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SAFETY MANAGEMENT OF NUCLEAR POWER PLANTS: Values and balance of attention

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List of content:

- 1 Introduction
 - 1.1 Safety management; control and learning
 - 1.2 The management of nuclear power plants (NPPs)
 - 2 Safety cultures and value systems
 - 3 Research into values and safety culture
 - 4 A Model
 - 4.1 A note on safety management strategies
 - 5 Some related theoretical orientations
 - 5.1 Internal Process Model
 - 5.2 Human relational model
 - 5.3 Rational Goal Model
 - 5.4 Open system models
 - 6 Values in interaction
 - 6.1 Financial management and quality management in interaction
 - 6.2 HRM and financial management in interaction
 - 6.3 Financial management and technology management in interaction
 - 7 General discussion
- References

Safety management of Nuclear Power Plants: Values and balance of attention

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 differentiate among 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, perceived as *internal* organisational focus topics, sets of matching *external* focus areas are identified. Upper management of NPPs is analysed as a movement in a problem space in which the organisation seeks to optimise and integrate partly conflicting values in a search for integration and adaptation to external demands.

1 INTRODUCTION

The present article will address issues of safety management in general and those related to NPPs in particular by an attempt to show some views and perspectives related to the subject and also provide some tentative ideas for further research. This paper grew out of an ambition to integrate some of the research traditions explicitly devoted to safety, such as the safety culture framework, with traditions that have had a more general focus on management, organisational culture and research about values. A framework model is presented that could be used to inspire further research as well as supporting new interpretations of already collected data. Nuclear Power plant has been the primary subject area for this article but the model presented may easily be generalised to other industrial branches.

Of special interest, in this article, are values held by management groups and their attempt to balance various issue domains. The present work is in line with, for example, research performed by Grothe and Kunzler (2000) in the sense that models of safety (and safety culture) is perceived in a context of general organisational culture and where cognition, behaviour, general job characteristics and technology are seen as interacting domains. The present suggestions are also in line with a social influence perspective on safety in which communication, power, influence etc are assumed critical. Furthermore, a strong inspiration for the present work has come from research by Reiman and Norros (2002); Oedewald and Reiman (2002) which have addressed many of the issues presented below.

1.1 Safety management; control and learning

Safety management is often conceived of in a cybernetic control framework: states are measured and compared with reference values as a basis for regulative action. The possibility of creating support systems for risk management departing from a control view is also given more and more attention: For example, in what Rasmussen and Svedung (2000) refer to as a *proactive risk management* framework, the following features are assumed to be essential for designing a risk management support system; Identification of the *critical decision makers* (inside and outside the organisation); *identification of the work spaces* (the criteria for role allocation); the *structure of the distributed control system* (i.e. the structure of the communication network that connects the decision makers); the *content of the information* flow among

decision makers; *risk awareness*; *capability of decision makers*; and ; *commitment of decision makers*.

A difficult problem with the control metaphor and the kind of normative suggestions exemplified above concern the rapid changes taking place in systems of today. The idea of making “boundaries visible” (i.e. the boundaries that separate safe from unsafe operation) requires a dynamic model of risk assessment that, apart from modelling the dynamics *given a reasonable stable system*, also can incorporate structural changes in technology, work practices, organisational structure, environmental factors etc. Attempts to connect issues of safety management to the sharp technological end of systems are still on the research stage and their future role as realistic tools for safety management remains unclear.

A second problem with the control metaphors of safety management is that they tend to *underestimate the cognitive heterogeneity* associated with different actors, groups and subcultures in complex systems. There are innumerable possible “states” for potential measurement in a complex socio-technical system and in lack of a comprehensive model of system dynamics, safety management partly becomes an issue of negotiation that depend on power distribution among different stake holders having various beliefs, different values and priorities of what could constitute a risk etc. In fact, there is a risk for development of “false safety” inherent in the control metaphors since officially expressed beliefs of assumed “boundaries” may be false, limited and insufficient representations of the system.

The most common criticism, however, towards the cybernetic control metaphor (although “control” is sometimes viewed in somewhat simplistic version) is that it seems insufficient for a model of learning that fosters new insights and change, especially in contexts of high uncertainty (Den Hertog, 1978; Markus and Pfeffer, 1983; Sitkin et al., 1994). To complement control strategies with approaches with a more explicit focus on generative learning and the cultural context in which learning take place has, consequently, emerged. Learning is viewed as a collective process involving transformation of knowledge between groups - various perspectives are transformed, discussed and negotiated (Wilhelmson, 1998; Mezirow, 1990).

The notion of safety as something in need of continuous construction and *reconstruction* through communication among actors is appealing but it may, however, overlook the importance of *decision making and action*. Researcher such as Mintzberg (1973) and Simon (1945), for example, have suggested that decision making and “managing” are almost synonymous concepts. A more complete view on safety management, thus, should consider not only the general system context, communication and the actors involved but also the *process of decision making in itself*. A particularly interesting perspective in this respect concern the *process of agreement* in management groups and the possible safety significance associated with such decisions. A recent dissertation by Tomicic (2001) gives a valuable oversight of factors connected with the process of reaching agreements in management teams. Although the work is not devoted to safety management per se, the research by Tomicic has general value for understanding safety management (which may be hard to separate from other management issues).

Tomicic distinguishes among two different perspectives on agreement in management groups: a cognitive perspective and a social influence perspective. The cognitive perspective focuses on shared values, beliefs and opinions whereas the social influences perspective address communication, interaction and processes of influence. The cognitive perspective has an obvious connection with cultural views about safety (i.e. the safety cultural tradition). Based on the “cognitive revolution” and theoretical frameworks such as, for example, represented by Weick (1995) an interest in subjective interpretations, “perceptions of organisations” and

cognitive factors associated with strategic change and decision making in organisations has emerged (Stubbart, 1989).

Knowledge, meaning, information etc are all concepts associated with cognitive perspectives of organisation and they also form a theoretical base for concepts such as “learning organisation” and “organisational culture”. With respect to safety management and decision making, the assumption about “shared cognition” also associates to efficiency of decision making in various ways. Some writers such as Brunsson (1982; Ginsberg, 1994) points to the experienced facilitative aspects of shared realities by a tendency to reduce uncertainty, save time and cognitive resources. Applied to safety management situations, the potential positive side of shared views has, however, to be balanced with the negative possibility of being limited in scope. This is an intricate problem: sometimes fast decision and subsequent action promote safety and sometimes not. *Cognitive heterogeneity* based on different experiences in subcultures, heterogeneity in areas of expertise, differences in values etc may increase the probability to detect harmful side effects of decisions, facilitate the detection of new boundary conditions etc. We shall return to this issue later.

Agreements are not necessarily a sign of shared mental models. There has, in fact, been a tendency to generalise research and methodology from individual focused decision making traditions to apply also for group settings (Walsh, 1995; Spender, 1998; Schneider and Anglemar, 1993) and thereby a tendency to underestimate the communicative, cultural and social factors that influence group decision making. This is not to say, however, that research conducted in more classical information processing and decision making paradigms are not of interest for generalisation to group decision making. On the contrary, research such as Millers (1960) conceptualisations about coping with information overload provides an interesting basis for hypotheses about decision making in safety management group settings. Another example is illustrated by the research provided by Kahneman and Tversky (1973; 1982; 1984) concerning cognitive biases relating to decision making.

To view the process of reaching an agreement as a social enterprise (for instance safety-related decisions) opens for a *complementary* analysis, which is not only focused on assumptions and values held by individual and groups (individual and shared cognition's) but also focus on the social dynamics associated with these settings. In relation to safety management, this perspective relates to studies of communication, methods of influence, power relations etc. As commented by Tomicic, the social perspective of decision making (i.e. agreement) is similar to a *political perspective on decision making* in which various interest groups attempt to influence each other in the decision process. Tomicic also refer to a study by Hickson et al, (1986) which found that “influence” and “issue complexity” were the most important factors to influence the decision process.

In summary, Tomicic, express the benefits of the social perspective of studying agreement as: “Unlike the cognitive perspective, social influence theory directs attention to social processes in which agreements are reached, and to aspects regulating who is involved in reaching of agreement and who is left out or kept out; who is able to introduce items on the agenda or keep them of; who is allowed to exert influence and who is not. Understanding of these issues are central to an understanding of reaching agreement and politics in organisations” (p. 20).

It is appropriate here, to briefly return to the control framework of Rasmussen and Svedung, mentioned in the beginning of this text. To identify those actors that have influence on safety, to understand the communication networks and the content of information was seen as an important base for designing risk management systems. The attention to these aspects, thus, appears to correspond to an interest for a social dimension of safety management. The focus on

knowledge and competence stressed by Rasmussen and Svedung also appear to match a cognitive perspective (although in a somewhat more limited interpretation of the term “cognition” than was discussed above).

Although cybernetic control metaphors, in theory, may be compatible with other perspectives focused on learning, social perspectives, communication etc, a major problem arise in the process of going from theory to implementation in real organisations. One of several reasons for this state of affair has already been mentioned; the high dynamics of complex systems, rapid structural changes, lack of sufficient fine-grained dynamic models, and the heterogeneity of subcultures found in large organisations. As discussed by Perrow (1999) it might also be the case that the great number of nodes and states to be monitored simply exceeds an organisations cognitive capacity. Introduction of defence in depth systems is believed to be a solution but this strategy has its own weaknesses as pointed out by Sagan (1996) and demonstrated in case studies by Dowell and Hendershot (1997). One may be pessimistic about the ability to ever be in full control of complex systems such as Perrow is, or demonstrate an optimistic view, such as, for example, is represented by High Reliability Theory (HRT) (for descriptions of HRT, see; La Porte and Consolini, 1991; Roberts, 1993; Marone and Woodhouse, 1986; Wildavsky, 1995). In any case, either being basically pessimistic or positive about complex risky systems, we will with high certainty continue to live with them and we are ourselves parts of them. Issues of safety management will remain to be an interest for research and practice. Integrative theories and research approaches that explore safety management from a multitude of perspectives could provide a fruitful approach to reach a deeper understanding of management and safety interactions in.

Departing from these introductory notes about more general issues associated with the management of safety in complex systems, the remainder of this report will focus on an attempt to bring the concept of value (and various value domains) in contact with different tasks and issues that confront management groups. A brief review of various traditions attached to safety culture and values will be presented together with a model that seek to integrate some of these traditions. First, however, some words will be said about the specific task of managing nuclear power plants and how this relates to issues of what I will call “balanced attention”.

1.2 The management of nuclear power plants (NPPs)

Management of NPPs raises concerns that in certain aspects are more demanding than for other industrial sectors. For example; issues associated with information management are of crucial importance because public confidence in nuclear power effects the survival possibilities of the industry. Another strategic issues concern the high requirements attached to systems for quality management – a subject that needs much effort and attention and also expose the nuclear sector for extensive regulatory demands. Moreover, and most important in this context, the deregulation’s of the energy market forces a need for more cost-effective production and external political uncertainties that, among other things, also present obstacles for the selection of long term investments strategies.

To be able to direct attention and manage issues such as those mentioned above is not an easy task given various resource constrains – consequently, management groups are looking for concepts, tools and techniques that can support and optimise 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 organisations. Safety management may benefit from applying such methods but it should be realised, however, that *safety related issues* in contrast to issues foremost associated with *financial issues* draws on partly dif-

ferent traditions, methods and management philosophies (although these issues are obviously connected seen from a safety management perspective).

An important aspect of safety management is here hypothesised to be 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. These 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, technological, human etc) and that beliefs and values associated to these various perspectives are made as explicit as possible 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* about the boundaries of safe operation, the importance of various issues as contributor to risk, and possible dynamics of the system. Safety management strategies relying on expert judgements 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). 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 support awareness about beliefs and values held by different stake holders and subcultures in a system. Safety management could benefit from these approaches, for example, by forming system groups (Andersson and Rollenhagen, 1993) 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 tasks domains. Values, therefore, partly reflects 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. Consequently, attempts to measure safety climate/culture should address conflicting value system, the nature of work, and the outside context of an organisation and interpret the result in a historical perspective of the organisation.

2 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. Researchers in cultures argue about many states of affairs, 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 have proceeded towards an enhanced interest for the concept of "culture" (in a more general sense of the concept) and thereby searched 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). These and

similar paths may be fruitful in order to elaborate further on the concept of safety culture(s) and the relation to safety management. It also seems clear that much research in safety culture have explored the concept more from a "safety climate" perspective rather than to explore complementary traditions in which the value concept has received a more elaborate discussion.

Nuclear organisations, as other organisation of a certain size and complexity, consists of many overlapping subcultures and it is reasonable to assume that such subcultures also are associated with people holding at least partly different belief and values. Subcultures can be differentiated based on many criteria's, 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) has suggested that values could be understood in an abstraction hierarchy. At the highest level of abstraction, values such as, for example, those described by Schwartz (1994) can be described in abstract and universal terms across different context. For the purpose of investigating a 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 also argues for a perspective of values described as a "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, there 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 set of values representative of different jobs and functions found in NPPs – for example, how could one characterise 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 organisational structures found in different NPPs reflect an integration (or separation) of value systems and what does that imply for 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 for the questions above NPPs could benefit both in safety and general efficiency, but to achieve this goal we need not only understand safety management from a theoretical side but also develop supporting tools. Edgar Schein (2000) has expressed the general subject well when he states 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"

3 RESEARCH INTO VALUES AND SAFETY CULTURE

The questions addressed above are indeed hard ones seen from a research perspective. Values are not easy to perceive and can only be captured indirectly as attitudes, behaviours and artefacts. To refrain from attempts to explore also more basic values is, however, also to refrain from possible knowledge that may be of great help to understand the management of NPPs. The authors personal experience from performing organisational assessments and incident analysis at NPPs also supports a view that many observed difficulties have a root in a failure to recognise and balance conflicting value systems. Conflict between production objectives (economy) and safety values are often taken as examples of possible value conflicts associated with safety. Other value conflicts may be represented by, for example: Innovative ambitions and possibilities comes into conflict with standards and quality systems; The values associated with the assumed benefits of traditional hierarchical organisations collides with emerging value systems that prides decentralisation, individual freedom and empowerment of organisations; Interest in technology for its own sake comes in conflict with actors that values cash-flow and short term financial results. All of this may create tensions in modern organisations and do, at least to some extent, evoke special problems for the nuclear sector.

Safety culture is sometimes perceived in a normative way as a set of *desired* states and processes and a common approach is to asses a current safety climate conceptualised as “safety culture dimensions” and compare this with the 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 off-shore industry Alexander et al. (1994) used questionnaires and interviews to identify differences in perceived culture among employees in a operating company with that of contractors and also explored differences between off-shore 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* (se also 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 than others” (pp 166-167). If one assumes that safety culture dimensions, such as the one suggested above, is important characteristics of a “safety culture/climate” then we would also need *management ideologies* that can support these desired values and attitudes and which are not in conflict with each other. However since NPP organisations include (which is reasonable to assume) 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 domain (financial, technological etc) and to study potential generic conflict and coping patterns.

In the earlier safety culture literature, the concept of value is often mentioned but seldom elaborated on in a deeper sense. Today research traditions exhibit a broader theoretical cultural theoretical that was seen previously. On such example is represented by Cox and Cheyne (2000) and their colleges. These researchers present a “multiple perspective model” of safety culture theory and assessment (see also James and Jones, 1974; Denison, 1996). This multiple perspective model argues for a measurement of organisational culture/climate in terms of several complementary approaches; (1) as objective organisational attributes (manifest in systems, processes, structures, reports etc) (2) as perceptions of the *organisation* as a more global entity (for example how the organisation “is seen” by external observers), and (3) individual perceptions, or how people in the organisation feel and think about safety related issues. Also the work by Carroll (1998) shows evidence of an eclectic research strategy of safety culture (performed in the nuclear sector). A problem, however, with broader cultural approaches seen from both a research perspective is that they are time consuming and “political 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 criticised from methodological grounds as applied in cultural research (Shein, 2000). On the other hand, research performed by Grote and Kunsler (2000) have demonstrated that questionnaire approaches provides useful information to assess safety culture related issues and it was found to correlate rather well with auditing approaches (expert judgements).

In conclusion, it appears that the current literature suggest that value related issues should incorporate a broad theoretical base and be investigated with approaches that draws 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 organisations. 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, these mentioned 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 are a limited set of basic functional issue domains of NPPs. Some of these issue domains (or focus areas) have a parallel also in separate organisational 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.

4 A MODEL

A first outline of a model is presented in figure 1 below. The model suggests four management topics (or issue domains) that together constitutes 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 problems is here assumed to be one of *maintaining a balanced attention* to the four areas in the model.

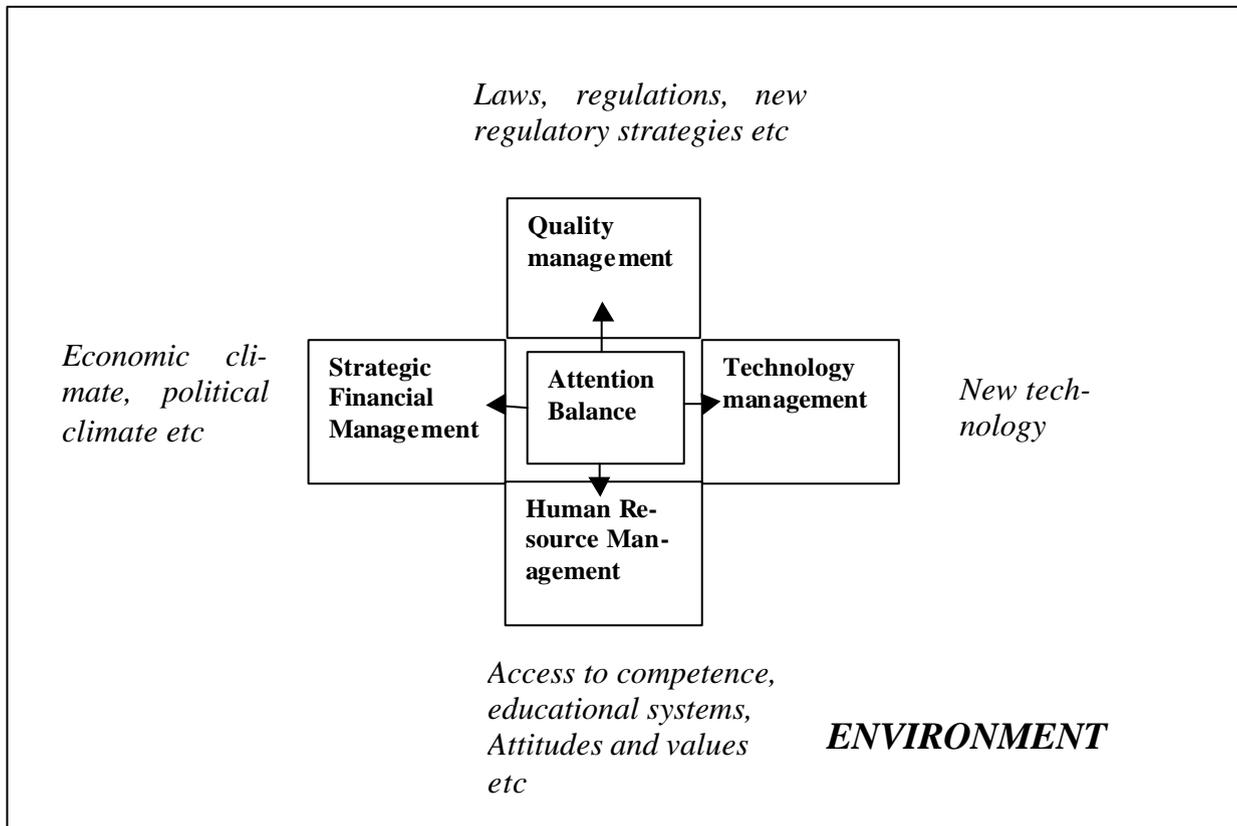


Figure 1

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 regulatory bodies and related organisational structures, processes and rule systems.

Technology management: By this area is here 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 organisation 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 jeopardise safety.

4.1 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 conceptualisations 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 behaviour 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 represent 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 take place and the safety significance of this decision is very uncertain (for instance a decision about a reorganisation 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 judgement. (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 formalise a decision which in reality were taken at a decentralised position in the organisation. (4) The members of the group, regardless of composition have, prior to the meeting, acquired *personal knowledge* of the four 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 does 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 trust 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 later shall discuss in more depth, 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 formalisation of a process that was conducted somewhere else. An interesting issue then

arises to what extent the “research” previously conducted in fact represent the full scope of issue domains of significance for safety – has balanced attention been achieved?. Given functional formal organisation 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.

5 SOME RELATED THEORETICAL ORIENTATIONS

The model in figure 1 has similarities with the “competing value framework”(CVF) proposed by Quinn and colleagues (see, for example: 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).

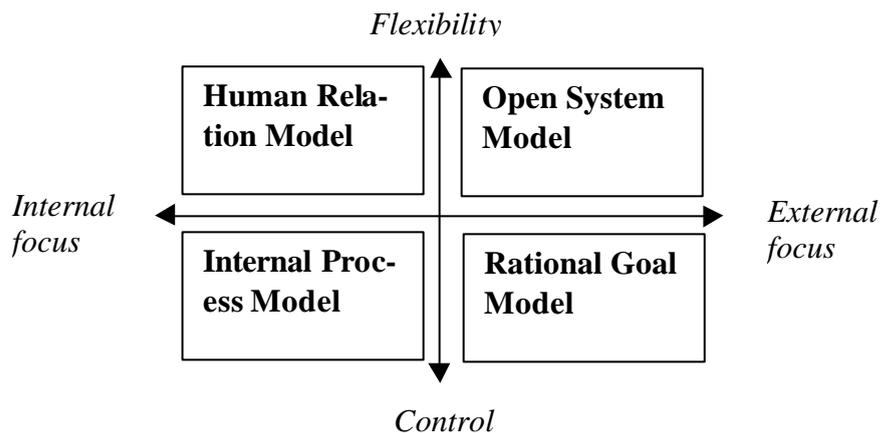


Figure 2.

The 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 found in the literature 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 Fig 1 does also share 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.

That organisations face inherent dilemmas associated with issue domains similar to the ones presented in figure 1, and that these issues are central for organisational survival, 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 hypothesis about what type of value structures that may associated with the issue areas shown in figure 1

5.1 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 labelled “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 organisation. This success of this model relies on that members of the organisation receive knowledge 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” shares similarities to a view of “safety culture” in which respect for rule-systems and general a 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 is valued in both “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.

5.2 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 de-*

velopment of human resources. Leadership roles are associated with mentor-ship 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 organisations. The safety culture movement in itself reflects an interest in human and their values. The decentralised 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 emphasis 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 organisational culture (and safety culture) that puts an emphasis on rule conformity on the one hand and those propositions that suggest the importance of a “questioning attitude”. Grote and Kunsler (2000), in their attempt, to analyse 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 organisations limits the possibilities for decentralisation.

5.3 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. A major management focus, thus, is an efficient organisation to adapt to external demands and market conditions. Management ideologies are characterised 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 borrows *some aspects* from the above ideology in the sense that a clear *powerful and strong* management commitment on safety are often named features that should characterise managers of NPPs. However, since the rational goal model *may rest* on value systems characterised by power, dominance and control, which are foremost 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.

5.4 Open system models

The quadrant flexibility/external focus of CFV is named open system model. Desired outcomes are growth and resource acquisition by means of adaptation and readiness. This characterisation 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 associates with open system models of this kind. An important general feature of open system models is their focus on the environment and context as determinants of organisational behaviour.

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 characteristics 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).

6 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 organisation is, according to the garbage can model far from a rational process; big and small issues are mixed; expert knowledge is not optimised and utilised; persons with limited knowledge in a subject matter takes 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 & Simon (1958) argued that management tend 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 that associates to various issue domains.

Departing from the model in figure 1, and with the assumption added, that underneath each of the issue areas there are corresponding value systems, one find the following combination possibilities:

	1 Financial	2 Quality	3 HRM	4 Technology
1 Financial		1.2	1.3	1.4
2 Quality	2.1		2.3	2.4
3 HRM	3.1	3.2		3.4
4 Technology	4.1	4.2	4.3	

Ascribing a direction of influence from one issue domain to another (based on underlying values), the following mutual transactions and influences are to be found (neglecting the internal interactions in a domain):

- | |
|---|
| <ul style="list-style-type: none"> 1.2 Financial values effect quality values; 1.3 Financial values effect Human Resource Management values 1.4 Financial values effect Technology Management values 2.1 Quality management values effect financial values 2.3 Quality management values effect HRM values 2.4 Quality management values effect technology values 3.1 HRM values effect financial values 3.2 HRM values effect quality values 3.4 HRM values effect technological values 4.1 Technological values effect financial values 4.2 Technological values effect quality values 4.3 Technological values effect HRM values |
|---|

Table 1. Issue domains in interaction.

The transactions above do, of course, become meaningless in lack of a view about what constitutes the “core” values in each domain. As has been argued above, it could be possible to obtain such information. Although value system might at first be perceived as highly arbitrary and situational dependent entities that might escape structural analysis they appears sufficiently stable for systematic investigation as indicated by some of the research commented on previously. Below I will present some further elaboration on this issue, based on literature, personal experiences and discussions with professionals associated with NPP: production. A more complete and empirically based discussion is addressed in an ongoing research project. Since financial issue attention due to deregulation’s and increased market competition have increased over the last decade, the interactions commented on will focus on financial management in relation to the other issue domains. The interactions are presented pair-wise but a more realistic model would, of course, assume more than on-to-one interaction possibilities.

6.1 Financial management and quality management in interaction

The meaning of the concept “financial management” in this context is an issue domain in which the financial effectiveness is focused and the values and belief systems that rest beneath these issues. Quality management (in a more traditional sense than TQM), on the other hand, 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 means that can be available to the lowest possible cost (which, of course, is not necessarily the same as sustained profit in a longer perspective).

That organisations may drift away from higher standards of safe performance have been commented by several researchers. For example, Rasmussen and Svedung (2000) notes: “It should be considered that commercial success in a competitive environment implies exploita-

tion of the benefit from operating at the fringes of the usual, accepted practice. Closing in on an exploring the boundaries of normal and functionally acceptable boundaries of established practice during critical situations necessarily implies the risk of crossing the limits of safe practices. Correspondingly, court reports from several accidents such as Bhopal, Flixborough, Zeebrugge, and Chernobyl demonstrate that they have not been caused by a coincidence of independent failures and human errors. They were the effects of a systematic migration of organisational behaviour toward accident under the influence of pressure toward cost-effectiveness in an aggressive, competitive environment. Consequently, the first step toward a proactive risk management strategy will not be to predict and avoid exotic causes of accidents, but to ensure operation within the design envelope, that is, to support management in respecting the preconditions for safe operation as specified during design” (p 8).

A general problem with many quality systems is how actors with multiple goals perceive them. Since one of the aims of quality systems is to impose restrictions for possibilities, which implies that quality systems and regulations, in fact, can slow down safety development. For example, by requiring very resource demanding licensee procedures some possibilities for safety development can be delayed. But, and more important in this context, is that quality systems in NPPs present a necessary resistance against unbalanced attention and use of management ideologies that tend to “forget” safety issues or treat them as “something that is taken care of somewhere else”.

6.2 HRM and financial management in interaction

Human Resource Management 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 to investigate the causal direction in a 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 the safety climate has been explored by, for example, Brown and Holmes (1986) who found three 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 emphasise 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 effected 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: ”Perrow and Friedlander, reviewing accidents in the industry from the point of downsizing conse-

quences show how downsizing, by increasing worries and 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).

6.3 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, did value 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).

7 GENERAL DISCUSSION

This article has presented a tentative frame of reference for some issues related to safety management in general and for NPPs in particular. The general research area of management and organisations is highly diverse and fragmented and is, despite serious attempts and modelling ambitions, only yet tentatively coupled to the sharp technological end of the system in a realistic way (at least this is the judgement of the present author). 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 flavour 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 organisations.

The safety culture tradition, mainly based on a cognitive framework and the idea of shared cognition’s 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* conceptualisation 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. In her empirical research Tomicic finds that agreements in management groups need not be based on shared cognition. She finds that if an agreement is shared or not depends on various processes and issues in interaction and also suggests different types of agreements depending on this - most agreements were found to have the characteristics of social agreements where the opportunity to influence were unevenly distributed

among the team members. Factors that influenced this process were; gap in formal authority, uneven distribution of competence, distinct distribution of responsibility, attitudes towards conflict and action, and style of behaviour. Tomicic also found that the factors observed served to limit the number of participants that were active and the extent to which different opinions came through in the group. As a consequence of formal authority, status, and differences in competence, decision making in the observed groups may reach a fast consensus with little of elaborate discussions and exchange of opinions. Tomicic also found that formal position was the strongest source of influence. Interestingly, Tomicic observed that “constellations of influence” changed depending on the issue in question, which draw attention to subjects discussed in this paper. Another way to express this would be that the participating members in the group represent various subcultures that, depending on issue, have more or less power to influence a decision. Another interesting aspects of the research 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 above present complications for a control metaphor of safety management due to the 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 too 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 not necessarily, increase the speed of implementation. This mode, however, does not guarantee high quality agreements which is important in 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 labelled “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 of several reasons. It is relatively easy to collect data/information but the analytical task to determine *what* data should be collected and *why* it is of importance for safety is a much more difficult task. The understanding of shared cognitive models (such as found in subcultures) is of importance to understand this process. But why an issue is considered important is not always a result of shared mental models and values but also, to a large extent, a result of social influence processes and power relations. The cybernetic control metaphor of safety should consider these factors in order to present a realistic view of safety management. Learning as a consequence of transaction among various value systems can be organised 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 organisation 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. It is when this balanced attention disappears that the devil stands in the corner.

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