeling activity to identify the main steps in planning and implementation of drilling operations. In doing so, one hopes to get a clear enough understanding of how the various steps in the planning operation depend on each other and what qualities (including safety relevant risks) are associated with the steps. Based on this analysis and modeling activity may result suggested improvements. Further investigation of these improvements may lead to a better understanding of how facilitated knowledge management could improve the situation.

Partly due to the complexity of the problem to be solved opportunistic planning may sometimes be the result. Again, there is a chance that opinionated people relying too much on their own experience may take the lead and neglect potential safety problems. Re-modeling of the work processes, re-educating people and/or introducing improved IT solutions may alleviate these problems.

It is indicative to look at the relationship between safety management/cultures and knowledge management. Attributes signifying a good safety culture may be grouped in five fundamental dimensions (1) safety leadership is clear,(2) safety is learning driven, (3) accountability for safety is clear, (4) safety is clearly recognized as a value, and (5) safety is integrated into all activities. Keeping in mind that Knowledge Management can be defined as an activity that improves the creation, distribution, and use of knowledge to create and retain greater value from core business competencies, the similarities between safety culture and good knowledge management cultures are obvious.

Knowledge management within an enterprise depends conclusively on the preparedness of the individuals of the organization to 'trade' in knowledge. There are many ways to look at this. One way is to look at three classes of actors: buyers, sellers and brokers (Davenport et al. 1997). As for any type of commodity, the role of the broker is to connect the buyers and the sellers. In this case, there is also a price to be paid, usually not cash. The price may be thought of in terms of three different classes of compensations: reciprocity, repute and altruism. Sellers may be willing to give away some of their knowledge if they expect to get some other knowledge or favour in return (at some later point in time). This effect is labelled 'reciprocity'. However, sellers may also be interested to share their knowledge and thus increasing their reputation as an important knowledge source. Finally, in the case of the altruistic compensation, people may be willing to share knowledge of sheer goodness or enthusiasm for a given subject.

We will not go into details on how knowledge is shared, but an organization must in some way or other favour this kind of knowledge trading. One basic quality needs to be mentioned: trust. Trust is the catalyst that make all this happen. Unless there is a minimal degree of trust, knowledge hoarding will be the result. People will try to secure his/her own position by monopolising the knowledge possessed by individuals. The logic is obvious since monopolized knowledge is the guarantee that employees will remain attractive and indispensable. It is the task of the senior management to provide an organizational culture favouring knowledge sharing, rewarding people when sharing knowledge with colleagues. Looking back to the safety contributing attributes mentioned above, we note that (1) knowledge management should be supported by clear responsible leadership (often denoted knowledge management champion),(2) knowledge management should be characterized by a sustained activity on identifying new knowledge to be acquired, (3) there should be an ongoing activity to assess if knowledge management is good enough, (4) knowledge management is clearly recognized as a value, and (5) knowledge management is integrated into all activities. Thus, we see that there are tight connection between knowledge management cultures and safety cultures, and in both cases it is very important that communication channels within the organization is kept open.

We will take one example from the nuclear domain to illustrate the importance of both good knowledge management and safety management cultures (Tsuchiya et al. 2001). The incident in question happened at the *Tokaimura nuclear fuel processing plant*. The JCO plant occasionally purifies uranium to be made into fuel for an experimental fast-breeder reactor known as Joyo, which requires fuel enriched to 18.8% ^{235}U. These higher levels of enrichment require greater precaution because of the higher probability of accumulating a critical mass.

The JCO plant needed to mix some high-purity enriched uranium oxide with nitric acid to form uranyl nitrate for shipping. The dissolving and mixing began on September 28, 1999. On the morning of September 30, 1999, three technicians were running fuel through the last steps of the conversion process. To speed up the process, they mixed the oxide and nitric acid in 10-liter stainless steel buckets rather than in the dissolving tank. In doing so, they followed the practice that JCO had written into its operating manual but which had not received approval from the safety authorities. For convenience, they added the bucket contents directly to the 45-cm-diameter, water-jacketed precipitation tank rather than to the buffer tank. That was a crucial error because the tall, narrow geometry of the buffer tank was designed to preclude the onset of criticality.

At approximately 10:35 a.m. the technicians added the seventh bucket and saw a blue flash. The two technicians near the vessel began to experience pain, waves of nausea, some difficulty in breathing, and problems with mobility and coherence. The gamma radiation alarms activated immediately. Two of the technicians died as a result of the radiation exposure.

Probably many explanations can be given why this happened; several safety barriers were broken. One explanation was offered by Tsuchiya et al in the paper referred to above (Tsuchiya et al. 2001). The conclusion offered in the paper is that the accident happened as a consequence of the combination of two unfortunate factors: (1) inadequate risk awareness by the top management, and (2) the famous Japanese “kaizen” principle. The ‘kaizen’ principle allows for small production improvements to be implemented without extensive and time consuming redesign of the production processes. Unfortunately, this is a double-edged sword. On the one side it leads to efficient and timely improvements in the production while at the other hand some less known principle of the production process may be violated and risk may be introduced (as was the case in the JCO accident).

In the last instance, the accident was the responsibility of the top management. However, they were probably never informed about the potential consequences of the ongoing malpractice, in other words the knowledge management was not working as it should. At the same time, the top management is also responsible for the knowledge management. In the JCO case, the top management believed that somebody else had evaluated the risks, created a safe working environment and did not bother to supervise that it was actually being implemented according to stated preconditions. They neglected the danger that subordinates might not report on less profitable conditions and did not care to ascertain that there was a sufficient degree of openness within the organization. One approach being tested out in Tokyo Electric Power Company (TEPCO) are policy exercises aimed at enhancing openness in Nuclear Power Plants control room. Lack of openness may lead to many kinds of situations where safety is being challenged. Another such incident was the disclosure of false TEPCO inspection records taken from the late 1980 to early 1990 regarding cracks at three nuclear plants. In order to deal with this fraudulent practise, TEPCO has started to apply gaming/simulation methods to train employees in 'openness' (Tsuchiya unpublished).

As seen from the perspective of top management, 'openness' should always be a feature of the goals of the organization. Only openness will assert that all information reaches the top management thus preventing knowledge to be buried at a lower level in the organization.

Going back to the radical reorganization of the oil drilling business now going on, essential contributing factors to good safety culture may get lost. For example, safety leadership may be neglected in the re-organization process and the good leadership from the previous organization may not have been preserved in the new organization. One reason for such an effect could be that it is the productive aspects of the organizational behaviour that come into the foreground because of wishes to produce from new wells at least as efficiently as before. Therefore safety aspects may remain a little more in the background. It is also much more difficult to overlook the safety related aspects of a re-organization than potential economic benefits because the factors contributing to an incident or an accident are often more covert. Analytical/systematic efforts to disclose this will only result in partial knowledge, and it is only after having historic data that one will feel confident that a new organization operates with an adequate safety level.

If we take the example of moving the directional driller's on-shore (which has been nominated as one typical organizational change in many Integrated Operations efforts) we may expect that moving these people from one working environment to another will have an effect on the information available to them. The directional drillers will meet other types of people and their understanding of an evolving drilling operation will be affected by the opinions of these peoples. Such as a change of context may have both negative and positive contributions to the general safety. Still it is very hard to know resulting contribution on beforehand. This is only known after some time of operation. Similar to knowledge management cultures, safety management cultures may need some time to develop.

Thus, it is not expected to acquire experiences resulting from advances within Integrated Operation quite yet. Still, there are examples that re-organizations of the past have contributed to accidents. One of the most recent one is the Snorre A platform (SNA) gas blow-out. The preliminary version of the official investigation report describes the accident as follows:

"*On 28 November 2004, an uncontrolled situation occurred during work in Well P-31A on the Snorre A facility (SNA). The work consisted of pulling pipes out of the well in preparation for drilling a sidetrack. During the course of the day, the situation developed into an uncontrolled gas blowout on the seabed, resulting in gas on and under the facility. Personnel who were not involved in work to remedy the situation were evacuated by helicopter to nearby facilities.*

The work to regain control over the well was complicated by the gas under the facility which, among other things, prevented supply vessels from approaching the facility to unload additional drilling mud. After having mixed mud from the available well fluid chemicals, this was pumped into the well on 29 November 2004, and the well was stabilized. With the well stabilized and the gas flow stopped, the work to secure the well with the necessary barriers could commence.

The PSA characterizes this incident as one of the most serious to occur on the Norwegian shelf. This is because of the potential of the incident, as well as comprehensive failure of the barriers in planning, implementation and follow-up of the work on well P-31A. Only chance and fortunate circumstances prevented a major accident with the danger of loss of many lives, damage to the environment and additional loss of material assets."

SNA was originally operated by Saga Petroleum, thereafter Hydro, and from 1st of January 2003 the responsibility was transferred to Statoil. This created changes in the structure of the organization that could be compared to changes coming from Integrated Operation re-organizations. The dissipation of knowledge is a possible outcome of the take-over. The official investigation report contains some viewpoints on the operator's (Statoil) coordinating involvement in the operation:

"*For this incident, we see that work methods have not involved expert groups from the main office, i.e. the Statoil organization in general, to any great extent. It could thus seem that the transition to Statoil's work methods and the introduction to governing documents have taken too long. During the time immediately prior to the incident and in parallel with the planning, processes were underway related to several organizational changes, both in the land organization and on SNA. There were plans for rotation of the lead drilling engineer, lead well engineer and the well operations supervisor. In addition, the senior manager for Snorre (manager RESU SN) was moving into a new position. Therefore, as planned, Snorre got a new manager on the same day that the incident took place."*

In addition, the report takes up the role of the contractors and how replacement of contractors may have contributed to the accident. The program engineer who was assigned the task of preparing the well program was hired in as a consultant for Statoil. The planning was largely left up to the program engineer, without much management, guidance, involvement and prioritization from senior management. In November 2004 there was a change of drilling contractor from ProSafe to Odfjell Drilling. Such changes may have created discontinuities that eventually lead to a fragmentary understanding of the implementation of the safety barrier at SNA.

CONCLUDING REMARKS

Safety Management is a challenging task when organization structures are being changed. Safety by itself presupposes that high quality knowledge is available, knowledge that would secure the required safety. Not all such required knowledge has been documented, and part of it is only residing as tacit knowledge in the heads of the employees. Thus open communication channels are required for adequate safety management to be implemented. In this way, Safety management resembles the more general field of *knowledge management*.

Knowledge management is a discipline that improves the creation, distribution, and utilization of knowledge to create and retain greater value from core business competencies.This ability depends on the capacity for organizing knowledge so that it can be used in situations when it becomes relevant. Attaining successful knowledge management also depends on the attitudes and willingness of the individuals of the organization to improve their performance in this respect. During a re-organization a lot of already established communication channels are disrupted and new ones need to be built up. This rarely happen instantly, and it is often required to collect experience over time to assess the new safety management and its resulting safety level.

REFERENCES

Davenport, T.H. & Prusak, L. (1997) *Working Knowledge: How Organizations Manage What They Know.* Harvard Business School Press.

Miller J.G. (1978) *Living Systems*. McGraw-Hill, New York.

Tsuchiya, S. Narushima, T. & Inanobe, M.(2001) Knowledge Management Aspect of JCO Nuclear Accident. *Paper presented at the ISMICK'01 Conference*.

Tsuchiya, S. (unpublished) *Corporate Business Ethics - Analysis and Leverage.*

Berry, J.R. & McCormack, N.J. (2003) Overcoming pore-pressure challenges in deepwater exploration. *Offshore, June 2003*.

Chapter 13: Elements of Uncertainity and Risk in Intercultural Contact

Ingemar Torbiörn
Department of Psychology
Stockholm University
S-106 91 Stockholm
itn@psychology

ABSTRACT

Intercultural exchange is discussed from a perspective of risk in terms of generally unwanted outcomes of contact. Elements of risk are identified at individual and organizational levels and it is held that risk emanates from basically the same psychological or human factors. At organizational levels, risk is taken to manifest as frictions or costs of transaction. At the individual level the commonplace phenomenon of substitution is proposed to mediate risk. The occurrence of substitution, i.e. acceptance without understanding or acceptance of what would normally not be accepted, may increase as well as reduce risk. The same holds for the non-occurrence or lack of substitution. The phenomenon is discussed regarding its relation to trust as well as to qualities of intercultural situations. It is argued that substitution may be either favored or disfavored depending on the situation in order to reduce risks in intercultural contacts.

Key words: intercultural contact, international management, cultural risk, transaction costs

INTRODUCTION

The concept of *risk* is normally not associated with intercultural contact. The focus on risk in this paper does not intend to portray such contact as generally or predominantly risky or problematic. Rather, the position taken here is that outcomes of intercultural encounters or contact are normally unproblematic, i.e. positive to the parties involved. Still, much research in the field emphasizes problematic aspects, this to an extent that Weiss (1998) held to reflect ”cross-cultural paranoia”.

In a social psychological sense intercultural contact means a confrontation between frames of reference or systems of norms belonging to different cultures. Every individual is to some extent the representative of norms emanating from some particular culture. Then, of course, contact with what differs from one´s own thinking and behaviours might possibly produce problematic outcomes. Depending on the context where contact takes place this could mean a risk of something unwanted, negative or even dangerous to occur. As processes of internationalisation imply a rapidly increasing number of instances of cross-cultural contact at several levels, e.g. for individuals, organizations, managerial decisions, work groups, etc. a systematic concern about what might imply ”risks” becomes more relevant. This paper shall deal with psychological aspects of intercultural contact in trying to isolate some elements of risk, not in the sense of some given probability but rather in terms of uncertainty as regards unintended or unwanted outcomes of contacts.

MEANING AND FUNCTION OF CULTURE

Culture is normally defined as a set of norms and underlying values that is shared and used by some group of people (Berry et al. 2003). Norms generally denote to a person what works best, what is preferred or what is normal. By cultural norms is meant what typically applies in a given situation or is used in a national context. Here cultural norms govern behaviours and interpretations among people in some, but not all respects. Besides cultural norms there are, for every member of a culture, group norms, e.g. organizational norms, and furthermore strictly individual norms that govern behaviours in situations where cultural norms do not apply. Thus, although the frame of reference of any individual to some extent reflects his or her culture, national culture does not govern all behaviours of its members, but only behaviours in some situations. Nor do the members of a culture constitute the culture itself, only the norms they adhere to do so.

A culture fills several important functions. At a social level it coordinates behaviors among people at a given point in time, and over time it coordinates across generations as new members internalise or get socialised to cultural norms. Here it is evident that cultures favor smoth and efficient interaction among members and represent an accumulation over time of experiences and knowledge. At an individual, psychological level culture fills three major functions. One function deals with *cognition*, that is the selection and interpretation of environmental information. Insofar as there is a cultural norm available, this means that the situation requires no problem-solving, and perhaps even that it may be handled in an unreflected manner. Here, culture favors efficiency in a persons handling of situations by supplying norms for appropriate actions and interpretations. Further, as regards *appraisal* of or the valuing of situations cultural norms may supply standards for judging what is good or bad, important or unimportant, acceptable or not, what to prefer or give priority to, etc. Cultural norms also fill important functions in terms of personal *identity*. Having access to internalised norms on how to handle situations helps an individual to experience familiarity with, security or trust in being able to successfully handle a context (”mastery aspect”). Further, cultural identity denotes to a person who he or she is and who is somebody else. This may be relevant in situations concerning acceptance or trust associated with ”we or them”, ingroup or outgroup relations, etc.

Elements of risk/uncertainty in intercultural exchanges

Based on the social and psychological functions of culture as described above it is easy to conclude that the functions above may be disturbed or fail in situations of intercultural contact, i.e. when cultural norms on one part are confronted with differing norms that are held by another part. This may generally cause unexpected, unwanted or problematic outcomes, and the more so as encounters may be of a bilateral kind, i.e. misunderstandings, non-acceptance, mistrust etc. may go for any of two parties. Theoretically, the situation may be further complicated insofar as the relation in terms of cultural norms of the two parties is non-reciprocal, i. e. what is seen as important or relevant by one party may not be seen so by the other. Generally seen, we propose here that many problems regarding intercultural encounters may reflect human, psychological factors according to table 1:

Table 1. Elements of risk/uncertainty from human/psychological factors in intercultural contact:

= bias from cognition: not understanding/ seeing/ knowing
/ disregard from relevant options
/ stereotyping

= bias from appraisal: acceptance / non-acceptance / ethnocentrism /
standards / values / priorities in one culture may not apply or be relevant in other culture

= identity level bias: mistrust before what is different / unfamiliar / strange
(we vs them dimension)
lack of confidence in handling situations
(mastery dimension)

Risk emanates from both parties in contact and in non-reciprocal ways.

Table 1 only refers to what may be due to real differences between cultures among parties. That is, problems due to clashes between other than cultural norms, e.g. group- or individual norms are not caused by the intercultural character of the context. Still such clashes are often wrongly attributed to cultural differences as these may be most apparent or visible. Insofar as real cultural differences exist it should be evident that the biases might imply risks in terms of causing unexpected or problematic outcomes or consequences. As human beings hold frames of references that are to some extent culturally determined, as they act as private individuals or as representatives of some organisation, biases of the kind described should be relevant and may cause problems in several instances of intercultural contact , e.g. in the management of international business operations, in heterocultural work-settings as well as in the lives of private individuals. This will be further discussed below.

Elements of risk/uncertainty in organizational behaviours

What is normally termed organizational culture is constituted by norms from some national culture in addition to a set of firm-specific norms at group- or organizational level. This, since all organizational activities take place within some national context. As organizations or firms operate internationally, i.e. across cultural borders this means that at least two or more national cultures are involved. As compared to strictly national firms international activities mean more options in that firms may take advantage of the use of norms or conditions not available in the home culture. At the same time this poses the generally most delicate challenge in international management, the so called central vs local dilemma (Doz, Bartlett & Prahalad,1981). Thus, in many instances of organizational behaviour it has to be decided which norms to use in foreign culture host markets, those of a firms home culture or headquarter or those prescribed by a local host culture. Both choices may be advantageous to company goals but both choices may also imply risks in economic terms or in terms of efficiency of operations, risks to people or environment, competitiveness, profitability, unethical behaviour etc.

Acting in a similar or standardized way across cultural borders may produce economies of scale. If, however, the norms of the home culture do not apply in a host culture this may mean failure, more costs or sanctions of some kind. On the other hand, so called local responsiveness or the use of host culture norms, may offer more options to firms as well as possible synergies, but it could also mean higher costs, or less efficiency as operations need to be differentiated across markets. For example, a major economic goal of EU to reduce the need for differentiation across EU national markets due to non-tariff barriers of trade, thus making EU more competitive versus other regions. More specifically if contexts in which international activities take place are governed by the same or similar norms, it is possible to act in standardized fashions across cultural borders. If cultural or national norms differ however, this may not be possible. Further, if the context of activities is subordinated to cultural norms (culture-bound) in one culture but not so in another culture where the corresponding context is open to firm-specific norms or not regulated by any specific norms, firms are free to choose between e.g to adhere to strict safety regulations of security at work as used in the home culture, or to use less strict or less costly regulations in a host culture. Such decisions imply both opportunities and risks of possibly great economic importance to firms. Further they may concern ethical conduct in terms of absolutism, i.e. always sticking to sacred values, or of relativism, i.e. always adopting local values. Thus mistakes in terms of both refraining from the use of home culture norms as well as adhering to such norms, have led to serious consequences in terms of loss of human lives (Donaldson, 1996).

Generally seen a choice or tradeoff between central or local (home- or hostculture norms) is needed in many instances of international operations. Such decisions and consequent behaviours or performance are generally subject to the types of bias shown in table 1. Thus misunderstandings, unsufficient discrimination, misperceptions regarding what is relevant for appropriate action, lack of knowledge or simply of competence may cause unintended, problematic outcomes. So do also appraisal of what is best or preferable, what to accept or not, as well as mistrust visavis what appears different or ”strange”. Such bias may affect decisions at several organizational levels as long as human factors are somehow involved. Thus it may affect or manifest itself in corporate cultures, adopted policies and strategies as well as in design and applications of administrative and technical systems. Further it may manifest itself through top-to-bottom chains of decisions as bias is strengthened or introduced in consecutive implementations of decisions.

One important aspect here regards staffing. The act of staffing, i.e. selecting individuals for certain roles or positions, and the use of this selected staff may be seen as one among other parameters of firms, or as a tool intended for company success or competitiveness. In international contexts, however, staffing may be important beyond a matter of just providing or allocating competence. Particularly, as concerns staffing of key positions, it means that the issue of what category of staff is used may be relevant, this as any individual, beyond professional skills, is a representative of his or her own culture, that is, he or she holds culturally determined norms for understanding and evaluating situations. As this staff also acts on behalf of their organisations, there should be, based on pragmatic reasoning, a link between staffing decisions and firm performance in local scenes of operations (Torbiörn, 2005). Such a link should manifest itself first through the functioning of the selected staff in the local setting. Besides professional qualifications such functioning may be due to complexities of cross-cultural role relations (Torbiörn, 1985; Dowling & Welch, 2004).

Cross-cultural role relations. As decisions on staffing key positions may be taken at corporate level in HQ´s of firms, environments that are often pervaded by home-culture norms, this may per se imply risks of making biased decisions, the consequences of which manifest at the level of direct intercultural contact. As seen in terms of social roles it should be clear that interaction may be complex in several ways. As the performance in crosscultural roles may not only be a matter of technical communication, e.g. through the understanding of languages or assessment of what is appropriate action, but possibly also of ethnocentrism and of trust (or lack of trust), it is evident that the fulfillment of role expectations that go with positions in international operations may depend on whether the person occupying the role is a representative of the home-culture of an organization or of the host-culture in which role performance takes place, or of some third culture (Zeira & Harari, 1977; Zeira & Banai, 1981; Torbiörn,1985; Dowling & Welch, 2004).

Thus it has been demonstrated that staff recruited from the home culture of firms, so called parent country nationals (PCN´s) may easily conceive of and accept role-expectations from HQ´s, but less so expectations from host culture role-senders, e.g. colleagues, subordinates. In addition, they may find it hard to translate their role conception into what is appropriate in the local host-culture context. Although PCN´s may enjoy trust or confidence from HQ´s they may not do so from their local colleagues.

Correspondingly staff that is locally recruited from the host-culture, so called host country nationals (HCN´s) may find it harder to understand and comply with expectations from HQ´s situated in cultures other than their own. Although they are familiar with the local context, perform easily in the host-culture setting and can meet expectations from local role senders they may enjoy less trust from HQ´s than do PCN´s.

Another category of staff is recruited from some third culture, i.e. neither from a firms domicile culture nor from the culture where operations take place, so called third country nationals (TCN´s). They may face difficulties in communicating with both HQ´s and with the local context. Furthermore, they may face lack of trust from both sides. They have been found to sometimes take on a strictly professional, detached and administrative attitude in their role performance (Zeira & Harari, 1977). The process of internationalization of business favors the use of TCN´s among firms although their careers are still more often lateral than vertical, i.e. the may not reach the top echelons of corporations. Today, as far as operative posts are concerned the use of PCN´s tends to be proportionately reduced in favor of the use of HCN´s although strategic level positions are often reserved for PCN staff (Torbiörn, 1997).

Cultural risks and transaction costs. Oliver Williamsons (1975) transaction cost theory is of a general kind and does not deal with intercultural aspects in particular. Still, it appears to hold relevance also for management across cultural borders. The theory explicitly links human factors in organizational behaviour with the concept of risk. It suggests that the birth of organizations, their structures, competitiveness and long term success is due to their handling of transaction costs. Such costs stem from tensions or *frictions* associated with the manners in which operations are performed, internally within organizations and visávis the environment of firms. Transaction costs emanate from frictions per se and from organizational efforts to reduce them. Risk is the source of frictions and of transaction costs, and is in turn caused by *information impactedness* i.e. by the fact that otherwise existing information may be locked in and not available for decision-makers. Information impactedness, and thereby risk, frictions and transaction costs, is the result of interaction between human and environmental factors. Human factors are of two kinds, *bounded rationality* dealing with capacity and limitations in the storing, retrieving and processing of information, and *opportunism* which refers to lack of candour or honesty in transactions, or simply to deceived trust. Environmental factors are also of two kinds, *uncertainty/complexity* and *small numbers*, the latter denoting that situations faced by organizations may be rare or inexperienced to the extent that information about them may not have been systematized into knowledge or competence.

The theory has been explicitly applied to research and theorizing on cross-border operations of firms and on international management (Doz & Hamel, 1998; Leepak & Snell, 1999; Erdener & Torbiörn, 1999, 2001). In an intercultural context information impactedness may arise from the interplay between bounded rationality and uncertainty/complexity due to additional information processing requirements as more things may be difficult to sort out, understand and assess correctly. Assymmetries in the complexity of cultural systems/cognitive frameworks and the associated skill level needed to function effectively across cultural systems may here increase *cultural risk* and *cultural frictions* (Erdener & Torbiörn, 2001). This may be attributed to the fact that parties in an intercultural exchange face *cultural barriers*, i.e. limitations in the capacity to understand, accept and adapt to certain norms of a given foreign culture depending on how different this culture is perceived to be (Torbiörn, 1988). Further, such barriers may be effective in non-reciprocal fashions between the parties involved.

As regards the environmental factor ”small numbers” limited experience within an organization of operating in a certain foreign culture may similarly add to information impactedness, risk and friction. Evidently this would also be the case insofar as opportunism is involved, i.e. as intercultural contact invokes the dimension of trust/mistrust. In such cases the ”we vs them” aspect may be prominent as may so called relational trust (rather than institutionalized trust or calculative trust). Western businessmen, for example, often experience that trust in some Asian cultures is not what is formalised and signed but what results from interaction between parties over time.

TRUST AND SUBSTITUTION IN INTERNATIONAL CONTACT

In the first section of this chapter social and psychological functions of culture were specified. It was suggested that these functions may fail in cross-cultural contacts due to bias in cognition, appraisal and aspects of cultural identity. Such misfunctioning may imply risks of unwanted outcomes. In this section focus is on one particular facet of intercultural exchanges namely on what is here termed *substitution*. Thus it is a fact that one sometimes, not only in intercultural contexts, accepts what is beforehand in a situation without understanding it, or that one accepts what one would normally not have accepted. As far as one may feel confident that the outcome of the exchange will be positive or unproblematic one may leave it to the counterpart to supply what is lacking with oneself, e.g. understanding, skills, etc. Thus trust may here be a substitute for understanding and/or, what would have been the normal case, for non-acceptance. Although substitution is an everyday or commonplace phenomenon it is held here that it is more often called for in situations of intercultural contact than otherwise, and that it is more relevant or important here for the appropriate coping with situations and for the outcomes of them. Substitution, where it occurs, may of course imply risks in terms of failures, tensions or breaks in the exchange insofar as it is due to the biases previously discussed. So may also the absence of or lack of substitution where it would have been appropriate. Heterocultural work groups, for example, need more time to function effectively than do homogenuous groups (Milliken & Martin, 1996; Watson et al., 1998). This may be accounted for by unsufficient substitution among members of groups in initial phases of collaboration. Thus substitution, where it is appropriate, may also contribute to positive outcomes and reduced risk.

The occurrence of substitution is closely linked to the phenomenon of trust as some kind of trust is a prerequisite for substitution. Regardless of ones understanding of a situation trust or mistrust may favor or not favor acceptance. (This applies besides the case where situational demands may promote a forced consent or acceptance, and besides the case where acceptance may be based on gullibility or naivety.) Trust is sometimes defined as ”a willingness to be vulnerable” (Jones and George, 1998; McKnight, Cummings,& Chervany, 1998) and holds three components, a risk of being hurt or harmed in some way, a dependence of the other part or of the situation, and the expectation that the outcome will be positive. Trust may be a matter of initial trust in a situation or it may result from repeated experiences of unproblematic outcomes where substitution has occurred.

A SUBSTITUTIONS PERSPECTIVE ON SITUATIONS

Generally seen it is the situation that determines whether trust, substitution (or no substitution) may be appropriate in reducing the risks of negative outcomes. Thus, for intercultural exchanges where the need for substitution and trust may be more pronounced than otherwise, it should be worth investigating into what situations or aspects of them would (or would not) require or promote substitution or trust. Thus looking at situations from a perspective of substitution may reveal instances of risk as well as, possibly, ways to reduce risk insofar as situations may be influenced or handled. For many commonplace, or recurring contexts this should be easier than to influence what is culturally determined in the cognitive frameworks of individuals. Here measures to set situations in order to promote (or hinder) substitution could reduce risks, and so could measures to promote trust. The option to influence or handle situations of intercultural contact may be more available to organizations than to individuals. Here some types of situations or contexts may be frequent or standardized, e.g. international negociations, leadership across cultural borders, heterocultural work-teams, etc. Some general facets of intercultural situations that may affect substitution are described below.

Time, duration of contact, and processes of adaptation are central for the phenomenon of substitution. In the initial phases or first turns of an intercultural exchange substitution or the lack of substitution are most relevant and affect risk the most due to unsufficient feedback and learning. A prolonged exchange allows for the sharing of information, adaptation and possibly convergence toward mutual understanding and trust (Kincaid,1988). This may reduce risk of unwanted outcomes by allowing for substitution but at the same time makes substitution less relevant in producing risk.

Anxiety before what is strange, unexpected or unfamiliar may call for the use of psychological defences. These may concern the effectiveness of communication (Gudykunst & Nishida, 2001) and hinder substitution where it is needed to produce unproblematic outcomes thus increasing risk. Here reduced uncertainty may favor substitution.

Cultural barriers require more substitution insofar as they are high, i.e. as the difference between cultures involved in an exchange is perceived as large by some or both parties. Here, although sometimes necessary, substitution may mean a greater risk. Thus Sarbaugh (1988) suggests that communication requires more energy and that the likelihood to achieve an intended outcome decreases. Furthermore, the degree of reciprocity as regards what norms are central to each of the parties of an intercultural relation may affect substitution and thereby risks. High reciprocity may disfavor substitution as central or valued norms are involved, but favor substitution in more periferal aspects. Low reciprocity may generally favor substitution as it may offer more opportunities of it. Low cultural barriers generally favor substitution but make it less relevant for exchanges.

Setting or the context where a cross-cultural exchange takes place should affect substitution. Familiarity with a corresponding context from the parties own cultures, e.g. restaurants, sports arenas, etc. may thus favor substitution or not do so.The same holds for relational demographics of situations (Tsui, Egan & O´Reilly, 1992) in that similarities in age, gender or profession of the parties may be more prominent than cultural differences. The setting may also require more or less of facework, i.e. the saving of ones own ”face” or that of ones counterpart (Ting-Toomey & Kurogi, 1998). This should affect the readiness for substitution.

Besides the facets of situations exemplified above, other factors of possibly less particular relevance for intercultural encounters should affect substitution and risk. Issues of power and dependency, of a common purpose or goal, of whether a situation is of a win-win or win-loose type should be generally important here. Insofar as situations or contexts of intercultural exchange may be influenced risks or frictions may possibly be reduced as such factors are taken into consideration as regards, e.g. leadership of heterocultural groups, international negociations, strategic and operational decisions in international organizations.

SUMMARY AND CONCLUSIONS

This chapter has focused on and been devoted to illustrating elements of risk in intercultural contacts. It has been held that such elements may be derived from basically the same psychological, human factors regardless of whether a contact or cross-cultural exchange takes place within or between organizations or at the indivudual level, and regardless of whether contacts are direct or indirect, e.g. occur in the application across cultures of policies or systems. Still it should be emphasised that the outcomes of most intercultural exchanges are unproblematic and that the notion of risk does not normally refer to danger or accidents, etc., but rather to tensions, frictions, inefficiency, or what is generally unwanted outcomes to one or several parties involved in such contact.

As regards international operations of firms elements of risk were illusrated at several organizational levels, in staffing decisions and in cross-cultural work roles. For organizational contexts the transaction cost model by Oliver Williamson (1975) was proposed as an illustration of the link between human factors and organizational risks or frictions. At the level of individual functioning the phenomenon of substitution was proposed as a mediator of risk. Further, the phenomenon of trust was linked to substitution as a prerequsite for it. Thus, where there is trust substitution may occur, where trust is lacking substitution may not occur. This complicates intercultural exchange as in some contexts cross-cultural relations per se may imply reduced trust. This may hinder substitution where it is required for unproblematic outcomes. Still, generally seen, as risk is increased where substitution occurs or does not occur this was held to be undesirable. As substitution or absence of substitution may decrease risk this was held to be desirable.

In this chapter it was also argued that the matter of whether the occurence of substitution is desirable or not is highly dependent on the situation at hand, i.e. the situation mediates the need for substitution. Thus, information on qualities of situations may be needed to judge risks or outcomes of cross-cultural exchange. Some examples of such qualities of particular relevance for intercultural contacts were discussed. Further, it was argued in this chapter that, in order to affect or manipulate risks, the situation might be easier to set or influence than might actors in the situation, as these represent deeply rooted cultural frameworks. It was also held that this option might be more available and rewarding in organizational settings and here primarily as regards frequent, recurring or standardized situations. Still, at organizational as well as at individual level, knowledge of what may favor or hinder substitution may facilitate the handling of intercultural contact. Here, more research on the interplay between situational qualities and substitution is needed. Likewise, at organizational as well as at individual level, the capacity to assess intercultural situations in terms of what substitution is requred or not required, desirable or not desirable, may be an essential component of what may be termed intercultural competence.

REFERENCES

Berry, J., Poortinga, Y., Segall, M. & Dasen, P. (2003) *Cross-cultural psychology: Research and applications*. Cambridge UK, Cambridge University Press.

Donaldson, T. (1996) “Values in tension: when is different just different, and when is different wrong?” *Harvard Business Review*, Sept.-Oct., pp 48-62.

Dowling, P.& Welch, D. (2004) *International Human Resource Management.* London, Thomson Learning.

Doz,Y., Bartlett, C. & Prahalad, C. (1981) Global competitive pressures and host country demands. *California Management Review*, 23(3), 63-74.

Doz, Y. & Hamel, G. (1998) *Alliance advantage: the art of creating value trough partnering.* Boston, Harvard Business School Press.

Erdener, C. & Torbiörn, I. (1999) A transaction costs perspective on international staffing patterns: implications for firm performance. *Management International Review*, No 3, 89-106.

Erdener, C. & Torbiörn, I, (2001) International staffing patterns and transaction costs: implications for alliance readyness and firm performance. In J. Genefke and F. McDonald (eds), *Effective Collaboration*, Chippenham, UK, Palgrave MacMillan.

Gudykunst, W. & Nishida, T. (2001) Anxiety, uncertainty and perceived effectiveness of communication across relationships and cultures. *International Journal of Intercultural Relations* 25(1), 55-72.

Jones, G. & George, J. (1998) The experience and evolution of trust: implications for cooperation and teamwork. *Academy of Management Review*, 23(3), 531-546.

Kincaid, D.L. (1988) The convergence theory and intercultural communication. In Y.Y. Kim & W. Gudykunst (Eds.) *Theories in Intercultural Communication.* Newbury Park, Sage.

Leepak, D. & Snell, S. (1999) The human resource architecture: toward a theory of human capital, allocation and development. *Academy of Management Review*, January: 31-48.

McKnight, H. Cummings, L.& Chervany, N. (1998) Initial trust formation in new organizational relationships. *Academy of management Review*. 23(3), 473-490.

Milliken, F. & Martins, L. (1996) "Searching for common threads: understanding the multiple effects of diversity in organizational groups." *Academy of Management Review*, 21(2), 402-433.

Sarbaugh, L.E. (1988) A taxonomic approach to intercultural communication. In Y.Y. Kim & W. Gudykunst (Eds.) *Theories in Intercultural Communication.* Newbury Park, Sage.

Ting-Toomey, S. & Kurogi, A. (1998) Facework competence and intercultural conflict: an updated face-negotiation theory. *International Journal of Intercultural Relations*, 22(2), 187-226.

Torbiörn, I. (1985) The structure of managerial roles in cross-cultural settings. *International Studies of Management and Organization*, 15(1): 52-74.

Torbiörn, I. (1988) Culture barriers as a social psychological construct: an empirical validation. In Y. Kim & W. Gudykunst (Eds.) *Cross-cultural adaptation: current approaches*. Newbury Park, Sage.

Torbiörn, I. (1997) Staffing for international operations. *Human Resource Management Journal*, 7(3): 42-51.

Torbiörn, I. (2005) Staffing policies and practices in European MNC´s : strategic sophistication, culture-bound policies or ad hoc reactivity. In H.Scullion & M. Linehan *International Human Resource Management - A critical text.* Chippenham, Palgrave Macmillan.

Tsui, A.S., Egan, T., O´Reilly, C.A. (1992). Being different: relational demography and organizational attachment. *Administrative Science Quarterly*. 37, 547-579.

Watson,W., Johnson, L.,Kumar, K., Critelli, J. (1998) Process gain and process loss: comparing interpersonal processes and performance of culturally diverse and non-diverse teams across time. *International Journal of Intercultural Relations*, 22(4), 409-430.

Weiss, A. (1998) Global doesn`t mean ”foreign” any more. *Training*, July, 50-55.

Williamson, O.E. (1975) *Markets and hierarchies*. New York, Free Press.

Zeira, Y. & Harari, E. (1977) Third country managers in multinational corporations. *Personnel Review*, 6(1), 32-37.

Zeira, Y. & Banai, M. (1981) Attitudes of host-country organizations toward MNC´s staffing policies: a cross-country, cross-industry analysis. . *Management International Review* 21(2), 38-47.

Nordic perspectives on safety management in high reliability organizations: Theory and applications

Edited by Ola Svenson, Ilkka Salo, Ann Britt Skjerve, Teemu Reiman and Pia Oedewald

This volume presents safety management in different high reliability organizations using different theoretical perspectives and empirical results. Safety management in the nuclear power industry, civil air transportation, the oil drilling and production industry and some societal regulators exemplify themes covered in the chapters of this volume. In addition to applications in a particular field, each chapter also presents information that is of generic value for the field of safety management. For those involved in management of safety and risk the chapters in this book will be of great value.

Many different organizations and funding agencies have supported the work covered in this volume including the Swedish Nuclear Power Inspectorate. However, without a grant from Nordic Nuclear Safety Research (NKS) the volume would not have been realized. The volume can be ordered from any of the editors or from Ola Svenson, Department of Psychology, Stockholm University, S - 106 91 Stockholm Sweden /osn@psychology.su.se/.

Title	Nordic perspectives on safety management in high reliability organizations: Theory and applications
Editor	Edited by Ola Svenson, Ilkka Salo, Ann Britt Skjerve, Teemu Reiman and Pia Oedewald
Affiliation(s)	Stockholm University, Sweden
ISBN	87-7893-193-2 *Electronic report*
Date	April 2006
Project/Sub Project	NKS_R_2002_04 SafetyManagement
No. of pages	194
No. of tables	20
No. of illustrations	29
No. of references	375

Abstract

The chapters in this volume are written on a stand-alone basis meaning that the chapters can be read in any order. The first 4 chapters focus on theory and method in general with some applied examples illustrating the methods and theories. Chapters 5 and 6 are about safety management in the aviation industry with some additional information about incident reporting in the aviation industry and the health care sector. Chapters 7 through 9 cover safety management with applied examples from the nuclear power industry and with considerable validity for safety management in any industry. Chapters 10 through 12 cover generic safety issues with examples from the oil industry and chapter 13 presents issues related to organizations with different internal organizational structures.

Although the many of the chapters use a specific industry to illustrate safety management, the messages in all the chapters are of importance for safety management in any high reliability industry or risky activity. The interested reader is also referred to, e.g., a document by an international NEA group (SEGHOF), who is about to publish a state of the art report on Systematic Approaches to Safety Management (cf., CSNI/NEA/SEGHOF, home page: www.nea.fr)

Key words	Safety management

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