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ISSUES AND JUDGEMENTS IN ACCIDENT INVESTIGATION

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Abstract

Everyone seems to agree upon the fact that accident investigation is necessary and important. There are several reasons for this view, but the most prominent ones are the learning aspects and the societal need to know what really happened. The TIEMS 2001 conference put accident investigation on the agenda, and some delegates concluded then, that a national accident investigation commission, working on a continuous basis, is the right pathway. In Norway, we have had three major accidents, which all occurred close to the entrance of the new millennium. Commissions nominated by the national authorities investigated all three accidents, and the investigations were published as public study reports.

This paper questions accident investigation as a narrative art. One commission carried out two investigations during 2001, the Åsta accident (train collision, 19 fatalities) and the Lillestrøm accident (train accident caused propane gas leak and fire, which threatened parts of the town). These investigations, with emphasis on the Åsta investigation, are selected to pinpoint the power in the hands of the investigators. The power is not necessarily utilised to support the ideal and public informed goals of the investigations. Hidden agendas and poorly supported conclusions are examples of factors that undermine the independent narrative. Our conclusion is that accident investigation is important, but accident investigation processes and methodologies should be reconsidered, at least the Norwegian state of the art. There is a need to develop proper requirements in order to assure that accident investigation serves its intended function.

Introduction

Norway has recently had three major accidents, the two train accidents (Lillestrøm and Åsta) and one at the sea – the loss of the catamaran Sleipner outside the coast of Haugesund (16 fatalities). The Lillestrøm accident had a ”happy ending”, despite the fact that the local community was paralysed for several days. Commissions appointed by the national authorities investigated all three accidents (NOU 2000: 30, NOU 2000: 31 and NOU 2001: 9).

The TIEMS 2001 conference in Oslo put accident investigation on the agenda. The trend seems to be in favour of establishing national and international joint accident investigation commissions. Sverre Røed Larsen (2001) presented some experiences from, benefits of and dilemmas in accident investigations. Røed Larsen’s work is normative, and it is highly influenced of his beliefs that an increased accident investigation effort is the right pathway to improve the national safety management performance. Ove Skovdahl (2001) presents the Norwegian National Railway

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Administration (NNRA) internal investigation of the Åsta-accident, and he describes some of the lessons learned.

In this paper the focus is on specific issues and judgements to be made in accident investigation, and particularly the investigators' power as the narrators of the "true" stories. In an accident inquiry the starting point is, of course, to reveal the truth about what really occurred and why the accident took place. But to reveal the "truth", i.e. all facts of the accident, is practically impossible. Ellinor Ochs (1997) describes narrative as; "It is our cares about the present and especially about the future that organize our narrative recollection of past events". Within this perspective, how shall we understand the investigations being carried out?

The remainder of this paper deals with specific issues in accident investigation. The issues relate to the *narrators*, the *mandate*, *accident modelling*, *methodological requirement*s and interpretation of *underlying organisational and operational factors*. The paper ends with a discussion of some effects of accident investigation.

Who is asked to tell their story?

Before anyone is asked to investigate an accident, there must be an event recognised by someone and the event must enforce an action. It is a "blink and wink"-situation, where the blink represents the events occurring in society. While the blinks continue to occur, the winks are the sudden considerations – "what happened" – and the time is stopped. One initial question is thus: *When does a blink become a wink?* Which criteria should govern the winks? Often media plays an important role in the decision process, but a general view is that the outcome of the accident must be severe (fatalities). The Lillestrøm accident had potential for a severe outcome, but in that case it could be questioned whether that wink was enforced by the Åsta-accident and the fact that the commission was already in place. The loss of the Sleipner A (Gravity Base Structure) in Gandsfjorden in 1991 was not investigated by a national appointed commission. This accident also had a fatal potential (approx. 15 persons on board) and the material losses (approx. NOK 3 bill.-1991) was much larger than in the Lillestrøm-case.

As the wink is established a commission is needed. In Norway, a guideline (G-18-75, 1975) describes governing rules for accident investigation commissions. This guideline recommends a lawyer as the chairman for commissions due to their knowledge in judgements of responsibilities and legal process rules. The Åsta and Lillestrøm commission comply with this recommendation. The members of the Åsta and Lillestrøm commission were limited to one lawyer (chair), four engineers and one sociologist. In addition, two associate lawyers were employed as secretariate.

The challenge is: *What kind of competence is needed in the accident investigation*? Is safety violation a matter of law and technology? No, it is not, safety is multidisciplinary, and the judgement relates how to balance the commission between legal, technological, sociological, psychological, cultural, and other disciplines. Balance in background experience and competence is critical for the narrative and public confidence.

The importance of the members being independent is often emphasised. What does this really mean? Sometimes the question is connected with legal qualification. But, can we say, the work will be independent, as long as the members are legally qualified?

The challenge is: *How to justify independence*? Dependency can be interpreted in many ways, from sharing values involved in the accident to sharing the same educational background with the involved parties. However, dependency is needed. We need commission members who, for example understand the railway activities, who are confident with research methodologies, who can review emergency response and who are able to scrutinize human factors. The question of

dependency could be replaced by confidence. The clients need to be confident that the group of investigators can develop the best possible narrative.

How to delimit the task?

What is the purpose of accident investigation? Usually the learning effects are emphasised, but in that case, how to answer the questions; what happened, why did it happen and how could it have been prevented? Investigators make a sharp distinction between investigation of causes and investigations of blame.

The challenge is: *How to select objectives of the investigation, and how to delimit the mandate to serve the objectives*? Accident investigations are a combination of observation of facts and judgements that are based on more or less consensus amongst involved parties. Blame and guilt are also placed in "independent" investigations, even though the blame is not necessarily related to the specific laws offended.

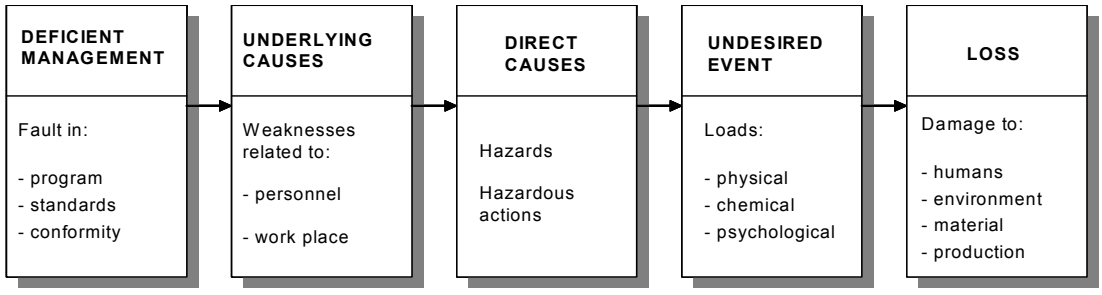
The Åsta-commission's mandate was: "to examine the facts of the accident in order to establish its cause" – that was the story as it really happened. However the commission was given total flexibility in their work, because their mandate was extended to "besides examine other conditions related to the accident". This means that the story expected from the commission change perspective from the narrow "why did the accident occur" to the wide "what could have prevented the occurrence of the accident".

Which accident model is relevant?

Accident investigators need to model the cause and effect coherences of the accident. It is simply impossible to completely reproduce the accident and its underlying circumstances (for example organisational factors). The investigators make their judgements about which models to apply. Models are simplifications of the real world, and they do have their weaknesses. The models are inaccurate, they are based on assumptions, and the models must be limited to specific issues or phenomena.

The availability of data is also critical for the narrative. The investigators collect evidence and data, they structure and analyse the information in their interpretive contexts. But despite the mass of information collected, there will always be lot of information lacking, for example due to vital actors may have died in the accident, evidence could have been deliberately or through negligence removed, or information could be lacking due to limitations of the frame conditions (economy, time, etc.) of the inquiry.

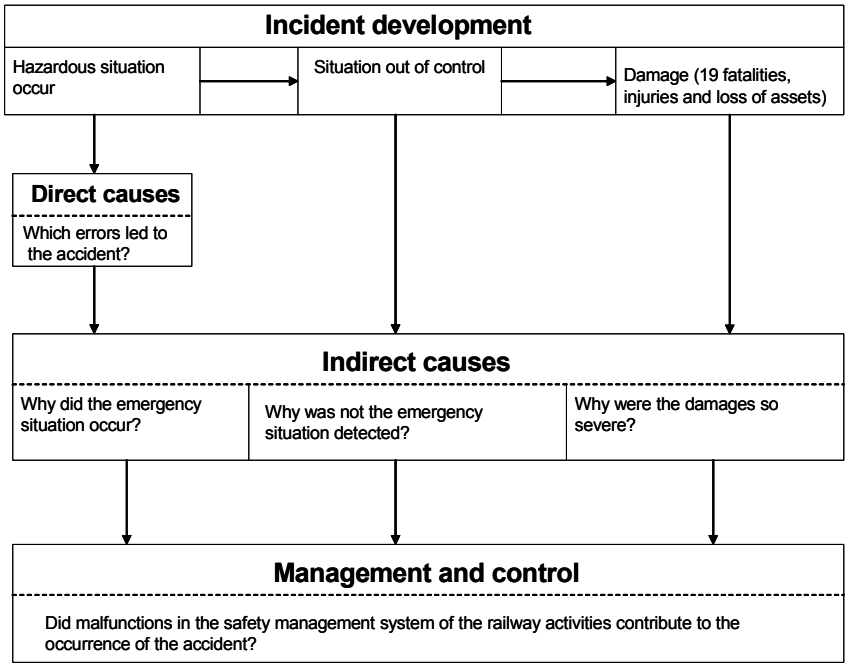
Figure 1: Loss Causation Model



The *Loss Causation Model*, see Figure 1, is a frequently used model, and it has its origin from Heinrichs domino theory. The Loss Causation Model is used by Bird and Germain (1986) to explain causes that leads to accidents, in order to develop adequate measures of loss prevention.

There exists no evidence that proves the coherence between underlying causes and losses, but Bird and Germain claims that the model is in line with recognised practice amongst safety experts and leaders throughout the world. See for example Sandve and Ringstad (1999) for a discussion of the Loss Causation Model, and for an overview of other models applied in accident and near miss reporting. The Åsta commission has also applied principles of the Loss Causation Model in their investigation, cf. Figure 2.

Figure 2: The commission's working model (NOU 2001: 30)



Models used in accident investigations have much in common with risk analysis models. They are event as well as phenomena oriented. However, the differences are firstly, that risk analyses focuses on multiple accidents, and accident investigation on the single accident. Secondly, the accident investigation is retrospective, while the risk analysis contains visions of the future. The modelling work in accident investigation relates to submodels of the overall Loss Causation Model, in order to better understand the occurrence of the accident. Such models could be *quantity-oriented* (physical or chemical) or the models could be *event-oriented (logical)*. Examples of quantity-oriented models are fracture mechanics to scrutinise the deformation of structures, and heat mechanics to understand the heat loads involved. The point source model is a quantity-oriented model. It is applied for calculation of radiation from distant fires, for example in order to determine the radiation acting on passengers being trapped in wrecked cars. The point source model reads:

$$I = \frac{fQ}{4\pi r^2},$$

where, f, is the fraction of combustion heat emitted as radiation, Q, the total amount of heat released in the flame, and, r, the distance from the flame.

While quantity oriented models describe the factors that determines the numeric value of a quantity, event-oriented models describe the conditions of the occurred event. A fault tree model is an example of an event-oriented model, describing events on a lower level leading to the accident.

Malfunction in the signalling system at Rudstad station is an example of a sub-event that could lead to a train collision at Åsta.

Independent of type of models used in the accident investigation there is uncertainty involved. With respect to the point source model, it is uncertain whether the model represents the real world. It is based on the assumption that all emission relates to a single point, which in most cases is not fulfilled. Uncertainty is also related to the quantities *f*, *Q* and *r*. In general, the uncertainty increases when the models are extended to include underlying causes and deficient management factors.

The challenge is: *What models to use and how shall we represent and deal with uncertainty*? If we depart from the ideal goal to reveal the truth, to investigate weaknesses in organisational and management factors, the issue could become minimised. Aven (2000) shows how uncertainties can be expressed by probabilities. This view could be useful also in accident investigation. The narrative is subjective, yes, but it is based on empirical evidence, which is open for assessments.

What methodological requirements should govern the investigations?

Is there any difference between accident investigation and scientific research? Accident investigation seems to be carried out with little regards to requirements. The report is a narrative where conclusions and recommendations are more or less related to evidences found in the investigation. Critical discussions with respect to models, investigation methodology and evidence collection (interview techniques, technical observations, expert judgements, etc.) are often minor or totally absent. It is a paradox that the theoretical basis of accident investigation methodology is so weak, when we consider the inherit power in the narrative. The Norwegian National Railway Administration (NNRA) was blamed and given a penalty of $US 1 million. The accident investigation report has also just recently been used by an insurance company to raise a recourse claim against the NNRA of $US 5.5 millions.

The challenge is: *What methodological requirements should govern the investigations*? The problem formulations are usually connected to "how" and "why" questions. Case study methodology, see for example Yin (1994) and Kaarbo and Beasley (1999), could very easily become employed as the investigation perspective. The Finnish anthropologist Pertti Alasuutari (1995) emphasises the importance of "Without an explicitly defined method, without clear rules which tells what conclusions one is allowed to draw from different kinds of observations, research easily turns into an activity where you try to prove your prejudices right". The judgement also relates to how the accident investigation can be used, for example to put forward legal charges.

Johnson (2000, 2001) has developed a scheme, the Conclusion, Analysis and Evidence diagram (CAE), in order to identify ambiguities and to determine which items of evidence are critical to particular lines of argument. Johnson's work is interesting, but could be problematic because the schemes could also introduce new uncertainty and further complicate the investigation. It becomes an analysis of the analysis.

How to deal with organisational and operational factors?

Organisational and operational factors are widely discussed in the research literature, for example Jacob and Habers (1994), Reason (1997), Øien and Sklet (1999), Rasmussen (1990), and Sandve and Ringstad (1999). No common view exists, neither about the terms and contents, nor the factors' influence on safety. Examples of typical factors are; work coordination, work procedures and degree of formalism, communication (external and internal), roles and responsibilities, organisational culture, safety culture, ownership, time pressure, resource allocation, competence (technical, organisational) and priority of goals.

The challenge is: *What organisational and operational factors to be selected for further scrutiny*? The investigators need to make judgements on what factors they will place weight and the single factors' importance or relation to the occurrence of the accident. This is not an easy task. The Åsta-commission has made their choice, which is discussed below.

The Åsta case. The NNRA is appointed as the scapegoat with respect to the Åsta-accident, and perhaps well-founded, if we put weight on the NNRA's own comments to the public report. Why blame NNRA? The NNRA had not absorbed, in accordance with the commission, NNRA were almost reluctant to, the concept "modern safety management". Modern safety management is risk based, and in accordance with the commission modern thinking requires that risk analyses shall govern all phases and areas of the railway activities. The Norwegian State railways (NSB BA), the train transport operator, is spared for criticism because they had carried out some risk analyses. The quality of those analyses was never questioned.

At best, the commission's presentation is based on their prejudiced attitude towards "correct" (modern) safety management. At worst, we suspect the members of the commission to "feather their own nests". The Norwegian safety and emergency management consultancy business, which offers risk and vulnerability analyses, has through a Royal Decree been given a perfect document that ensures intervention with the onshore activities in a way that no publicity campaign could achieve.

Modern safety management, as described by the commission, has an inherent interpretation of risk being an objective property of the activity or system being studied, and it is heavily based on historical numbers. This implies a sharp distinction between what is the true risk and what is perceived risk. This is a very invidious approach to risk. Particularly, due to the fact that many "experts" claim to know the truth and the experts' attitude is that lay people and others are driven by feelings and irrational behaviour. This is an old and positivistic perspective, which unfortunately is widespread amongst many environments working with safety and emergency management, including the members of the Åsta and Lillestrøm accident investigation commission. The explanation is simple. This perspective maintains a pattern of power with an utter authority to the experts. Nobody wants to give up their authority and position, the aim is merely to create a stronger dependence to or demands for the experts' services.

The commission do not stop here. They recommend that risk analyses shall frequently become updated in order to contribute to the daily operations of the railway activities. The updating, they say, should be performed as often as every third year. Who is able to understand this? Of course it means more projects to the consultancy business. However, we perceive these recommendations as unfair to an activity that is remarkably weakened and vulnerable to criticism after the accidents. And remember, the existing risk analysis tools do not capture organisational and operational factors that can give decision makers vital support in operations. Risk is not something that can easily become measured in operation, like for example reading a pressure level of a manometer. Risk is an evaluation of uncertainty related to the alternative outcomes of the future. The analysis tools are inappropriate for managing the daily operations, this is a fact that is widely agreed upon.

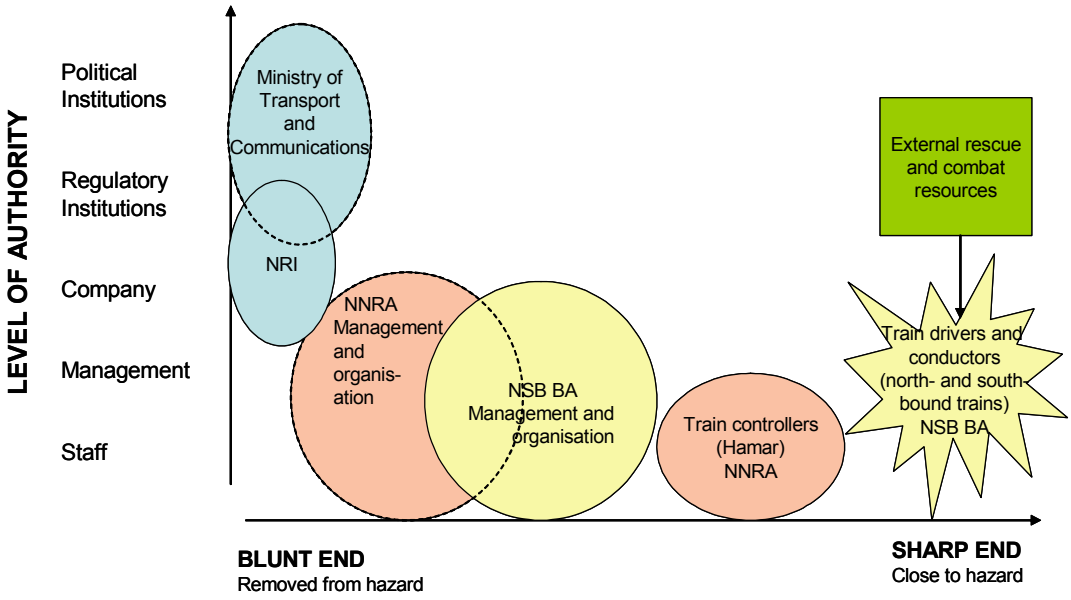
When we also know that the risk analysis consultancies, as the commission, are dominated by engineers, we find reasons for concern. Safety and emergency management is highly cross-disciplinary, to which competence in the areas of psychology, sociology, anthropology, medicine, etc. are often more important than technological competence. Risk based approaches to safety management thus need to involve every layer of the activity, in this case the railway transport activity. People simply need to understand the fundamental issues of the risk based safety management. The United Kingdom Offshore Operators Association (UKOOA), an association of the oil company managements in the UK commented modern safety management (UKOOA, 1999): "A change from – *tell me what to do* – to – *show me how to do it* – to – *involve me in it* – has taken

place". The risk analysis is a debate over safety, and disagreement amongst the disciplines might prevail. Some want to place emphasis onto the technological factors, others claim that the organisational factors are most important, some highlight the operational conditions, while other will claim that human factors and heuristics plays an important role, and culture and genetic conditions etc. are all causal factors that might be applied to explaining negative outcomes or the occurrence of undesired events. When risk analysis is used by other disciplines than the engineers, remarkable progress can be expected.

Risk and vulnerability analyses are powerful tools, but only as an integral part of a safety management process, i.e. we emphasise the use of the analysis tools. There is a substantial amount of costly analyses carried out by experts, which has and have had little or no effect at all. In the oil and gas industry there are a lot of such examples. Our experience is that the oil and gas companies in the Norwegian sector highlight the benefit of analyses in which they have been heavily involved, in the sense that confidence in the analysis tools is created and the risk reducing measures stemming from the analysis are based on a common understanding. Such analyses are an integral part of the planning process of an activity. Analyses performed in order to satisfy authorities contribute to undermine the respect of the safety and emergency management discipline. Up to date, very little, if any, research exists on evaluating the effect of risk analysis and modern safety management.

By all means, the Åsta accident investigation has revealed lacking and insufficient barriers and other critical conditions at the Røros line. The NNRA internal accident investigation (Skovdahl, 2001) also supports this view. The differences between the two investigations are related to what has been regarded as acceptable solutions, acceptable risk, whom to blame, and which parties to be investigated. Figure 3 is an illustration of the parties investigated in the Åsta accident, where the horizontal axis shows the distance from the accident location, and the vertical axis shows the level of authority. The frame is based on Kőrte, Aven and Rosness (2002).

Figure 3: The investigated parties in the Åsta-accident



The Åsta commission selected their model, which placed focus on the NNRA's safety management system. The NNRA management and organisation was blamed. The train driver of the northbound train and the train controllers (NNRA) located in Hamar were also criticised. The Ministry of

Transport and Communications, the National Railway Inspectorate (NRI) and the Norwegian State railways (NSB BA) were very moderately criticised. The rescue and combat resources were not exposed to criticism at all, and the investigation of their activities was very superficially performed. The power of the commission's model is remarkable. Every party shown in Figure 3, and other parties, could have been criticised in a way that would have totally changed the ever standing conclusions.

For example, over 90 % of the municipalities in Norway have carried out risk analyses, and there is a widely accepted practice to design the local fire brigades – fire prevention arrangements - by the use of risk analyses. However, there are reasons to believe that the risk analysis processes have not been very good. Along the Røros line, on which the Åsta-accident occurred, there are ten municipalities and ten fire prevention arrangements. The NSB BA and others traffic the line, and above them are different authorities responsible for surveillance, safety and emergency management (NRI, the Ministry of Transport and Communications, inspectorates, ministries, etc). We have not registered that any of them, before the Åsta-accident, reacted against the risk level at the Røros line, a risk level that the commission has found alarming and totally unacceptable. It is not only within the NNRA that modern safety management is lacking. The power of accident investigation and the inherent methodology is enormous. Weick (1991) has investigated the Tenerife accident (583 people killed) by using Normal Accident theory (Perrow, 1984). In order to reveal the power of accident investigation we propose a similar analysis for the Åsta-accident.

Summary and discussion

What is the truth about accident investigations? Are they really efficient tools in the overall public safety management work? There are many consultants and researchers who support this view, but their evidences are weak. The major argument is related to preventing the accident from reoccurring. Of course, a similar accident will never occur, thus the argument may stand indisputable with or without accident investigation. As far as we know, there has been little research questioning or evaluating the effects of accident investigation. The discussion has been based on prejudices about the goodness of such inquiries, without critical objections. Before any conclusions with respect to formal set ups of, for example, joint accident investigation commission, more research is needed. The area is complex, and we think that, so far, the evidences supporting the benefits are evenly distributed with evidence supporting more dubious effects, such as:

- The main objective of accident investigation is to put the public opinion to rest.
- Accident investigation is a tool for the national or local authorities to maintain or restore confidence and avoid damaging conflicts.
- Since there exist few or no criteria for when and how to investigate accidents, these issues are political. Strong parties involved in accidents can manipulate the choices.
- Accident investigation as a narrative art contains numerous weaknesses.
- "Weak" parties are harshly criticised in the accident investigation conclusions and recommendations than "strong" parties.
- Even though there is a conscious attitude to avoid blame in the investigations, placing guilt affects the investigators. The investigators are prone to cognitive (judgemental) bias – no tradition exists to avoid cognitive biases in accident investigation.
- Being a national appointed investigator is connected with strong prestige, especially in controversial cases (for example the Åsta-accident). The clients (media, authorities, relatives, etc.) expect dramatic and clear results from the inquiry, and these expectations influences the work of the investigators.
- First line actors (the sharp end) become more criticized than second and third line actors (the blunt end).
- The contents of the investigations are strongly influenced by the competence (formal and experiences) of the commission, and their prejudices.

- The causal relationships presented in the investigations are strongly influenced by the accident outcome, i.e. the consequences of the accident. The investigation of the Åsta accident, for example, had a stronger focus on blame than the Lillestrøm accident.
- The learning perspective of accident investigation is poorly founded. The learning effects are minor, especially for actors not directly involved in the accident.
- Accident investigation results are often fronted in political populist cases, which usually "fall to the ground" without long term results.
- The performance of the rescue and combat resources are seldom evaluated in accident investigations, and thus there is no tradition for criticism of the external (often public) emergency management.

Accident investigation is a difficult area, but important. If we maintain our beliefs that accident investigation is an important tool in societal and organisational learning, financial and human resources must be paid. Some of the conclusions and recommendations drawn in the Åsta and Lillestrøm accident reports are not very well supported. We struggle to find an adequate research design and frame conditions for accident investigations, and, strange to say, Norwegian authorities seem to maintain an indifferent attitude.

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