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Independent accident investigation: a modern safety tool

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Abstract

Historically, safety has been subjected to a fragmented approach. In the past, every department has had its own responsibility towards safety, focusing either on working conditions, internal safety, external safety, rescue and emergency, public order or security. They each issued policy documents, which in their time were leading statements for elaboration and regulation. They also addressed safety issues with tools of various nature, often specifically developed within their domain.

Due to a series of major accidents and disasters, the focus of attention is shifting from complying with quantitative risk standards towards intervention in primary operational processes, coping with systemic deficiencies and a more integrated assessment of safety in its societal context. In The Netherlands recognition of the importance of independent investigations has led to an expansion of this philosophy from the transport sector to other sectors. The philosophy now covers transport, industry, defense, natural disaster, environment and health and other major occurrences such as explosions, fires, and collapse of buildings or structures. In 2003 a multi-sector covering law will establish an independent safety board in The Netherlands. At a European level, mandatory investigation agencies are recognized as indispensable safety instruments for aviation, railways and the maritime sector, for which EU Directives are in place or being progressed [Transport accident and incident investigation in the European Union, European Transport Safety Council, ISBN 90-76024-10-3, Brussel, 2001].

Due to a series of major events, attention has been drawn to the consequences of disasters, highlighting the involvement of rescue and emergency services. They also have become subjected to investigative efforts, which in return, puts demands on investigation methodology.

This paper comments on an evolutionary development in safety thinking and of safety boards, highlighting some consequences for strategic perspectives in a further development of independent accident investigation.

Keywords: Accident investigation; Safety tool; Independent investigations

1. Safety thinking in transportation

Over the decades, various ‘schools of thought’ in safety thinking have been developed, varying in focus and methodology, depending on the sector and on the scientific disciplines in which they emerged. Scientific interest in safety has been dispersed across engineering design, technological, social, behavioral, judicial and managerial disciplines, each with their own paradigms, notions, methodologies and techniques. An integral safety notion is emerging, but has not yet acquired a worldwide harmonization and acceptance. At best, safety is defined as an interdisciplinary activity.

An explanation of the various notions may be given by exploring the three schools of thought in safety as performed by [1].

In addition a fourth school is defined as ‘System Deficiency and Change’ [2]. Each of these schools represent a different pattern of thinking and can be considered as consecutive, representing the societal and scientific safety concepts of their times. These schools are supported by extensive literature covering a wide variety of domains and scientific disciplines.

1.1. Tort law

The ‘Tort law school’ as defined by McIntyre, has a long history and roots in the US railway industry since the end of the 19th century. It goes back to the introduction of safety engineering design in the railway industry to cope with the carnage among railway workers. Lorenzo Coffin is stated to be the first railroad safety advocate and champion of safety legislation in the USA. He was the first in line of a series of safety advocates, followed by people such as Ralph Nader

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in the automobile industry or Mary Schiavo in the aviation sector. He had a pioneering voice for the merging of two streams of safety technology and government policy control. Out of this development, an engineering design approach emerged, focusing on certification and standardisation of technical designs and products. This development found its counterpart in 'forensic engineering'. This discipline focuses on technical failure and fact-finding for the benefit of tort and litigation in liability issues concerning accident investigation, mechanical and structural failure of buildings, constructions and products [3]. Driven by a number of catastrophic events from the 1960s to the 1980s of the previous century, legislative efforts expanded safety litigation to almost every area from occupational and environmental to product safety, all modes of transportation and other major hazard activities. Moreover, the concept of failure is central to understand engineering, for engineering design has as its first and foremost objective the obviation of failure [4]. Lessons learned from disaster can do more to advance engineering knowledge than successful machines or technical designs. Such learning does not only refer to enhancing the safety of design products, but refers to enhancement of the design process as well.

1.2. Reliability engineering

Reliability engineering became a new engineering school based on the problems of maintenance, repairs and field failures during the Second World War. In communication and transportation, the rapid growth in complexity and automation fuelled the development of sophisticated techniques in probabilistic risk assessment (PRA). The drive to understand the likelihood of hardware malfunctions and errors, led to the adoption of PRA in many high-risk industries, among which the process industry and energy supply sector [1].

After laying a basis for the design of man-machine interfacing in the Second World War in the military sector, the ergonomics area rapidly expanded to these industrial domains. It was only a natural development that the focus of mechanical reliability engineering expanded to the area of the human factor, predicting human reliability. Cognitive aspects of human error came to maturity through the work of James Reason, which defined and operationalized the concept of human failure. Most recently, the reliability concept has expanded from the technical aspects into organisational aspects of systems. The concept of High Reliability Organisations by Laporte and Normal Accidents by Perrow examined the complex relationship between organisational culture and safety.

1.3. Systems engineering

The modern systems engineering school developed with the dawn of space transportation. This approach focused on accident prevention and was heavily supported by the development of safety standards, specifications and operating instructions. The Systems Safety concept calls for a systems life cycle safety analysis and hazard control actions from the conceptual phase of a system on into the design, development, manufacturing, construction, operation until modification and finally demolition [5].

However, this quantification of risk standards raised questions about the acceptability of such risk levels and the application of scientific methods in assessing design consequences. Based on the analysis of a series of disaster, the sociologist Turner defined disaster not by its physical impact, but by its social impact: a significant disruption of existing cultural beliefs and norms about hazards and their impacts. He introduced the systems concept to sociological analysis of accidents and expanded the technical systems approach into socio-technical systems. An even further expansion of the systems scope of a disaster redefined disaster as 'crisis': unique events, embedded in the social context in which they occur, irrespective of their origin and causation, deprived from their specific (technological) characteristics. The focus shifts from sectoral and technical-analytical towards social-managerial, in which 'crisis' is a 'battlefield of subjective constructions, definitions and feelings, where objective risk analysis and expert based norms do not work any longer' [6]. As a consequence, causes of accidents may remain obscured or even become irrelevant. The complexity and dynamics is assumed to be so overwhelming, that a shift in focus to administrative responsibilities of national and local authorities is legitimate. This concept implicitly restores the notion of blame.

1.4. System deficiency and change

In addition to these three 'schools of thought' a fourth school has emerged during the last decade. Based on the operational experience of Transportation Safety Boards throughout the world, a school of 'safety deficiency and system change' is developing [2,15]. Essentially, this school elaborates on the systems engineering approach and transforms notions from accident investigation experiences into a theoretical framework. In this school the concept of independence is crucial, separating the investigative mission and efforts from allocation of blame and vested interests of major stakeholders. This school also separates the investigations from scientific preferences or biases of a technical, behavioural, organisational or cultural nature. A fundamental issue is how to achieve a neutral and objective analytic result as a basis for safety enhancements. Consequently, this school no longer focuses on 'deviation' from a normative performance, but refers to 'system deficiencies'. It emphasises the need to implement sustainable safety changes in the system rather than issuing recommendations without monitoring their lasting effects [7]. The focus is on safety critical characteristics in its structure, culture, contents and context with respect to safety critical performance throughout the life cycle of the systems.

These characteristics can be identified and analysed along the lines of:

- An analysis of the primary processes and relevant actors during design and operation including their safety critical strategic decision making issues. However, such a pro-active encompassing analysis is not always feasible in practice due to the complexity and dynamic nature of transportation systems.

Therefore, a second reactive approach remains indispensable:

- An in-depth and independent investigation into systemic incidents, accidents and disasters. Such independent investigations may provide a temporary transparency as a starting point for removing inherent deficiencies in such systems.

2. Evolution of safety boards

2.1. Life cycle stages and working processes

Assessing current practice of boards, an evolution of safety boards is revealed. A gradual development in five stages can be identified, growing from a technical investigation agency within a Ministry of Transportation into an independent, inter-modal organisation charged with maintaining public confidence in transportation safety through the introduction and promulgation of empirically-based recommendations that addresses systematic deficiencies in transportation safety [8].

To guarantee a successful mission, five primary working processes of boards have been identified in an international survey of best practices of multi-modal transport boards in the USA, Canada, Sweden and Finland and a number of single mode boards in The Netherlands [8]. These five processes of a safety board move the board from the decision to undertake an investigation of one or more accidents or incidents through the analysis of the events into formulations of recommendations to prevent or mitigate future accidents and finally to assessing the effects of those recommendations. Accompanying these actions are ongoing communications with the involved parties.

A recent survey on available methods for accident investigation revealed deficiencies of these methods in complying with demands from the ‘safety deficiency and system change’ school of thinking [9].

2.2. Diversity in rationalities

It should be realized that actors involved in these new, open and participative approaches also may have fundamentally different notions of risk and may apply different and even conflicting rationalities.

To understand risks and safety issues two different lines of reasoning are available:

- An ‘inside-out’ vision of commissioners, designers, engineers and other actors which have an oversight of structure and contents of complex systems during their design, development and manufacturing. They are capable of defining complex interactions, couplings and causal relationships within the system, risk management, mitigation and control included. They are less capable of dealing with the actual behavior of the system in its dynamic social environment in terms of risk perception and risk acceptance issues.
- An ‘outside-in’ vision of operators, users, risk bearers, regulators, administrators and other stakeholders which have to cope with the system characteristics in its operational environment. They are capable of dealing with global risk notions and causal relations at an aggregated level, but lack a profound insight into the functioning of complex systems. They may concentrate on perception and acceptance rather than controlling risks.

An ‘inside-out’ vision is likely to define risk in terms of a program of requirements and standards, as a consensus document for the actual design and manufacturing. An ‘outside-in’ vision is likely to define risk in terms of a defined reality among actors, negotiating risk as a ‘social construct’ to achieve consensus on perception and acceptance between stakeholders. If such a consensus is lacking during events with a high social impact such as disasters, a ‘battleground’ situation may occur.

2.3. Public safety assessor: a new mission

Historically, independent accident investigation has dealt with major accidents within a sector, focusing on technical investigations, human factors and operational practices. Two trends are emerging: The first trend sees major companies aim at accident prevention and improving their safety performance following principles of responsible care. The second trend sees increasing openness and involvement of the public sector due to changes in public risk awareness and acceptance, in particular on rescue and emergency aspects.

The private sector is evolving in a direction similar to that of public safety investigative boards. For example, operators of transport companies, especially in the aviation sector, are well aware of their responsibilities towards their employees and passengers [10,11]. Since safety deficiencies may have their origin in organizational processes and personal factors they are also affected by weaknesses in these processes, such deficiencies may lead to unwanted events. Rather than allocating blame to individual operators, identification of latent and active causes that may lead to incidents is required to avoid reoccurrence by adjusting and developing the operational system. Safety responsibilities are both pro-active to prevent accidents as well as reactive to cope with emergencies, assisting in official investigations and prevention of re-occurrences. There is an increasing willingness to an internal investigation of events for the purpose of learning and recommendation of corrective actions

[10]. To reduce the accident rate further, a wide arsenal of pro-active safety efforts and programs is available within many organizations. In contrast with a decade ago a very data rich environment is available, consisting of mandatory accident information, voluntary information sources on minor accidents or incidents and normal operations, automatically stored records such as those in Flight Data Recording equipment. Many sources of information exist over a wide spectrum of events: Flight Operations Quality Assurance programs, confidential reporting systems, incident investigations within companies, manufacturers and insurance companies and many others. Much effort is spent on sharing information on accidents, error studies and accident assessments in comparison to analysis of normal operations [11]. In order to reduce the accident and incident rate further, a shift in focus is required towards prevention, finding the indicators for normal performance. Such investigation can be only performed in-depth, identifying vulnerabilities in the system, independent from operational and maintenance functions [10]. Consequently, aviation companies become even more interested in independent safety investigation.

2.4. A role in rescue and emergency issues

Over the past decade, several major events have occurred across Europe dealing with infrastructure related disasters. Public and political concern has been raised about fires in the Channel Tunnel and tunnels in the Alps region, high speed train crash at Eschede in Germany and a series of railway accidents in the UK, capsizing of the passenger ferries Herald of Free Enterprise and the Estonia, grounding and sinking of sea-going crude oil tankers and several air disasters. In the aftermath of these events, questions have been raised about the preparedness for such disasters and capacity for emergency response, salvage and rescue. Consequently, a need for prevention, policy harmonisation and regulation at a European level has been identified, initiating draft Directives for tunnel safety and the establishment of safety agencies in all modes of transportation.

Such attention has not been restricted to the operational phase of complex transportation systems. Also during the design, development and construction of a series of major infrastructure projects in The Netherlands it became clear that rescue and emergency preparedness lacked transparency and consistency across these projects in view of this European wide safety awareness. This awareness was fuelled by several factors:

- A wide variety of safety aspects exist, causing fragmentation of attention and procedural interference during various phases of the project developments and at the various levels of managerial responsibility.
- Clear terms of reference were not yet developed for this type of projects, while clarity about acceptable societal risk standards beyond quantitative individual risk levels was lacking, in particular for the rescue and emergency aspects.
- A lack of clarification regarding division of responsibilities across project phases and levels, in particular with reference to rescue and emergency tasks of fire fighting, medical support and trauma care and public safety.
- An almost complete lack of understanding of lay stakeholders and the general public with regard to residual risks and safety responsibilities of stakeholders in the operational phase, combined with a reduced public risk acceptance.

2.5. Safety boards as problem providers

This evolution from technical-investigative and sector-specific committees into independent and interdisciplinary based diagnostic instruments for socio-technical systems yields a superior capability to advocate for safety, provide a public voice advocating safety, provide transparency in the complexity of systems and contribute to a proper functioning of a civil society. The products of a fully evolved board may serve as input for risk decision making by private and public stakeholders in the management of complex systems during their design and operations. Safety boards may serve as ‘problem providers’ to other stakeholders in the system. Consequently, fully evolved boards may add to the learning potential of organisations. Moreover, they may serve the integration of safety into the engineering design process at a socio-technical level.

3. Strategic options: the multi-perspective

Existing boards have served as organizational role models for new boards. In some countries however, different organizational models has been applied, with similar success. The organizational model does not prove to be a key issue in fulfilling the independent investigation mission as it is defined by the socio-economic and political context of the country [12].

A more strategic issue is the ‘multi’ issue: what are the strategic options and alliances available? Safety boards have developed several adaptation strategies to respond to changes in their environment. Two different strategies are under discussion with an identical perspective: achieving a legally based, independent position, professional credibility and public confidence, high quality performance and critical mass to ensure continuity [12–14]. These strategies are essentially: combining various sectors on a national basis within one agency or development of multinational boards within a single mode of transportation. It may be obvious that assessing and selecting a strategy will depend on national, modal, cultural, legal and political considerations. It may not be surprising that different preferences exist across modes and nations.

3.1. Multisectorality

Multi-sectoral boards are a growing phenomenon. So far, only Sweden, Finland and the Netherlands have legal authority in independent accident investigation outside the transportation sector. Occasionally, they perform investigations in the process industry, or after a serious fire. Other boards are asked to support investigations outside their jurisdiction. A world-wide trend can be noticed towards multi-modal boards due to a number of contextual influences such as harmonizing policy issues across modes within a world region. The European Union strives for harmonization of the policies of its member states in order to open up internal markets irrespective of the sectors. Pressure exists from national parliaments towards mutual learning across modes and even sectors. Implementation of the notion of 'integral safety' is advocated, with an investigative interest in system deficiencies originating from pre- and post-event phases.

In the debate, arguments pro and contra multi-modal independent investigation agencies are brought up [8,12,13].

Arguments in favor of multi-modal agencies are:

- Sharing resources in administration, facilities, senior management, training may provide a critical mass and a defense against budget cuts and benefit economy of scale effects.
- A critical mass in knowledge is required to maintain high quality performance. Skills are transferable in managing major accidents, reviewing reports, or support by non-modal specialists such as metallurgists and human factors.
- Combined experience can improve transparency of organizational and managerial issues for senior staff (CEO's and Board members during conduct of major investigations, training needs, dealing with the public and press, quality of reporting, drawing up of recommendations, flexibility of resource allocation and other general issue at a senior staff level).
- Synergetic co-operation may emerge from methodological and procedural similarities, leading to harmonization of investigative methodologies.
- A similar approach across all sectors provides similar quality of investigations, policy harmonization and a single philosophy, leading to increased public confidence in investigations.

Arguments against multi-modal agencies are:

- A loss of in-depth modal expertise and credibility in the sector due to a dilution in focus by combining various modes and sectors.
- Absence of learning potential due to dominant substantive differences between modes which exceed apparent similarities.
- Domination by outsiders with insufficient expertise and insight, focusing attention towards issues and solutions at a generic and aggregated level.
- An attitude of segregation and compartmentalization within modes hampers a willingness to co-operate.
- Loss of required skills and expertise during fact-finding and analysis in single major-event investigations, especially relevant where a leading role in major investigations is required.

Although the test of time will have to confirm the trend, none of the present multi-modal boards wants to go back to a single-mode concept [13].

3.2. Multinationality

The only existing multinational, single-modal independent accident investigation committee is the Air Transport Accident Investigation Commission (ATAIC). This agency is a subcommittee of the Interstate Aviation Committee of the Commonwealth of Independent States. ATAIC consists of the 12 member states of the former Soviet Union and has a record of maintaining the achieved safety level in commercial aviation after the disintegration of the soviet civil aviation sector.

Especially in aviation, multi-national single mode boards have been advocated in Europe. The main reason for this preference is the present safety level in the sector, specific nature of the modality and international scope of its operation. Within the sector there is also some disbelief whether aviation can learn valuable lessons from other sectors. National investigation agencies are supported by non-governmental umbrella organizations such as the International Civil Aviation Organization (ICAO) with a specific Annex (13) on accident investigation. The European Commission is in a process of establishing single-mode European Safety Agencies for aviation, the maritime sector and railways, including national independent accident investigation agencies.

The argument for multinational single mode agencies however has to face the fact that nations will not easily give up autonomy, nor will States transfer theirs to federal levels such as is the case in the US, Canada and Australia. At the same time, a trend towards multi-modal agencies in Europe may emerge for reasons of efficiency, resource allocation, inter-modal learning potential and policy harmonization across Member States. There does not seem to be a single best strategy and the different systems coexist [12].

4. Conclusions

Safety boards cover a specific range of major accidents in the accident spectrum and are faced with new mission elements, such as victim care and family assistance and emergency and possibly in the near future, a public safety assessor role.

There is a shift in attention towards the end of safety board principal working processes emphasizing change and com-

munication based on an integral safety approach, including rescue and emergency phases.

To maintain operating on a high quality level, a critical mass in organization, substantive knowledge, network and information infrastructure is required, pressing for co-operation among boards across modalities, sectors and nations.

There is a growing consensus that such investigations may require separate institutions with formal and functional independence such as Transportation Safety Boards with their own, specific methodology [2,13]. The concept of independent accident investigation has a generic potential, expanding its application to other sectors outside transportation, such as defence, other high-risk industry, natural disasters, threats to health and environment, and major events such as explosions, major fires or the collapse of buildings and structures [14]. The concept deals with an integral safety notion, addressing events throughout their sequence through a multidisciplinary investigation into all causes, before, during and after the event. Consequently, safety enhancement and system change recommendations may cover issues of proactivity, prevention, preparation, repression and after care.

Independent investigations are considered a right of every citizen and a duty of society and may as such be of great significance to a democracy to function properly. Such rights should be anchored in law [13].

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