Safety Management, what do we know, what do we believe we know, and what do we overlook?

Veiligheidsmanagement, wat weten wij zeker, wat weten wij dat wij niet weten, en wat zien wij over het hoofd of negeren wij actief?

Andrew Hale [1]

Samenvatting

De laatste twintig jaar is algemeen overeenstemming bereikt over de functies van een veiligheidsmanagementsysteem en hoe deze functies in een samenhangend geheel kunnen worden ondergebracht. Nu wordt de aandacht gericht op de invloed van organisatiecultuur op de veiligheid van voornamelijk hoge risico bedrijven. Het belang van het managen van het conflict tussen veiligheid en andere doelen van de organisatie wordt langzaamaan pas geaccepteerd als een belangrijk onderwerp. Het centrale model voor veiligheidsmanagement is nog steeds bureaucratisch van opzet. Dit is niet adequaat voor MKB bedrijven, voor nieuwe technologieën, of voor nieuwe bedrijfsstructuren die nu aan het ontstaan zijn.

De kwaliteit van veiligheidsmanagementsystemen wordt aan de hand van audits vastgesteld. Auditen is echter meer een kunst dan een kunde, de wetenschappelijke onderbouwing van de techniek ontbreekt.

Het managen van veiligheid moet, voor een organisatie, gezien worden als een dynamisch leerproces waarbij organisatieveranderingen zowel een bedreiging voor bestaande prestaties kunnen zijn als het belangrijkste instrument voor verbetering.

Dit artikel geeft een overzicht van de stand van de wetenschap over verschillende aspecten van veiligheidsmanagementsystemen. Wat weten we, wat geloven we zonder dat daar bewijs voor is, waarin vergissen we ons en wat zijn de uitdagingen en onopgeloste onderwerpen in de komende jaren?

Summary

The last 20 years have seen the development of broad agreement on the necessary functions to be fulfilled by a safety management system and how they relate to each other in a coherent whole. However, there are many gaps in our scientific knowledge. Attention is now focussing on the way in which organisational culture impacts on safety, particularly in high hazard industries. The central importance of the management of conflicts between safety and other organisational objectives is only slowly being accepted. The central model for safety management is still a bureaucratic one. This is not adequate for SMEs or the range of new technologies and company structures emerging. Safety auditing as a means of assessing management systems is an art with very little scientific basis and needs more validation. Safety management must be seen as a dynamic learning process in which change is both the major threat to existing achievements and the major tool for improvement.

The paper develops these issues in the form of a brief review of our current state of scientific knowledge about the influence of different aspects of the safety management system. What do we know, what do we believe but have no proof of, what may we be mistaken about and what do we face as challenges and unresolved issues for the coming years?

Index Terms: Conflict resolution, Safety culture, Safety management, Safety performance indicators.

Introduction

For the last thirty years safety management has been a central focus for scientific research and regulatory attention in the third age of safety (Hale and Hovden, 1998). Both technical and human failures have become seen as things which organisations could and should predict and control. Safety must and can be achieved despite these technological and human failures, demanding a robust design based on 'defence in depth' and an effective safety management system (SMS). Defence in depth means that, for each barrier (material or immaterial) which we insert to prevent a hazard scenario developing, the organisation needs to identify what the essential requirements are for it to work: how must it be provided and its functioning guaranteed? These essential requirements form the basis for management.

The revolution in safety regulation, which swept across Europe in the 1970s and 1980s introduced the idea that the regulator should assess companies based on their safety management systems and not on their compliance with detailed and specific rules, which were always threatening to become outdated. This change led to an explosion of research into the way in which management systems for controlling safety should be developed, structured, assessed, and improved. This has now progressed far enough that national and international standards for safety management (e.g. British Standard Institution, 1999; SVV, 1997), modelled on the ISO standards for quality and environmental management systems have been developed. Their development and, in particular, their use are still subject to strong resistance from some

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employers' federations, who fear that regulators will make them mandatory, but they are gaining acceptance, particularly in the area of assessing contractors' and suppliers' safety management, but also within larger companies. Corporate managers, in the same way as regulators, need to know that the different sites of the company are managing risk and company image competently. If they plan to take over another company, they need to assess how well its safety is managed. If they plan to reorganise, de-layer, outsource, or otherwise restructure the company management, they need to know whether this will dangerously weaken safety management. After almost three decades of research, we know a great deal about what good safety management is. However, there are still considerable gaps in our knowledge. This paper reviews both sides of this equation briefly. It first makes a number of assertions based on our current knowledge of how safety management works and can be assessed, in order to sketch the nature of our relatively secure knowledge. These are based on a continuing set of studies, a number carried out in Delft, in collaboration with international partners, which have assessed safety management in the chemical and steel industries, the railways and a range of other industries. More detailed arguments for the assertions can be found in other literature (Bellamy et al., 1999; Hale, 2000; Groeneweg, 1998). It then sketches the gaps in our knowledge, grouped broadly under the headings:

- What do we think we know, but are probably mistaken?
- What do we know that we do not know?
- What do we deny that we need to know, or take account of?

In such a broad survey the issues raised are necessarily incomplete and the arguments underlying them can only be sketched.

What do we know quite securely?

Safety management system structure and function

Safety management has become such a fashionable term and focus of study that we may be in danger of thinking that it will solve all our problems. We need to see it as something to be added on to good engineering and human factors, not as a substitute for them. No matter how good management is, it cannot make up for poor design and lack of operating competence. Its task is to anticipate all significant risk scenarios and to design measures to eliminate them, or at least to reduce and provide robust control of them. In risk analysis terms we can formulate this task as a "common mode" influence which is designed to keep all failure probabilities in the fault tree at the lower ends of their intrinsic bounds. In work carried out for the European Union on assessing management systems for major hazard companies (Bellamy et al, 1999, Duijm et al, 2004) and for railways (Hale, 2003) we have defined the functional elements of a good SMS as the following:

1. A clear understanding of the company's primary production processes and supporting processes such as energy supply, storage, maintenance, etc., with all the scenarios leading to significant harm. This risk inventory and evaluation must anchor the safety management system to the specific hazards of that specific company. The task and job safety analysis must be rooted in a functional analysis of the processes, so that the deviations in the flow of those processes, which can lead to accidents, can be traced to their origins and linked to barriers (Swuste, 1996; Koornneef, 2000; Duijm et al, 2004). Functional analysis means that the steps in the process are defined by their goals and not at the level of the specific way in which the goal is currently achieved. In this way the analysis is more generic and can be used even if technology or applications change so that the goals are achieved in other ways.
2. A life cycle approach to safety management, considering how all the system elements are designed, purchased, constructed, installed, used, maintained, modified and disposed of. The risk analysis must cover all of the phases of these life cycles which are under the influence of the company and address the prediction loops (feed-forward) and learning loops (feedback) between them.
3. A problem solving cycle identifying, controlling and monitoring these scenarios at three levels:
   - On-line risk management by people in direct control of the risks, both under conditions of normal operations and in any non-nominal and emergency states (operational level)
   - Plans and procedures, resources and controls developed for preparing, guiding and optimising the on-line risk control. These form the explicit, often (at least in bureaucratic organisations) written operationalisation of the SMS (tactical level)
   - A structure and policy level which, at intervals, reviews the current operation of the SMS and makes structural improvements to it (strategic level)

   These three problem-solving levels have different time dynamics, from seconds up to days at the first level, weeks and months at the second, to three to five years at the third.
4. Feedback and monitoring loops ensuring assessment against performance indicators at each of the three levels. Failure to meet the objectives represented by the performance indicators must trigger correction at each level and learning through loops which provide the connection between the levels and which trigger review and improvement in policy, procedures and system structure
5. Systems at the middle level, linked to the staff and line functions of the company, delivering the crucial resources and controls to safety critical tasks at the lower level. These are: (in brackets are the company functions dealing with them)
   - The availability (manpower planning) at all times for critical tasks of people who are;
   - Competent, with the necessary skills and knowledge to operate safely in all situations, including improvising in unexpected situations (selection & training) and;
   - Committed and motivated to be alert, take care of themselves and others affected by their work, perceive risks appropriately and achieve the safety criteria set out – this applies both to the workforce and the management,

right to the top (supervision, incentives, appraisal, and organisational culture [see later for a discussion of culture]).
- Communication within and between groups working on related or interlocking tasks, including handovers, information to new staff, etc (meetings, media, channels, formal permits, protocols, plans, logs, etc.).
- Procedures, goals and rules for specifying what to achieve in safety, and/or how to achieve it (safety manuals, etc).
- Technical design of plant and hardware and its safe modification to provide optimal safety (design, layout, change management)
- A user-friendly and ergonomically responsible interface in all life cycle phases (design, technical services)
- A system to manage conflicts between safety and other company goals explicitly, e.g. in production and maintenance planning, purchasing, design, etc. (top management, organisational culture)

The link between the main elements of the total structure is shown in figure 1, which is drawn from the work carried out to develop a generic safety management structure for the European railway industry in the SAMRAIL project (Hale, 2003). The life cycle aspect is implicit in figure 1. It shows on the left-hand side the primary processes (1), which have been analysed by a RIE or other risk assessment method (2) for all life cycle phases (LCPs), to derive the direct barriers and controls (b&c) needed to control the risks found (3). From this analysis we also derive the safety management system needed to keep the barriers functioning (4). The learning system consists of the inspection of the processes and barriers at the operational level (5) and the auditing of the management system at the tactical level and the review at strategic level (6). The incident and accident registration and analysis system (7) picks up at operational level the shortcomings in both the RIE and the control and management system. The elements in the model are deliberately defined as functions to be fulfilled and not formulated in terms of how they should be implemented in detail. That differs per hazard, per technology (Rasmussen and Svedung, 2000) and per organisation, depending on the specific scenarios which it has to manage and on the culture of the organisation.

Recent publications in this journal showed this diversity for chocolate sweet production (Blom and Swuste, 2002), waste incinerating plants (Zwanikken and Swuste, 2002), and steel manufacturing (Swuste et al., 2002).

What we think we know, but actually do not?

Safety and bureaucracy

The vast majority of studies of safety management come from the large, bureaucratic organisations, which run high hazard technologies, such as power utilities, process industry, mining and transport. These are machine bureaucracies or divisional companies in the terms of Mintzberg (1983). There are relatively few studies of small and medium-sized companies (SMEs) and even fewer of organisations in new technologies such as the bio-industries, or in professional bureaucracies such as health care or laboratories. Scientific evaluation of safety management is very limited in the literature and, hence, we tend to over-generalise the results we have. Although the high profile disasters of the last decades have largely come from the industries where the most studies have been done, the total toll of deaths and major injuries is much higher outside these high hazard industries. Recent disasters in the Netherlands, a catastrophic firework factory explosion (Oosting, 2001), and a café fire (Alders, 2001), have also underlined the fact that multiple deaths can easily occur in places not thought of as major hazards. Yet our models of good safety management tend to be bureaucratic in nature. The opposition of employer's federations to the certification of health and safety management is largely based on the fear of the SME that such rigid straight jackets of rules and paperwork will be imposed on them also.

Most of the writing on the subject up to the last few years has concentrated on the structural, rational frame, as defined by Bolman & Deal (1984), which emphasises rules, responsibilities, reporting structures, authority, plans and checks. The structural models which we have, also tend to be static ones. The picture they give implies that an SMS could be designed perfectly once for all and then simply left to function, with only a system for detecting and correcting deviations from that perfection. Rasmussen (1994) has argued powerfully that this is a utopian view, since all organisations are subject to constant pressures from competition and local optimisation, which push them closer to the danger areas in which accidents can happen. They need constant signals to detect that edge of the danger zone and constant steering to keep them away from it. Above all, it is impossible to predict in advance all hazards and the effect of all new technologies and organisational structures. Learning has therefore become central to our notion of a good SMS.

Auditing and self-regulation

In our risk society the public has become sensitive to major hazard and to the perils of new technology. Major hazard companies have learned that it is in their own interest to manage risk, as part of their license to operate. Self-regulation, relying on auditing of the SMS, either by government or third party certification (Gundlach, 2002) can hope to provide a satisfactory regulatory regime for such companies. The contention is, but it is as yet unproven, that audits should be based on such a generic structure as is outlined above, in order to make them reasonably universal tools for assessing a wide range of companies. They then need to be worked out in detail to focus on the risk scenarios of concern for a particular audit. If we can develop audits at the functional level indicated above, we can hope that they will also be applicable to SMEs. What the acceptable answers are, which show that the organisation has implemented the functions, will be far simpler in the SME than the large company. For example we may accept much less extensive paperwork systems in a small company, provided that the company can demonstrate that its key employees have the information in their heads and that there is satisfactory cover for absence and a succession plan for loss

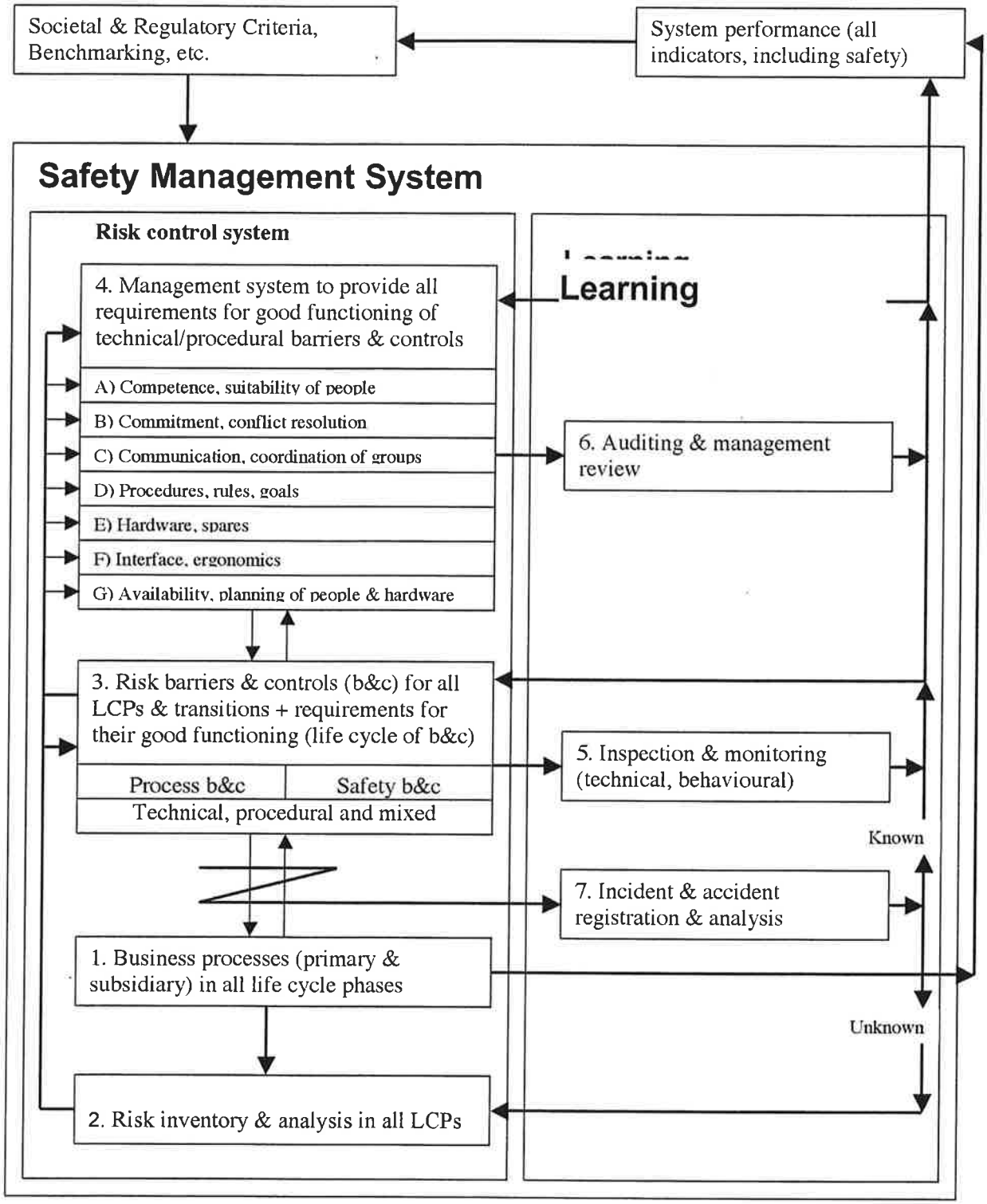

Figure 1 Elements of a Safety Management System

or illness of such key personnel. The alternative is that we develop tailored lists of specific questions per industry and size of organisation, which we can use to audit different companies.

An additional problem with small companies is that they cannot be relied on to police their own safety. The probability of a significant accident is too small to motivate them without external enforcement. The investigation of the café fire on New Year's Eve in Volendam shows yet again that local authority enforcement can be undermined by local interests and a lack of independence. Goal-directed legislation is subject to too much room for interpretation to have teeth in such circumstances. This is another argument for more specific rules for the SMS for SMEs. It is certainly a reason for breaking down the resistance of the employers' federations of SMEs to the production of an auditable SMS standard, which would need to be rather specific to support and also pin down the SME (Kirwan et al., 2002).

What is the best form of audit will also depend on the quality and experience of the auditor. If we are to use relatively simple, but abstract, high level audits based on functional elements, we demand much more of the auditor to assess the acceptability of the answer given by the company. The auditor will need a deep understanding of the technology, the scenarios to be managed and the ways in which the company may try to pull the wool over his eyes and falsely claim it is well managed. It is questionable whether the level of qualifications and experience demanded by certification bodies, and also by many government inspectorates, is up to this level of competence.

SMS for major hazards and for minor injuries

We have too easily in the past ten years assumed that the SMS for controlling one type of hazard, say a loss of containment of a toxic or explosive chemical, is the same as that for controlling any other, say the risk of falling down stairs, of contracting dermatitis through contact with chemicals, of exceeding environmental pollution levels, or of having a high sickness absence due to work conflicts and stress. The assumption has been that safety, health, environment and quality management systems are the same and can be assessed with the same standards (CEN, 1998). At a very high level of abstraction, such as that found in ISO standards, this may be largely true, but as we descend into the details it becomes increasingly untrue. We have found too often in major hazard companies the lost time injury rate as global performance indicator of the SMS. This is an indicator responding largely, at least in good process industries, to such common-place accidents as falls from stairs, lifting in stores, or slips and trips in the car park, and not one telling anything about major hazard control (Hale, 2002). The focus, the detailed actions and problems at the level of plans and procedures and of on-line risk management, is very different for different types of hazard across the safety, health and environment field. Both the SMS and audits and performance indicators which assess it need a far sharper focus than they often have at present, in order to convince us that they are seeing the wood for the trees and are not being lulled into a sense of false security by the low level of lost time injury. It may not be necessary to alter the structure of the audit or the basic questions asked by it. What needs to change is the scenarios and barriers about which the questions are asked (Hale and Guldenmund, 2004).

Hazard inventories

Risk assessment in SMEs is generally conducted with simple checklists, listing types of hazard (noise, machinery, work at heights, lifting, chemicals, etc.). These are fine for reminding inspectors to check for hazards which are constantly present, but do not prompt them to think about the circumstances under which a hazard will manifest itself in an accident. None of them encourage thinking in terms of risk and how it arises; in other words none of them incorporate thinking in terms of scenarios. Hence, the inventories of so-called risks, which the companies have as a result of carrying out these mandatory risk assessments, are really only inventories of hazards and of no use in planning prevention (Jager, 2002). This removes the very basis for safety management outlined in the previous section. Yet the safety and health advisory services and inspectorates in the Netherlands continue to accept the use of these checklists, except in high hazard companies where safety cases are required. A current research project funded by the Ministry of Social Affairs and Employment, which is developing risk based scenarios for the control of hazards (Hale et al, 2004) will hopefully fill this gap. The research team is analysing all of the accidents reported to the Ministry over the period since the beginning of 1999 to identify the common scenarios for each of the accident types (a total of about 25) found, the barriers which failed and the management tasks and resources which are necessary to keep the barriers in place.

What works in the SMS?

Our proven knowledge of the effectiveness of the different elements of an SMS is woefully small. We have accepted much on the basis of "applied common sense". Governments have been reluctant to fund the necessary longitudinal studies of developing safety management systems to understand how they work, or the comparative studies of good and bad companies to see what features are crucial. Audit organisations have also rarely funded validation of their measuring instruments. Until we accumulate more of this research we will stay in a pre-scientific stage of knowledge. In particular we need far more studies across the full range of industries and types of company to extend our knowledge from that about only large purely bureaucratic organisations to smaller companies run on different lines, research organisations, hospitals, universities, contractors, family businesses, etc., which are all organised on very different principles (Mintzberg, 1984).

Two reviews by Shannon and co-authors (1997) and Hale and Hovden (1998), described the lamentable state of research into the effectiveness of different aspects of safety management. In many cases there was not even evidence from accident studies or case studies to support the widespread beliefs which management texts and safety consultants promulgate. Safety management and changes in the SMS are therefore governed far more by fashion and the smooth tongue of the management consultant selling his wares, than they are by hard evidence of success. Companies try to get round this lack of evidence by benchmarking their SMS against their more successful competitors in the same industry. However, this often results in a process of successive addition of parts to the SMS. Because a successful company uses a particular audit or performance measure or applies a certain method of involving staff in safety decisions, it is assumed that their success must depend on that aspect. Hence the other company adds it to its own SMS, often without removing any other parts of the system, or integrating it with them. As a result, the SMS gradually becomes more opaque to those operating it, who no longer know what measures what or what controls what in the system. The SMS of high hazard companies often shows this possibly unnecessary complexity (Hale et al., 1999).

Accident and incident reporting

The last decade has seen a great deal written about the necessity for companies to develop into learning organisations

(Senge, 1990). Practically all companies of any size have an incident and accident reporting system with this objective and many are quite content with what they have. However, a long series of studies (Koornneef, 2000) on how to set up such a successful learning system in a company has shown us that this is practically never achieved, because the task is underestimated. Companies think that it is enough to collect as much incident data as possible and then see what to do with it later. This is a recipe for failure, because organisational learning must be organised, and requires a 'motor'. This motor must consist of one or more learning agents, who have the task of encouraging the notification of incidents, of filtering out and highlighting new incidents/risks, encouraging the development of solutions and monitoring the application of lessons learned. Agents need to be close to the workplace to understand the context of incidents, but also close to the decision-makers to exert their influence. In large organisations this may mean that two levels of agent are needed, who must stay in close communication. Safety staff can seldom fulfil the role of the former group, yet companies often see safety staffs as owners of the accident reporting system. It requires investment of resources, time and enthusiasm and its use must be constantly rewarded. Usually companies underfund their reporting systems and see running them as an administrative duty for a relatively lowly staff member.

Learning systems should be designed from the output end, by asking the question: 'what can we change, what do we need to learn to decide whether to make such a change, and, hence, what information do we need to collect? However, most current systems are designed from the input end – what information can be easily collected? The first step is to establish what choices can be made and by whom, when it comes to improving safety and what information is needed to make them. Then that information can be targeted. And finally learning is only complete when practice changes. Learning systems with no feedback to the input end are doomed to a short life.

What do we know we do not know?

There is a fine line between the previous section and this one. What will be dealt with here are the subjects where there is, in my view, a reasonable consensus that they are at the frontiers of our current knowledge and that they need to be researched. An overarching concern is that we lack good ways of visualising safety management systems in a way that managers can see how they work and what needs to be safeguarded when making organisational changes; that employees can see what their role is in them; and regulators can see how they work as they assess them. Figure 1 is an attempt to summarise the complexity at a generic level, but already produces confusion in some, while still not providing enough detail for real decisions and assessments of how it works in practice.

Culture and learning

What is missing above is an explicit concern with culture. It is useful to see this as the motor which makes the structure of the SMS work and resolves problems encountered in applying it. The literature on safety culture (or safety climate) is growing fast, but is still confused. It seems better not to talk of a safety culture, because this implies something separate, but to talk of the effect on safety of an organisational culture. Only the extremely good companies have a culture where safety is central. One question we have not yet faced squarely is when can we expect an organisation to have safety as a central objective and when must we accept that it can never be more than a peripheral concern alongside, or even way behind company survival and production.

There is also, as yet, no consensus over the dimensions of culture, in other words how to measure it. Once researchers have measured it, few, if any, can point to evidence as to which of their dimensions, if any, strongly influence safety performance. The research field is too young for that (Guldenmund en Swuste, 2001). The following is therefore a personal attempt at a summary, drawn from a recent collection of research studies in a special issue of Safety Science (Hale, 2000).

The impact of organisational culture on safety is reflected by the importance this topic is given as a goal by all employees, but particularly by top managers, alongside and in unavoidable conflict with other organisational goals.

Are actions favouring safety rewarded even if they cost time, money or other scarce resources?

It is the involvement felt by all parties in the organisation in the process of defining, prioritising and controlling risk; the sense of shared purpose in safety performance. Are the workforce seen as important partners in defining how to achieve safety, or are they seen as passive people who should follow the safety rules they are given?

Another item is the creative mistrust which people have of the risk control system. This means that people should always be expecting new problems, or old ones in new guises, and should never be convinced that the safety culture or performance is ideal. The mistrust must be only of the system and not of the persons in it. A role for health and safety staff in very good organisations may be as a professional group constantly questioning and seeking the weak points in the prevailing system. Creative mistrust flourishes in an atmosphere of open communication, where all levels in the organisation talk about failures as learning experiences necessary to imagine and share new dangers.

This leads to the reflexivity about the working of the whole risk control system. If coupled with a willingness to blame individuals or groups only in the case of unusual thoughtlessness or recklessness, this can drive a responsible learning culture. A blame culture is a defensive and non-learning culture in which information about mistakes and failures is seen as a weapon.

A good culture has the belief that causes for incidents and opportunities for safety improvements should be sought not in individual behaviour, but in the interaction of many causal factors; hence the belief that solutions and safety improvement can be sought in many places and be expected from many people, most notably those who have to work with the technology and the hazards.

The items mentioned above give an indication of what a superlative culture could be for managing safety. It does have safety as a central goal. The organisations managing the major hazard industries which could cause major social disruption if

a disaster occurs in them have an obligation to strive for this perfection. It is an important question to debate, whether we should expect such perfection of the lower hazard technologies.

Developing the SMS

Because of the very limited longitudinal research on safety management systems there is no clear answer to the question whether there is an optimal order in which to develop the various aspects of an SMS. It seems plausible that there is some sort of maturation process for an SMS, which cannot be short-circuited without running into trouble. Anecdotally at least there are some characteristics of very good companies which are shared by very bad ones. For example the best performing chemical companies concentrate very strongly on the role of individual workers and workgroups and try to inculcate them with a strong belief in the importance and attainability of safety through their own efforts. The responsibilities for safety are fully integrated in the line and there is little or no specific safety department and only a small safety manual. This emphasis on the central role of the worker is also found in very poor companies, and is called pathological in Westrum's terms (1991). The difference is that the good company has genuinely internalised a strong belief in safety in all personnel, and is active and questioning in its approach. The management of the poor company claims to integrate safety in that way, but there is no implementation in practice and the workforce resents the problem being pushed onto their plate by a dismissive management. In many companies between these two extremes the emphasis has been moved deliberately away from a concentration on the individual to one on the design of the work situation and its effect in eliciting unsafe behaviour [see for example Culvenor (1997) for a strong advocacy of this shift]. Too many companies think they can go from no SMS to a fully-fledged safety culture in one step, just by preaching at the workforce. However, it is more plausible to conclude that an organisation has to go through these stages in turn, requiring a shift from a blame culture in order to put in place all of the hardware and procedures of an in-depth risk control and the structure of an explicit SMS to manage them, before it can return to the individual worker as the remaining element in the system to be influenced. Proof of this hypothesis is lacking, however.

Multi-organisational systems

There have been many calls in the last few years for more research into the management of safety in multi-organisational systems [e.g. Wilpert and Fahlbruch (1999)]. The tidal wave of outsourcing, decentralisation, privatisation and return to core business has swept over Western industry. The result is a much greater complexity of organisational boundaries in high hazard activities such as chemical sites, railways, airlines and airports. These match now the complexity of sub-contracting in the construction industry, which has always been seen to be a major challenge to improving safety. Attempts have been made in the chemical industry to use audits to admit contractors to the list of organisations allowed to tender for work (SSVV, 1997). These are now coupled with tighter supervision and involvement of the contractors in the principal company's own SMS, to exert more control over the sub-contractors. Unpublished evidence from employing companies indicates that this approach would appear to be quite successful. However, this tight a control over contractors raises the question what is the remaining difference between these 'house-contractors' and the old fully owned maintenance department, which were outsourced a decade or so ago. In other settings, such as airports, attempts to set up an integrated SMS across the different actors (airport, airlines, ground handling, ATC, etc.) have been limited and subject to strong opposition (Hale, 2001). In the railways there have been strenuous attempts to tackle this aspect of privatisation, notably in the UK (Maidment, 1998, 2002), but it is far from clear, given the record of major accidents in that country in the last few years, that they have been successful.

What do we ignore, or even deny that we need to know?

This final section returns to issues which are important but undervalued and under-researched. The difference here is that there is an active denial from many that they are relevant or can be researched.

Conflict and emotion are central to risk control

Many managing directors in their speeches to shareholders, or in their dealings with regulators are inclined to deny that safety is in conflict with profit. They and their chief safety advisors argue that safety is good business and that safe companies are usually among the most successful on the stock market. Whilst not wishing to deny that there is an overlap between safety and long-term survival, or that safety can cost surprisingly little if decisions are made at the design stage about it, I would argue that we should honestly accept that safety management will always be in conflict with other company goals (Rasmussen, 1994). The conflict can be eased by integrating safety into plans and designs from the beginning, but it can never be eliminated. A company director who denies that safety conflicts with production merely demonstrates that his company does not have a mature culture and SMS. Our only hope is to manage the conflicts explicitly, rather than denying them. We need to integrate the tradition of research from sociology and political science, which has studied these conflicts, into the management research tradition in order to study the political aspects of organisations, and also look at organisations as a field of conflict or battleground, where different interests compete for limited resources and form strategic alliances based on horse-trading and local expediency (Bolman and Deal, 1984). Rational structure will not do on its own, but that is all that most audits and certification is limited to. We must also not underestimate the role of emotion in driving decisions; from the boardroom to the shop floor the horror of injury and disaster, the fear of ridicule and loss of face, the pride in achievement and the compassion for suffering are powerful factors which often override rational, cost-benefit driven calculation.

The inevitability of organisational change

An implication of encouraging learning organisations is that the SMS will be constantly changing. We know that change is the opportunity for improvement, but we have long seen change also as the enemy of safety, since it modifies well-tried systems. This paradox is one which needs to be grasped firmly by companies in order to pluck the fruits of change, whilst avoiding the thorns. Change management systems for vetting modifications to hardware and plant have long been accepted by the process industry as an essential part of the SMS. They have rarely as yet been applied to organisational changes. Yet companies cheerfully strip out whole layers of management, outsource safety-critical tasks and reorganise whole divisions, without fully assessing in advance the expected effect on the integrity of the SMS. A clear functional model of the SMS and of the mapping of those functions onto the organigram can provide the basis for such an assessment - an organisational HAZOP. Such an assessment of proposed organisational changes has recently been mandated for the British nuclear industry (Williams, 2000). Only if this sort of control is exercised over organisational change is it conceivable that safety management assessment can be factored quantitatively into risk assessments of major hazard installation. Only then would there be sufficient guarantee that good management would not be removed overnight, or eroded over time, increasing unacceptably the risk to workers and residents living around the factory.

Subjecting organisational change, at least in high hazard companies, to prior assessment for its effect on safety would also go some way to removing the sense of the inevitability, or at least of the uncontrollability, of such change. Safety assessment now scurries along behind the car of the change agents trying to pick up the pieces and rebuild the shattered risk controls. It is time that it got more into the front seat, with at least access to the brakes. Managing directors, or consultants, who then complain that safety does indeed put a brake on progress, might be reminded, extending the metaphor, that they probably would not feel very comfortable driving their own car with no brakes, minimal steering and a very unclear view through the windscreen (due to a lack of clear risk assessment).

Conclusions

This article has argued that safety management is still in a pre-scientific stage of development in many respects. It has only a limited, but growing, research literature. It is governed by fashion and not evidence and it has a one-sided, rationalistic view of what it is trying to do. We do know fairly clearly what the structure of an SMS should be, but we are still struggling to understand its functioning, its culture and its politics. There are many challenges to be faced. Not least of these is the need to question and document what is done, but above all what works. Thorough benchmarking of good against average against poor companies (measured in terms of accident performance) can provide a rich source of data. We can also learn a great deal from careful longitudinal studies of developing SMSs. Above all what is needed is a critical and questioning attitude to the fashionable 'truths' and a degree of humility in limiting the application of the limited body of knowledge we have to the applications (industries, type of companies) to which it is applicable, rather than over-generalising it.

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