



## Modern accident investigation – Four major challenges

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### ABSTRACT

Nowadays, ‘investigation’ is a very commonly advocated approach and consequently is becoming an umbrella concept. ‘Investigation’ includes many types of approaches on different system levels. Originating from transport accidents and crime scenes, ‘investigation’ ranges from genocide, natural disasters, via discrimination, health care to crime fighting, economic fraud and ethical questions in engineering and management. In such a changing operating environment and widespread applications, accident investigation must reassess its distinctive role, purposes and operating conditions. It must clarify and communicate its specific aims and functions and performance to such an extent that it maintains its credibility, capability and quality in the eye of professionals, politicians as well as the public. Based on an assessment of the past performance of leading investigation agencies, practical experiences during major *ad hoc* accident investigations and changes in the operating environment, a SWOT analysis identified several issues as internal and external challenges in the future conduct of major investigations. Finally, the article proposes several priorities, challenging each stakeholder and expert in the investigation community to contribute from its own perspective to improve accident investigation theory and practices.

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### 1. The challenge of investigation

In many European countries, the public perception into the risk of accidents, crises, disasters, and catastrophes is growing. Data about event chains, accident scenarios, immediate and root causes, and experiences from such tragedies are often gathered through various types of investigation commissions or boards. The use of such commissions may serve as *one option* in applying an adequate, systematic method for developing appropriate measures to reduce the risks or minimize injuries and damages from disasters, accidents and other unacceptable major events. Historically, ‘investigation’ has been a concept that is widely applied in specific domains, such as crime fighting, engineering design, product liability and major transport accidents. Due to changes in its operating environment, public appreciation and broadening of its applications, accident investigations have come under public and political scrutiny and have raised scientific interest in their models, methods and practices.

Based on several field observations, surveys, the Working Group on Accident Investigations of the European Safety and Reliability Data Association (ESReDA) performed an expert opinion assessment applying an analysis into the challenges during the conduct

of ‘investigations’ (Roed-Larsen, Stoop and Funnemark, 2005). This analysis revealed four challenges of both the external conditions under which such investigations have to be conducted as to an internal nature with respect to the actual conduct, required skills and competences. These challenges deal with their independence, scope, methodology, safety training and competence. In the article, each of these four major challenges is described and discussed, while some proposals are presented for discussion in order to improve accident investigations in practice.

Investigations of accidents have a long tradition in three of the main transport sectors: air traffic, sea traffic and rail traffic (ETSC, 2001). Road traffic accidents have generally been treated as single events and have been investigated by the police (ETSC, 2005). Many countries have institutionalized a separate investigation body in one or more transport fields, frequently based on international regulations such as in aviation (Stoop, 2004). Also other technological accidents, for instance in factories or power plants, must be investigated, in line with mandatory requirements. In addition, natural disasters like earthquakes, flooding, wildfires etc., are frequently investigated, but usually *ad hoc* as a single, unique event. A special type of accidents represents a new challenge to the investigation community: a natural disaster that triggers a technological accident with complex consequences and complicated interactions. Such an accident that emerges from natural as well as technological origins and that gradually may develop into a major disaster does not necessarily fit into the conventional analytical model used during investigations. Investigation bodies or

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separate investigations may be set up or implemented by various institutions or organisation – parliaments, governments, ministries, inspection bodies, international organisations, private enterprises, etc. In recent decades, there has been an increasingly clear distinction in accident investigations between the search for causes and preventive measures after accidents, and the police investigation to ascertain guilt/blame and to settle legal claims regarding liability for deficient performance (EC, 2006). In other types of investigations on both individual and collective levels (e.g. concerning economic matters like fraud, corruption and insider dealing; or questions concerning sexual harassment and discrimination, scientific quality, psychiatric cases, terrorism, genocide etc.) borderlines with criminal investigations are quite often vague, with high priority to the question of individual or collective blame and guilt or political responsibilities (Van Vollenhoven, 2006).

Consequently, today accident investigation is faced with several challenges; there is a lack of integration on various institutional levels (global, regional, national, local) and between sectors, dealing with different interests held by stakeholders, organisational and methodological shortcomings. Although the number and consequences of major accidents on the global level seem to be rising, this article will focus on the situation in Europe.

## 2. Safety investigations of accidents in Europe

In order to deal with technological disaster of a familiar nature, the European Community has made investigative bodies in the air,<sup>1</sup> rail and sea sector mandatory by directives in recent years. Accident investigation procedures have been implemented in high-risk industries, like the process industry and power plants (Roed-Larsen et al., 2005). In addition, in July 2004 the EU appointed a special expert group to advise the Commission on a strategy for dealing with accidents in the transport sector (EC, 2003). The methodology subgroup, established on 8 December 2004, successfully proposed in its report of 3 July 2006 several recommendations to the Commission's Group of Experts (EC, 2006). This document now has status as a Guideline on a Methodology for Safety Investigation of Accidents in the transport sector, and is to be employed as a reference document for European and national legislators and administrations.

On the national level, terrorist attacks in the transport field in Europe (e.g. Madrid 2004, London 2005) with deeply tragic consequences, have been investigated by several bodies. The facts and conclusions have been reported in various reports, adding the security dimension to the traditional accident investigation tradition.

However, in addition to technological accidents, including industrial accidents, food scandals, and security challenges, Europe has faced many severe natural disasters during recent years. Their devastating and overwhelming consequences have drawn political and public attention, demanding a public governance response in dealing with the aftermath with respect to emergency and crisis handling.

The *20th Century Asian Disasters Data Book* summarises the situation in Europe as follows (ADRC, 2002):

In Europe, 70% of the total disasters are caused by windstorms (27%), floods (26%) and earthquakes (16%); Europe also has more wildfires (8%) than other areas. As to human fatalities, 46% were due to earthquake and 20% to extremes of temperature, as in cold waves. Windstorms (30%), floods (22%) and drought (22%) also greatly affect people. In terms of economic effects, it is floods (56%) that cause the greatest damage in Europe.<sup>2</sup>

The number and consequences of disasters in Europe have increased by recent years. Statistics from the *International Disaster Database*<sup>3</sup> indicate that in Europe (20 countries) in the period 2000–2003 at least 234 natural catastrophes of large severity occurred; in addition, 96 disasters in the same period are classified in the database as industrial accidents, miscellaneous accidents and transport accidents. Altogether, these various disasters have left several hundred thousand people killed or severely injured and millions homeless or/and otherwise affected. The estimated costs of damage caused by disasters in Europe during that period amount to millions and millions of Euro.

Many of these natural disasters have been investigated by *ad hoc* commissions set up by the parliament, the government, or the ministry in charge.

## 3. A SWOT analysis; emerging issues

Accident Investigation Commissions or Boards face several challenges from changes in their external operating conditions and context. Based on the ESReDA inventories (ESReDA, 2003, Roed-Larsen, Stoop and Funnemark, 2005), an analysis of current operational practices and the SWOT analysis, major external issues beyond the control of safety investigation agencies have been identified:

### 3.1. The broad use of the investigation method

Investigation, as a specific approach and technique, has during recent years been widely used in several fields in society – and at local level, at national level as well as at global level. Often, whistleblowers may play an important role in the first phase of the disclosure process. The advocacy for independent investigations has created its own opposition in an advocacy for a judicial approach to accident investigation (Van Vollenhoven, 2006). Their focus, however, is on the legal questions; the possible legal responsibility of individuals, their judicial liability and the normative aspect – the allocation of blame. This legalistic development challenges the modern accident investigation approach in many respects, among others in the focus on individuals instead of systems, in concentration on legal aspects instead of identification of multiple causes, and in persecution of legal justice (or maybe revenge) instead of promoting preventive measures.

### 3.2. The rapid technological and organisational innovation

In view of recent developments with respect to technological innovation – in particular in the ICT domain- and organisational changes and global market developments, a new approach of systems modelling in high-risk industries seems to become necessary. In many cases the level of physical evidence is missing in the fact-finding phase because systems operate virtual without physical components. They may fail at a functional level rather than due to mechanical failure caused by mechanical overloads, or operating outside the designed performance envelope (Vaughan, 1999; Leveson, 2004). Accident models, which provide transparency in the systems architecture, structure, operating conditions and context as well as insights in the systems dynamics, do not yet exist. Such accident models and systems models are yet to be developed (Benner, 1985, 1996, 2003). There is a challenge for the scientific community to improve the modelling of systems complexity and dynamic behaviour (Sklet, 2002; Stoop, 2004). It may be necessary

<sup>1</sup> EU Council Directive 94/56/EC article 6. '... be functionally independent...'

<sup>2</sup> Based on information in *20th Century Asian Disasters Data Book*, ch. 2 (August 2002).

<sup>3</sup> All data from EM-DAT: The OFTA/CRED International Disaster Database. www.em-dat.net - Université Catholique de Louvain. *Thirty years of natural disasters 1974–2003: The Numbers* (UCL, Brussels, November 2004) gives a broad overview.

to shift towards a non-linear systems approach, treating safety as an emergent property of complex and dynamic systems rather than a quantifiable performance parameter (Amalberti, 2001; Hollnagel, 2004; Dekker and Hollnagel, 2004; Dekker, 2006).

### 3.3. The complexity in a vulnerable society

Modern societies are vulnerable. Many societal functions are tight interconnected, and especially many areas in the infrastructure are vulnerable. At the global level, environmental questions are only one example of the many complex connections that exist. International interrelations have had several consequences – not least for the development of accident investigation, as exemplified by air transport: aviation accident investigations have seen a wide application, and international interrelations and harmonization has been crucial for their acceptance. From the beginning with ‘lighter than air’ aircraft, aviation has been international. There has been a need for supra-national agreements because hot air balloons could drift across national state borders and zeppelins proved to be unsafe due to their vulnerability and limited manoeuvrability. National sovereignty of the airspace and safety of aviation were at stake. In international sectors such as aviation and shipping, a dilemma emerged due to the fact that on one hand aviation should be organized at a sectorial, international level based on consensus among all parties involved, while on the other hand each country had to maintain its national sovereignty complying with its own legal system and national legislative culture. Today, a main challenge within accident investigation is the need for international harmonization under conditions of dedicated approaches towards specific industrial and societal sectors in order to comply with quality and credibility standards.

### 3.4. Societal changes

In a larger historical and sociological perspective, the traditional division of power between the three estates – legislative, punitive and executive powers – is changing. While government retreats from active participation in safety assessment, this function of substantive judgement however still remains. Simultaneously however, government gets increasingly involved in public–private partnerships, multi-actor networks and international policy making. A public safety assessment role over such distributed networks with delegated responsibilities cannot be allocated to an international level of supra-national institutions such as the EU, ICAO, IMO or ILO, due to their involvement in these configurations. Safety investigation agencies may fulfil a role as public safety assessor, replacing the national government as a referee in a societal discourse on the societal acceptability of major accidents. If such a role is not recognized, political sectors and private companies will increasingly become entangled in a process of being conquered by judicial regulation on behalf of political and administrative bodies and their powers. The investigation method, so far especially outside the field of technological accidents, is also to in increasing degree characterized by these developments in its international operating context.

## 4. Major challenges facing accident investigation bodies

The above mentioned examples of challenges to modern accident investigation bodies may be looked upon as *external* challenges. In order to cope with these external challenges, accident investigations consequently also face several *internal* and yet unsolved challenges with respect to their own functioning and performance. Such coping and adaptation is reflected in the scope of the Guidelines for Safety Investigations of Accidents as developed by the ESReDA Working Group on Accident Investiga-

tion in preparation to the ESReDA Ispra seminar (Roed-Larsen, Stoop and Funnemark, 2005).

Four major challenges were derived from the SWOT analysis in responding to the critiques on the concept of ‘independent investigations’:

### 4.1. Independence

Most accidents investigations are declared to be independent, by mandate, structural position, composition, and functions. The results – the description and interpretation of facts, the analysis, conclusions and recommendations – are all held to be objective findings and proposals. This applies to permanent as well as *ad hoc* commissions, and to public as well as private investigations. However, a closer examination often reveals a undefined notion of ‘independence’.

Some examples of institutional or administrative restriction to independence found during the analysis, are:

- The most prominent body on the international level – the US National Transportation Safety Board (NTSB)<sup>4</sup> – was originally established under the Ministry of Transport in United States. These institutional ties undermined its formal independence, and the NTSB was in 1975 set up as a body responsible to and reporting to the US Senate. Its five members are appointed by the US President and approved by the Senate, so that some degree of political influence is maintained over the NTSB. The importance of such political appointments on the personal level has been clearly demonstrated in connection with the selection and composition of judges to the US Supreme Court.
- The same power constellation applies to the US Chemical Safety and Hazard Investigation Board (CSB).<sup>5</sup>
- In Sweden, regulations<sup>6</sup> regarding The Swedish Board of Accident Investigation (SHK) require that the Director-General of the Board and one of the investigators shall have formal legal training and experience as judges.
- Most national public investigation commissions in the transport field are subordinated bodies under a Ministry, often Ministries of Transport or Justice.

The challenge is to provide the structural and functional conditions to enable an investigation body, team and investigation process that are really independent, as measured on such important indicators of independence as organisational freedom, legal freedom, financial freedom, adequate resources and appropriate in-kind expertise, transparency, free publication, and follow-up actions. A limited number of independent investigation agencies have united in ITSA, the International Transport Safety Association, based on the aforementioned admittance criteria.

### 4.2. Scope

By tradition, a single sectoral- or a case-based approach is still common in many countries. This has various consequences. The sectoral approach limits the accumulation of experience to only one sector in the society. Sometimes, the frequency of major accident in one sector in one country is too low to allow more general

<sup>4</sup> The status of US NTSB is defined in the code, title 49, § 1111 General organization, ‘...is an independent establishment of the United States Government’. Established 1967, all organizational ties to the Department of Transportation were severed in 1975 under the Independent Safety Board Act.

<sup>5</sup> The US CSB define itself as ‘...an independent federal agency charged with investigating industrial chemical accidents’..., see also homepage: [www.csb.gov](http://www.csb.gov) under CSB Mission & History.

<sup>6</sup> Förordning (1996:282) med instruktion för Statens haverikommission, § 6. See also [www.havkom.se](http://www.havkom.se)

conclusions about causes or adequate measures. The added safety contribution from analysis of only one accident is usually limited. The advantage of cross-sectoral – or even more, cross-national – comparison, knowledge exchange and learning is usually lacking. The single-case approach is often combined with the appointment of an *ad hoc* accident investigation commission by the public authorities. The composition of the members in the commission is often biased in favour of individuals with a legal/judicial background, and the commission's power to supervise the follow-up of recommendations as well as other continuity preferences is frequently missing. The most serious defect, however, is the lack of institutionalized and systematic public safety investigation of accidents and near accidents in important societal sectors with high-risk activities, such as the health sector, consumer services and products or in agriculture.

Since the 1990s, a more holistic scope for the permanent accident investigation commissions – as all transport accidents or all kinds of national, large-scale accidents – has been developed in Finland, Sweden, Norway, and the Netherlands. This model has many advantages, both in the analysis of single accidents and in safety studies and safety promotion, but implementation has remained limited to a few countries. The challenge is to demonstrate the broader safety benefits and mutual learning potential and to improve the investigation process and methodology.

However, based on national, historical, legal, practical constraints, operational conditions and contextual factors, a wide variety of national organisational varieties has to be acknowledged. Discussing the benefits of a common scope across modalities, domains and sectors focuses on the benefits or common learning, sharing experiences and exchanging best practices, rather than forcing each national agency in a standardised framework or identical organisational structure.

#### 4.3. Methodology

Many investigations prefer and apply a traditional approach: insight and knowledge is gained, based on previous experiences with standing operational practice. This has been widely used in sectorial approaches, such as aviation, maritime and railway accident investigations. In a European survey of accident investigation carried out by the European Safety, Reliability and Data Association ago among several organisations, most respondents indicated that they did not apply a standard method (ESReDA, 2003). Those that did use a method had a simple approach: 11 organisations used different methods, but the use of only *one* method per organisation was common, while 8 organisations used only one method (Roed-Larsen et al., 2004). Yet, the scope of available basic methods is considerable: one overview lists 14 main categories of formal methods of major importance (Sklet, 2002). In practice, there are even more: many companies have in addition developed their own methods. In order to reflect the complex chain of events and multi-factor causes involved and to handle problems arising during the investigation process, a range of methods should be employed.<sup>7</sup>

In general, the situation in Europe today shows an absence of a multi-methodological approach or use of standardised and validated methods during the analytical phase of the investigation process. Such absence may not only weaken the analytical rigour of the investigation process, but also may jeopardize the drafting of recommendations, which should be based on the findings and conclusions of the analysis. Hence, this may jeopardize achieving a professional, public and political consensus on the follow-up of the lessons learned during the investigations (EC, 2006).

The problem is not only the need for the more scientifically based development of new, improved investigation methods. Even

more crucially: throughout Europe, standard methods are not implemented, and there is a lack of relevant expertise and satisfactory application in formal investigations (Kahan and Stoop, 2004; EC, 2006).

#### 4.4. Training and competence

In order to conduct a modern investigation, competent, qualified and experienced investigation staff is required, sharing a common basis with other experts and participants in the investigation process. There is an emerging need to provide training at a qualified academic level, which facilitates experts, investigators, managers and stakeholders to cooperate during major investigations. Investigators, confident with operational experiences gained in their domain, may lack the necessary expertise to use scientific methods in their work or do not have the necessary competences to participate in international and interdisciplinary investigations after a major event. Simultaneously, during their involvement in an investigation, many stakeholders will lack the necessary expertise in how to use investigation methods and lack proficiency and experience due to a low exposure to accidents in their company.

However, so far, systematic and organised training and competence development have mainly been the responsibility of major players within sectors. In addition, some service institutions with special training and competence skills, often within a segment of the post-industrial society, offer training courses and seminars on a commercial basis. These kind of elementary and relatively brief learning programmes in accident investigation are, however, not common within European nations.<sup>8</sup> Also some university institutes in Europe are engaged in systematic training activities and may also offer academic studies with the aim of enhancing competence in investigating methodologies and techniques. In general, advanced investigating skills and scientific based competence seem to be lacking or not fully implemented among the staff of several *ad hoc* or permanent public safety investigation commissions or boards, and among employees participating in private investigation groups or sections organised by large companies or international enterprises. In order to deal with these deficiencies, several transportation safety investigation agencies have established in-kind facilities for training and certification.

The lack of adequate investigating competence and the need of ongoing competence development in general among investigators has been emphasized in some recent publications with the aim of evaluating the work of investigation commissions (Ayeko, 2003). The urgent challenge to public authorities and research institutes in Europe is to develop and implement harmonized, high-standard basic training courses for investigators. The EU however, has not yet granted proposals to initiate such a European investigation training programme.

### 5. Prioritizing challenges

Today, the situation in the investigating community is very fragmented, and there is an urgent need for improvements. The four challenges noted here are examples of areas, which must see comprehensive improvements in the coming years.

Some improvements could include:

#### 5.1. Independence

The Public Safety Investigation Body should be set up permanently, independent of any public authorities; it should be

<sup>7</sup> Op. cit., pages 71–72.

<sup>8</sup> See e.g. Arthur D. Little's core and supplementary learning courses (3/2 days) in formal inquiry/Formal investigation in England and Det Norske Veritas' course (2 days) in general accident investigation in Norway.



impartial and objective with high degree of autonomy, and should be structurally, functionally and organisationally independent of public bodies, commercial interests and the interests of victims. The degree of independence should be as high as possible in combination with access to all necessary resources, in order to support accident research and to promote the necessary development of expertise. A 'full' independence however, is not possible or even desirable because such 'independence' may disengage an investigation commission from its operating environment and professional network and will hamper access to insights already gained from the past performance and dynamics of the complex systems under scrutiny.

### 5.2. Scope

A multi-modal or, even better, a holistic cross-sectoral national or international investigation body will benefit in many ways from a broader approach than is common in many countries. Since the 1990s, the Nordic countries have some experience from extending the scope of their public safety commissions: two are national and cross-sectoral in scope (Finland, Sweden), one is an investigation commission in the transport field (Norway), and the fourth (Denmark) is bi-modal, covering air and rail accidents. Of course, investigation specialists with a high level of expertise in the relevant field of investigation should participate in the investigation team together with safety system generalists. Since investigation agencies are –by their legal mandate– the monopolists in their sector, their professional credibility, skills and ability to conduct high qualified investigations, must remain undisputed. The broad scope of a safety investigation agency may be quite different from the expert scope of individual agencies staff members.

### 5.3. Methodology

Systematic use of scientifically based methods will structure the investigation process and enhance the identification of causes, the interpretation of findings and the validity of recommendations. Due to broader application in different modalities and domains, and a harmonization of national safety policies across EU member states, there is also a growing need for harmonization of an investigation methodology. A systematic, synchronized approach will also facilitate use of cross-sectorial knowledge and measures at the national level, and encourage international comparison and implementation of recommendations within the EU policy framework. Specific attention is required to the various phases of the investigation process, discriminating between competences, participation in a multi-disciplinary working environment and knowledge networks. Investigators should be capable of maintaining communication and cooperation across stakeholders, have the ability to pursue several lines of investigation simultaneously, while keeping in control of managing the investigation process.

### 5.4. Training and competence

A minimum level of investigation skills and investigation competence should be developed and specified as necessary requirements for investigators participating in public investigations or is employed in accident investigation commissions or boards. Special attention should be paid to the need of updating and expanding the investigation competence and proficiency, especially supplemented with scientific results and knowledge, communication and cooperation skills and the ability to participate in change processes. At the institutional level, an establishment of a broad European training and accreditation institution should be considered.

## 6. Conclusions

In conclusion, modern accident investigations face a series of challenges which have to be met in order to cope with recent developments in quality assurance and public credibility of their performance, internally as well as externally.

On one hand safety investigations have to face internal criteria in improving their performance by creating an improved basis for their operational practices. The main issues deal with their independence, the scope of their investigations, the development of a methodology and training and competences of their staff.

On the other hand, external influences are present which put additional demands on the qualifications need to cope with changes in the operating context, such as an increasing emphasis on legalistic approaches, challenging the concept of blame free investigations. In addition a rapid development in information and communication technology puts additional requirements on investigative skills and domain specific qualifications. The need for collective learning positions safety investigations not on a company level, but on at least a sectorial level, preferably a multi-modal or even multi-sectorial level. Finally, due to changes in governmental oversight, control and its institutional relations with public, private companies and politics, national governments do no longer accept the role of public safety assessor. Safety investigation agencies may be the new public safety assessors. If so, such agencies however, should be fully equipped to serve this role in the future.

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