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ASPECTS OF RISK ASSESSMENT, CONTROL AND PREVENTION

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The contributions to this Worklife 2000 workshop and special issue of the Safety Science Monitor touch upon several aspects crucial to safety management. The perspectives and concepts presented are from areas which include, but are not specifically dedicated to, occupational health and safety. Safety at work, however, represents the prime target area of the workshop and the discussion initiated here, and hopefully continuing through the year on this site, should be seen as an attempt to seek the potential of initiatives, approaches and applications in non-occupational areas to the management of safety at work.

These comments are not meant to be exhaustive to the theme of the workshop, but rather to provide some perspectives from the target area of work-related risks.

1 CONTROL OF INFORMATION

Systems of risk control rely upon the type of direct or indirect information indicating hazards and risks available to support decisions. The reporting system provides the basis for the management of safety. If reporting only covers part of the real risk problem or if there are inherent biases or weaknesses in the communication routines, the management of safety will be ineffective or irrelevant to the prevention of injury.

The reporting system in its widest sense also provides the basis for the image forming about the problem to the public and the decision makers at all levels in the system. If there are mismatches between the categories used in the reporting systems and reported in the media and the sorts of measures which the controllers of the system use to control the safety, this causes problems - the decision makers find the information useless; the public fails to understand how the risks are really controlled; the result is loss of confidence on both sides.

What we are dealing with here is the primary means of making risks and risk control visible, so that it can be explicitly managed. Chronic disease has always been hard to make visible, except in the case of localised "epidemics" in the long or short term, e.g. for asbestos or legionella. Hospital risks have been hidden by passing them off as medical complications. Risks in industries largely populated with small companies are so spread around they are invisible to the companies themselves. Transport risks are always much more visible - even the road or pedestrian ones. We come across them in our daily lives. However, even if the risks are visible, it does not mean that it is easy to collect the necessary data to understand the working of the control system. That is still a huge challenge.

The flow of risk information is a crucial criteria in the system of safety management. In the general area of industrial safety, in work environments where there are no extraneous motives for managing risk, there generally are no systems for communicating *risk* linked to the management of safety. Information about the consequences of risk - *injuries* - are available through systems of workers' compensation or the industrial safety inspectorate and, in some jurisdictions, through the hospital system. Such systems are potentially useful for risk control and safety management, but only if they can be linked to, and used by, decision-makers in the relevant corporations. They seldom are.

With the present pulverization of industrial risk, ie. with increasing proportions of workers becoming self-employed contractors or managers of small businesses, the reporting of work-related trauma and disease is less likely to be reliable and unencumbered.

Minor injury and sickness is increasingly under-reported or claimed under general medical/social insurance rather than workers' compensation, or just suffered as a loss of health by the small business operator (Larsson & Betts, 1996; Larsson, 1998). The structural and organisational weakness of many new, "out-sourced" small businesses operating in high-risk areas makes such potential risk information increasingly unlikely.

This also implies that actual responsibility and decisions related to risk are shifted from the social organisation of work to the private domain of the injury victim.

As an example of advanced and applied control of risk information the US Aviation Safety Reporting System (ASRS) is often quoted (Ödegård, 2000). The core trait of the ASRS is to utilise experienced former pilots and air traffic controllers to collect, interpret and analyse incidence reports representing transgressions of or deviations from the flight regulations. To generate reports the US Federal Aviation Authority has accepted a principle of "transactional immunity" whereby fines or other sanctions are withheld, for a certain period of time, in exchange for a useful report of the incident.

Could such a system be transposed to apply to the safety of patients in a hospital? Or to workers in manufacturing or construction? How could that be done? By the power of what organisation? Which type of political change could see such a lateral application of good practices across boundaries?

In a new thesis from the Safety Science Group in Delft, Floor Kornneef demonstrates that an ASRS type system kan be transposed to a hospital (Koornneef, 2000). However, Koornneef demonstrates convincingly that information from accidents or from safety performance measures has a limited "shelf life" in both time and space. If it is not of immediate use by the work group which generates it in checking and improving their normal work, it will deteriorate in quality and usefulness. That means it must be able to work on single incidents and measurements. That is one of the secrets of the ASRS. It has very short feedback loops. Once that part of the system is working, it is possible to graft onto it, or derive from it, the parts which work on recognising patterns. But, even then, we need to spend a lot more thought in designing the filters and frameworks for interpretation and decision making so that information which travels up to senior management, or to national level decision makers has useful content. Currently the vast majority of schemes at company and national level generate little light.

Potentially, the risk information available to the Industrial Safety Inspectorate through risk assessments and inspections, together with the structured outcomes of the claims information in the public fund workers' compensation system, can provide clear indications of the distribution of risk over industries, companies, occupations and exposures/activities (Larsson & Field, 1999). However, such systems are less immediate, ie. the subject of the report tends to be removed in time from acute trauma, and the potential consequence of the risk is normally less severe than the loss of an aeroplane and 300 passengers.

There is no scientific definition of what constitutes the appropriate content of occupational risk information. The philosophies of industrial safety are more general and far less focused than the functional and very structured definition of risk in the civil aviation processes. Clearly, such narrow and precise definitions of risks, pertaining to defined sequences of operation, could be easily transposed from aviation to hospitals. For applications to industrial safety problems, however, you would have to consider exposures which are both inherently hazardous and represent well-structured and detailed work processes. Few such processes would be associated with the major bulk of occupational trauma and disease.

2 WHO AND WHAT IS EXPOSED?

An interesting common trait in railway, shipping and aviation is that while risk control aimed at reducing loss of stock, capital and third party damage has become more sophisticated, with automated control of rolling stock, software-driven signal systems, and navigation programs with many integrated safety features, there is not necessarily an application of these developments to the safety of workers.

Different areas of transportation represent interesting examples of how the quality of safety management depends on who and what is exposed to risk.

Rail

Advanced systems of train movement control, automated signal-box systems with several layers of redundancy, automated signal-related braking in locomotives, and two-way radio communication - all of these rail safety systems have been deployed since the 1940's, particularly in high-density rail traffic areas like in urban commuting and subway systems.

The front end of the moving train has been subjected to a significant volume of research and development in relation to the driver and the driving environment; fatigue, vigilance, the consequences of shift work, signal detection, and different aspects of ergonomics (Käcklund et al, 1999). And in areas where crash consequences have been deemed unacceptable, automated systems have been put in place.

In contrast to this, the work environment and risk exposure in shunting yards, in rail cargo terminals, in track building and repair, and in the maintenance and repair of rolling stock represent classical areas of high incidence of occupational trauma and fatality, and these areas have had few improvements in modern times.

As rail transport has seen increasing and often commercially unfair competition from road transport, traditional rail transport systems have been chopped up into their different constituent parts ideally buying and selling services and products to and from each other. Obviously, such exercises have implied a shedding of, often, archaic staffing levels and functions. But safety does not necessarily improve when the locomotive, the signal system, and the track repair crew are operated by three completely separate companies, without a joint information and communication system, as has been shown by recent Australian examples of rail crashes. For safety levels to be kept intact in cases of rail privatisation, safety must be a very high profile aspect in the contractual arrangements between the separate companies (Maidment, 1998).

Aviation

The pointy end of the aeroplane, together with the control tower, is the sophisticated and expensive end of aviation safety. The cockpit represents the front-end of our knowledge of different aspects of human performance in relation to functional risk control. The layers of redundancy operating in civil aviation have, most certainly, been developed to counter the unacceptable consequences associated with losses of aeroplanes.

However, for as long as commercial aviation has been developing, the safety management staff of the ground operations in the aviation industry has been complaining that few of the approaches applied to save hulls and passengers are adopted to control hazards and reduce risks on the ground. Thus, the handling of baggage around luggage areas and the loading of cargo holds, particularly in narrow-body aeroplanes, represent an archaic work environment and some truly challenging and unsolved ergonomic problems.

The aviation industry has faced a similar economic onslaught as the rail transport industry; air traffic control, airports, airlines and different ground services (cargo, catering, passenger handling) these days are operated by different commercial organisations under their own priorities and interests.

Again, safety has not been improved by the erection of new boundaries between areas which really need to be included in the same information and communication system. An example from Holland shows how regulators have attempted to force the development of an Integrated Safety Management System for Schiphol airport by anchoring the responsibility for such a coordinated system as a requirement placed upon the director of the airport (Hale, 2000).

Sea transport

Long distance sea transport has always represented high risks of severe injury and death to its workers. The East India Company ship always took on 4-6 more ratings than they initially needed in order to have sufficient crew numbers on the return voyage.

Modern systems of sea transport have benefited from greatly improved navigational systems, which represent the crucial aspect of the safety of the ship. Coastal navigational systems for communication and control have been upgraded, and busy shipping straits are monitored electronically and via radar in similar ways to aviation.

Manning levels in long distance sea transport have dropped, and one of the traditionally worst areas of occupational trauma - the manual handling of sea cargo - has disappeared through containerization. However, deck hands and other categories seafarers still represent extreme levels of occupational trauma and disease in most national statistics.

In a description of the work environment for fishermen Stoop (1990) showed the contrast between the huge sums spent on electronics to find the fish and to navigate, and the relatively primitive conditions for gutting and freezing the fish. You might expect that the navigation equipment would have reduced collisions, but it did not, because of the fatigue of the crew after the fishing leading to failures to see or respond to collision warnings!

Nuclear power

The nuclear power plant is an extreme example of the discrepancy between high-order safety management practices and low-level poor working environment. The post-Chernobyl investments in up-graded technical safety and further layers of redundancy resulted in hundreds of new engineers and many new sophisticated emergency installations in the Swedish nuclear power industry.

However, the recurrent close-down, overhaul and maintenance cleanings of the facilities are still performed at the traditional high levels of occupational risk, with excessive manual handling and fall risks, not much different to the traditional high-risk work in other parts of the energy industry (ie. water and gasworks, petroleum process plants, off-shore installations). Very little of the subtle and scientific control of risk applied in the planning and running of the nuclear reactor has been applied in the designing of safe maintenance work in the reactor hall.

It seems obvious to this observer that commercial transport activities on rail, at sea and in the air - and the generation of nuclear power - imply ample resources invested in safety management systems, often technically advanced with several layers of redundancy to counter-act occasional drops in human performance levels and avoid drastic loss of cargo and rolling (floating, flying) stock, or, indeed, nuclear disaster. However, the occupational health and safety of those who man and operate these transport and energy industries at the lower end of technological sophistication has not improved in a comparable way.

There are presently worrying tendencies in many countries to sub-optimize, and perhaps to decrease safety performance, when traditional transport and energy technologies are re-organized with the help of accountants.

3 EXPOSURE - DECISION POWER

Hospitals, roads and work

Risks need to be visible to the people who have the power (as individuals or pressure groups) to push for decisions. Some health risks related to work are visible to the victims, but often long after they leave the company; poor safety for patients can be categorised as complications, road deaths are spread over large areas of jurisdictions. However, there seem to be important differences between *patients*, *drivers* and *workers* in terms of how well the potential injury consequences and the probabilitites with which these can strike have been made visible to the exposed.

Maybe the actual proximity to risk and to potential injury consequences could be used as an analytical and differential aspect of safety management. Patients, drivers and workers represent interesting examples of potential victims of injury and the way their control over risk-exposure is perceived and presented.

The volume of medical mistakes and the number of patients killed or severely injured by medical treatment each year is far greater than the national road toll. The size and severity of this problem has been well documented in the USA and in Australia (Brennan et al, 1991; Wilson et al, 1995) but steps to implement comprehensive patient safety systems, in order to bring under control and reduce mishaps and medical errors, are hampered by the perceived conflict with the traditional role and status of the medical professional, the hierarchical structure of the medical establishment, and the absolute lack of power and influence by the patient in need of medical care (Vincent & Mol, 2000).

In contrast, safety in road transport represents exemplary development over the last three decades. Important improvements in vehicle and traffic systems design, together with improved emergency care, have reduced the incidence of road fatality and severe road trauma, in the developed world, significantly. It is, in fact, impossible to find another comparable area of successful safety management, if relative exposure and functional outcomes are taken into account. The reduction in occupational trauma and fatalities in the Scandinavian countries between 1950 and 1980 could perhaps be a parallel, but this was accomplished by way of elimination of dangerous and outmoded technologies and the shifting of large proportions of the workforce from high-risk manufacturing/ transport to low-risk retail/public service jobs. Contrary to this, road transport since 1970 has just developed an incredible volume of doing more of the same, but with systematically reduced risk of fatal or severe trauma.

Traffic exposes all and everyone is a potential injury victim. The massive public and market support for vehicle and traffic system safety is based on the generality of exposure and the market power of the customers and potential injury victims driving the development of car safety features, seat belts, air bags, dual carriage ways, round-abouts and other road safety improvements.

Work risks, on the other hand, are extremely skewed. Some workers in some industries are consistently 15-20 times more likely to suffer severe injury or fatality than the average employed, but 80% of the workforce are exposed to low levels of risk. The variation and heterogeneity in exposure and the lack of generic counter-measures, in combination with risk exposure being a core industrial relations negotiating tool, make successful occupational safety management highly selective and exceptional.

Ideally and legally, the employer is responsible for risk exposure. In the real world, however, coping with occupational hazard within the wide perimeter of general safety is normally delegated to the risk-exposed worker. Widespread tendencies to outsource risk-coping through the sub-contracting of hazardous tasks (eg. cleaning, maintenance, repair, etc) increasingly lodge the actual responsibility for risk with self-employed and small business operating workers. Their power to influence and control this exposure is often very limited, both due to lack of influence over the environment, design and running of the company with which they are sub-contracting, and also through highly competitive pricing in areas virtually devoid of industrial safety inspectorial control.

In conclusion, the risk-exposed *worker* would need to emulate the position of the *driver*, or at least be empowered to improve his/her influence over more of the hazards in the work environment. The *patient* critically needs an independent and structural defence of his/her interests against the potentially dangerous service-providers.

Since the exposure problems of the *worker* and the *patient* are selective and marginal, whereas the problems of the *driver* is general and main stream, solutions to occupational safety management and patient safety would only be sectorial, selective and specific. Comprehensive no-fault insurance solutions can provide the basis for compensation, rehabilitation and, potentially, selective prevention and safety management for workers and patients, as they have shown to be able to do for drivers.

Examples like Swedish workers' compensation, Finnish patient insurance and Australian third party traffic insurance represent powerful risk information systems, where selective risk information has been extracted and applied for prevention purposes. The development potential in terms of decision support tools and the interaction with risk-exposed for the purpose of customized safety management is slowly being realized.

4 SYSTEM BOUNDARIES AND INTERACTIONS

The papers illustrate the problems of obtaining a clear picture of risk and of deciding what level of system we will consider when making decisions about prevention. Nuclear power is the most centralised and clearly definable system. The companies in control of the power stations are highly visible and appear easy to regulate. However, even here, the risk is spread. If we take a life cycle view of it, we must consider the hazards from uranium mining to nuclear waste disposal, which are inevitable risks if we make the central decision to use nuclear energy generation. The low-level radiation risks are also diffusely spread around a broad population. Which aggregation should we use to decide about nuclear safety: the generating plant? The full life cycle?

Hospitals too are large and visible buildings, but already here the control is much more diffuse. There are separate and sometimes conflicting hierarchies of administrators, doctors and other professionals. The interactions between them are complex. The functional processes in the hospital are often not clearly defined, so that risks created in one step in the process manifest themselves in another, without a link being made by those involved in either step. This creates problems of knowing who to address and make responsible for action. There is enormous scope for passing the buck. Added to this is the fact that, in most countries, there has only recently been the realisation that unacceptable safety risks are present. Only slowly is it becoming widely visible that large, avoidable risks are present, which cannot be hidden as inevitable consequences of life-saving medical practices. This has been fuelled by scandals, e.g. over handling of blood products for haemophiliacs in France, or over surgeons in the UK continuing to operate despite very poor results, which should have alerted the authorities to questions of competence. One of the issues in these cases is who are these "authorities"?

The transport sectors also differ in their degree of organisation into recognisable systems. Rail was up until recently a monolithic national system, but even it has major risks which have got little attention because they are seen as marginal to that system - e.g. level crossing accidents, passengers injured at stations, suicides jumping in front of trains. Rail shares with aviation and sea transport that they are each a complex interplay between infrastructure, vehicles, passengers, freight companies and transfers. If something goes wrong, which element is to blame? Which element should be changed? These are difficult decisions which interact and sometimes conflict with each other. Blame is related to liability, choices about change are related to the possibilities for achieving that change.

5 METHODS AND APPROACHES

A range of approaches to the control of risk are exemplified in the different areas of transportation and nuclear safety. Systems engineering, safe design, technical process surveillance and energy control represent the main strategies deployed and probably the main safety efficiencies gained. In addition to this, human factors, cognitive psychology and occupational hygiene provide insights into better control of human error rates and thus have further improved reliability.

Historically, the main gains in work safety have been achieved through improved systems engineering and safer technical design of work processes. Perhaps due to the great variation of industrial hazards and exposures, the analysis of the worker as a decision-maker and a psychological *subject* has been less prominent in safety science. The focus has rather been on the analysis of the worker as an *object* of hazardous hygiene exposures and how protection against such hazards should be deployed (ie. hard hats, steel-capped shoes, ear-muffs, gloves, etc).

It is quite obvious, perhaps especially so from the examples in this workshop, that work safety still represents a residual problem in the industrial system. Risks to workers are problems of epidemiology and ergonomics rather than problems of systems safety. Risks to workers are generally controlled with behavioral rules, painted foot-paths on the shop-floor and the voluntary wearing of personal protective equipment by individual workers.

The most common control methods applied to occupational safety are archaic, low-grade, individualistic, voluntaristic and inefficient. The common work safety paradigms underpin conclusions about risks being devolved to the exposed, and injury being the result of individual behavioral failure on the part of the worker.

There are, of course, exceptions to this negative description in some countries, notably those in North West Europe, where there has been some good progress with improving inherent safety in the normal occupational safety area; e.g. in construction, logging, agriculture.

But again, the parallels with *drivers* and *patients* point to methodological approaches which could be emulated in occupational safety in order to control work-related trauma and disease.

The major change in the development of road safety has been the shift in focus and philosophy from "the nut behind the wheel" to the integrated traffic system and traffic process parameters. Vehicle safety, crashworthiness, passive interior passenger safety, and road environment improvements, together with specific targeting of risk groups (eg. young drivers) and risk behaviors (eg. drunk driving, speeding) - and reasonable levels of sanctions - represent activities and synergies integrated into a systems approach.

The *driver* is still the main recipient of messages and behavioral cues, but he/she is no longer seen as the main focus of road safety, but rather as a fairly predictable component in a complex but structured transportation system. The development of intelligent transport systems (ITS) indicates that road traffic will become increasingly structured with new and added layers of vehicle safety and driver/operator redundancy.

The *patient* is the passive working material in the hospital system and he/she is taken into hospital due to the risk his/her condition already represents. The environment, procedures and substances of the traditional professional medical approach concentrate singularly on the patient's condition and are reluctant to treat the management of patient safety as a systems issue. Poor communication, poor technology and design, lack of monitoring resources, and unsafe medical trade practices (learning by doing, extreme shift length at call, etc) are systems components explaining most in-patient accidental losses (Larsson & Ödegård, 1993).

The *worker* will, increasingly, become an independent operator and contractor, and the different industrial arenas in which he/she provides services will vary in terms of risk levels, predictability and structure.

Based on overview information about negative outcomes of exposure, ie. injury and disease, hazardous occupational exposures can be identified. However, the structure of occupational risk information is in most systems developed to suit legal action or compensation claims. To be useful for safety management such information must be upgraded and the output from such information systems must become much more sophisticated in order for proper systems and counter-measures analysis to be possible.

The *worker* and the *patient* share the objective need for an actual coherent safety management system, with defined criteria for hazard and risk, with clear criteria for reporting and information flow, and with accepted and available methods for containing, reducing and eliminating risk.

The *worker* and the *patient* are both aspects of social roles which are marked by a certain lack of influence over decisions crucial to their exposure to risk. These two roles also lack appropriate and functional methods of safety management, probably due to lack of social and political support for such methods, or due to the influence of interests or groups objectively opposed to such an empowerment (ie. employers, medical professionals).

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The control of risks at work is a social task which demands the combination and coordination of many different perspectives, disciplines and approaches. It seems clear to us that there are indeed areas of successful safety science and risk control practices which could and should be translated and modified into areas of hazardous work and industrial activities, especially to those areas of the present and future labour market where the level of risk is medically, socially and economically unacceptable.

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