



Discussion

The case for research into the zero accident vision

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ABSTRACT

This discussion paper is written out of a concern. We noticed that many companies with a good safety reputation have adopted a zero accident vision, yet there is very little scientific research in this field. The zero accident vision addresses the accidents causing deaths and severe injuries among company staff. In Finland, where more than 280 companies are currently a member of the Finnish 'Zero Accident Forum', we see that this has supported the member companies to realize significant safety improvements over time, even though their safety performance was already much better than the national average when they joined the Forum (Virta et al., 2009). We therefore make a call to the safety research community to undertake research to better understand and support safety strategies based on ZAV.

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1. Introduction

Improving safety of complex industrial systems and preventing deaths and severe injuries is one of the most difficult tasks for company managers. To help facing this challenge, researchers developed a number of concepts and methods. In this paper we briefly present four of them: accounting for complex contexts; setting up norms, rules and performance indicators; identifying the role of safety climate and safety culture; studying human behavior.

In the meantime, a number of companies developed policies and methods that allowed them to reach excellent levels of safety and very low rates of severe accidents. The Zero Accident Vision (ZAV) appears as one of the most popular. In Finland, where more than 280 companies are currently a member of the Finnish 'Zero Accident Forum', we see that this has supported the member companies to realize significant safety improvements over time, even though their safety performance was already much better than the national average when they joined the Forum (Virta et al., 2009). Therefore, an expert group on safety culture was established within the PEROSH Network (The Partnership for European Research in Occupational Safety and Health), which aims at promoting ZAV, identifying and analyzing outstanding practices in

accident prevention and safety culture (EZAV, 2011). We regard the zero accident approach as a very important innovation that deserves the full attention of safety researchers. The aim of this discussion paper is therefore to bridge the ZAV principles and methods with the current trends of safety research and to plea for dedicated research efforts to further investigate the qualities, limitations, do's and don'ts relevant for ZAV.

There are two main parts in this discussion paper. In the first part we discuss on dilemmas and limitations that affect progress in safety performance to day. We will thereby focus on the complex context, the role of performance indicators, safety norms and rules, safety culture and human behavior as factors that to some extent all contribute to safety, and at the same time imply limitations in the improvements possible through the risk control strategy. In the second part of the paper we focus on the Zero Accident Vision and discuss the opportunities implied by ZAV and the commitment strategy for safety.

2. Why are safety improvements difficult?

Improvements in safety are usually expected from sound technology and a process of continual improvement resulting from systematic management of safety risks. It is thereby presupposed that safety management systems imply a process of regular adaptation and updating: a constant search for the best solutions and the need to regularly reflect and review existing safety practices. We will argue that approaches based on ZAV imply a great potential for further safety progress.

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The growing complexity of systems and organizations, however, increasingly requires an approach to safety which goes beyond the simple rational analysis of technical systems, organizational patterns and procedures, to account for the dynamics of processes and actions that influence or are directly involved in safety. Weick (1987) even characterizes the management of safety as managing a 'dynamic non-event'. This implies several challenges for the functioning of safety management systems, organizational culture and the awareness and behavior of the agents involved.

In practice, focusing on specific risks or practices leads to the neglect of other relevant issues. This means that risk management in its present forms faces its limitations, both from a practical and a theoretical perspective. As a consequence, safety management can be less effective than intended and generate unexpected and undesirable side-effects:

"There is some evidence that making subsystems safer could make the overall system less safe because of the propensity of humans to take less care personally when a system takes more care" (French et al., 2011, p. 761).

To address these limitations, Reniers et al. (2011) propose a holistic model "IDEAL S&S" that aims at optimizing an organization's safety and security performance by integrating safety and security culture and climate with performance management. This dynamic model addresses three dimensions: People, Procedures and Technology; it identifies two fields of tensions: optimal resources vs. deployed resources, and short-term vs. long-term goals. Although the IDEAL model is an interesting innovation for supporting implementation and development of a safety culture in a company, it globally addresses safety and not precisely the prevention of accidents causing deaths or permanent injuries, which is our concern in this paper.

3. Complex contexts

Generally, the environmental conditions and the external and internal contexts are regarded as important factors influencing complexity and safety (Rosness et al., 2012). Rasmussen (1997) for example, points out the importance of on-going cost reduction pressure on safety, and introduced the term 'drift to danger' for such contextual vicious processes.

Snowden (2000) and Snowden and Boone (2007) proposed the CYNEFIN framework to "see things from new viewpoints, assimilate complex concepts and address real-world problems and opportunities". Snowden distinguishes four different decision contexts for risk management:

- Known (scientific knowledge): causes and consequences are understood and can be anticipated; decision-making consists of identifying the risk, understanding the context and applying known responses.
- Knowable (scientific approach): causes and consequences can be determined if enough data are available. Data must be collected to decide which procedure to apply.
- Complex (social systems): causes and consequences can be determined after the event. Decision is made by situation analyzing, exploration of alternatives, problem formalizing and setting implementing flexible strategies.
- Chaotic: causes and consequences cannot be identified. Decision makers must test actions and observe results until they can make sense of the situation.

Snowden's main conclusion is that human reliability analysis models are representative of known and knowable contexts, and that the majority of managerial practices are not appropriate when

managers face complex or chaotic contexts, for which a more systemic approach is needed. This is also highlighted by French et al. (2011).

"It is not currently possible to perform summative risk and reliability analyses for any system in which human behaviour and activity can enter the complex or chaotic spaces. Governments and regulators should be concerned because this accounts for the majority of the technological systems currently being operated and commissioned. This does not mean that they are unreliable or unsafe; only that we cannot assure their reliability or safety to within some negligibly small probability. Modern perspectives on risk demand a systemic rather than an atomized perspective of the technical, human an organizational features of systems" (French et al., 2011, p. 761).

Renn (2008a,b) initially studying the precautionary principle, followed similar paths and developed the concept of risk governance, arguing that traditional risk management models are not working in uncertain, complex or ambiguous situations. To some extent this was also clarified by Perrow's 'normal accident theory' (Perrow, 1984), stating that hazardous industries with processes that are complex and tightly coupled will always be confronted with (low probability) 'normal' accidents.

There are two important avenues to deal with 'normal accidents' in complex settings. The first avenue is to search systematically for alternative production processes that are inherently safer as an integrated part of the safety management process (Zwetsloot and Ashford, 2003). The second avenue is the route of 'high reliability theory' and 'resilience engineering'. These closely related approaches provide a new vision on risk management, by addressing the capacities of organizations to face risky situations while maintaining their essential missions. In High Reliability Theory five characteristics of organisations are regarded as essential: preoccupation with failure, reluctance to simplify, sensitivity to operations, commitment to resilience, and deference to expertise (Roberts, 1990; Weick and Sutcliffe, 2007). As part of the resilience engineering approach Hollnagel (2011) and Steen and Aven (2011) characterize a resilient system by four abilities: (1) responding to usual and unusual threats in robust and flexible ways; (2) monitoring what is happening, including its own performance; (3) anticipate risks and opportunities; and (4) learn from experience.

4. Performance indicators

Hopkins (2011) argues that for each risky situation, the decision maker must establish where the risk stands in a continuous scale from insignificant to extreme, and where the acceptable limit stands. That is why managers need rules, which often seem inappropriate to operators.

"Generally speaking decision-makers need rules, not numerical risk acceptance criteria, to guide their decisions. Given that decision rules serve to dichotomize the risk continuum, they are inherently arbitrary to some degree. What this means is that for cases that fall immediately on one side or the other of the cutting point, the rule may seem unnecessarily strict or alternatively unreasonably weak" (Hopkins, 2011, p. 111).

Oien et al. (2011) argue that performance measurements may be divided into reactive monitoring and active monitoring. The former means identifying and reporting on incidents (near-miss and actual incidents), and learning from mistakes, whereas the latter provides feedback on performance before an accident or incident occurs. Lagging indicators are related to reactive monitoring and show when a desired safety outcome has failed, or when it has not been achieved. The leading indicators are a form of active monitoring used as inputs that are essential to achieve the desired safety outcome.

“Using Reason’s accident model (the ‘Swiss Cheese Model’), leading indicators identify the holes in the risk control system during routine checks, whereas the lagging indicators reveal the holes in the barriers as a result of an incident” (Oien et al., 2011, pp. 158–159).

Even though lagging indicators do not allow the assessment of the safety level, they are most frequently used in organizations. “How is the state of being ‘healthy and safe’ determined? Outcome measures, such as lost time injury frequency rate, tell us little about performance in health and safety” (Blewett and O’Keeffe, 2011, p. 1014). Blewett and O’Keeffe argue that Safety Management System audits present a drawback when they end up with a mark, as this may result in concentrating efforts to get a good mark instead of taking other measures that could improve health and safety of the workforce.

5. Norms and rules

Hohnen and Hasle (2011) argue that norms drive managers to focus on measured entities, and to define the framework of activity as a set of procedures and measures that can be audited, thus reducing the focus on work context, psychological aspects and professionalism of frontline operators.

Audit systems to some extent transform that which they are supposed to audit, by creating or transforming the work environment into distinctive types of procedures and technologies that can be internally and externally audited (Hohnen and Hasle, 2011, p. 1023).

“Viewing safety in terms of accidents and near misses turns safety into manageable procedures and auditable performances. In this way the uncertainty about accidents is broken up into rational processes based on linear cause-and-effect logic. This way of thinking essentially presupposes that accidents are viewed no longer as accidents but rather as rational events that could have been prevented had the right procedures been followed” (Hohnen and Hasle, 2011, p. 1026, citing Power (1996)).

This discourse around the respect of rules is associated with the responsibilities of the experts and of decision-makers. The expert chooses the methods to assess the risks and sets up the boundaries between what is acceptable and what is not. The decision maker’s role is to apply experts’ rules with the parameters of the current situation. This approach works with known and knowable situations, but less with complex, ambiguous or chaotic risks or situations.

Then there are the risks that – due to complexity – cannot be foreseen. In such cases safety management is becoming ‘managing the unexpected’ (Weick and Sutcliffe, 2007). As a consequence, Hopkins (2011) argues that ‘risk aware’ operators should also be entitled to violate the existing safety rules.

“There are sometimes exceptional situations where it is obvious that rule-compliance will lead to unsafe outcomes but there is no time to invoke the procedure modification process. In these situations we want our risk aware operators to exercise their discretion and violate the procedure. But this is very different from the routine violations that are designed to get the job done more easily or more efficiently” (Hopkins, 2011, p. 113).

6. Safety culture

Another symptom of the fact that present safety management approaches have a limited potential to improve safety any further, is the growing attention – both in safety science and safety practice – to safety culture. As stated by Hale and Hovden (1998), we now

live in the ‘third age of safety’ wherein improvements mainly depend on safety culture and behavior.

Safety culture corresponds to a set of beliefs, perceptions and attitudes that reflect the importance that people in the organization put on safety, for them and for others. Safety culture is generated and continued through mostly unconscious socialization processes. It is often regarded as a social construction.

“Culture concerns what and how people believe, feel, think and how they behave (over time) and how this is reflected in collective habits, rules, norms, symbols and artefacts. How and to what extent such patterns of cognition, behaviour and associated norms influence safety are indeed interesting and important issues – some cultural patterns might be helpful whereas other might be less so” (Rollenhagen, 2010, p. 269).

Recently, there has been a shift in focus from measuring safety cultures to safety climates which have been described as the surface manifestation of the underlying culture, and as such, are observable directly using a combination of psychometric and qualitative approaches (based on the work of Zohar (1980), see for a recently validated method Kines et al. (2011)). These methods are often conducted in the form of surveys or safety audits with the intent of revealing deficiencies in developing safety climates before disaster strikes. This allows leaders to take proactive corrective actions before a system erodes to a level where disaster is essentially inevitable (Lofquist et al., 2011, p. 533).

Safety culture should be tuned to the type of risks existing in the organization. In a site where major hazards exist, there may be at the same time a safety culture for occupational accidents and another one concerning major hazards. Not accounting for such differences may end up with major investments put on risks that are visible like slips and falls at the detriment of what is not visible, as maintenance of metallic piping containing toxic chemicals that may trigger a major accident.

“If we do not know what type of safety we are talking about and what requirements this inflicts on ‘culture’, then the concept of safety culture seems less valuable in practical contexts. In fact, generic models of ‘safety culture’ do not seem meaningful unless we first have an explicit view about the general conditions and requirements assumed to affect various types of safety in different contexts” (Rollenhagen, 2010, p. 270).

A nowadays well-known example is the blind spot for information relevant for process safety management that arises when managers focus primarily on personal safety – in their safety processes, monitoring and culture (Baker, 2007; Hopkins, 2009).

Trust is a key element for safety as long as collective action is concerned. Weick (1993) illustrates the role of trust in collective mind:

“Reliable performance may require a well-developed collective mind in the form of a complex, attentive system tied together by trust. Nevertheless, conventional understanding seems to favour a different configuration: a simple, automatic system tied together by suspicion and redundancy. The latter scenario makes sense in a world in which individuals can comprehend what is going on. But when individual comprehension proves inadequate, one of the few remaining sources of comprehension is social entities. Variation in the development of such entities may spell the difference between prosperity and disaster” (Weick, 1993, p. 378).

Morals and values also play a significant role in safety culture. Differences of perception among stakeholders about moral issues may represent a risk factor, as they drive individual attitudes that cannot always be anticipated or understood.

“Different moral principles are applied depending on situational circumstances. Thus, in some situations it is considered a sign of proper/right moral when strictly adhering to rules, whereas in other situations we guide and assess moral decisions (and acts) depending on an assessment of consequences. Still other situations evoke discussions about character and attributions about whom to blame and praise. Often, a number of moral principles are being involved in the same situation” (Rollenhagen, 2010, p. 275).

Different groups of people may belong to different organizational cultures, depending on their story or on the influence of some individual in the group. Schein (1996) suggests that there are typically at least three subcultures in organizations: (1) an operator culture, or line organization that considers work to involve interconnected systems and co-operation among people; (2) an engineering subculture that values technical, error-free solutions; and (3) an executive subculture that focuses on the financial bottom line. Different agents with different risk perceptions and subcultures therefore are the key to modern safety management.

7. Human behavior

Along with the development of automation and computer technology, designers have emphasized automation to reduce the frequency of human interventions, but this technological approach of safety presents operators as sources or risks and not as providers of safety:

“The culture of nuclear power plants, as in most technological organizations, emphasizes the importance of avoiding problems through engineering design and managerial controls and, when necessary, fixing problems. Typically, people who operate the technology are seen as a potential source of trouble that must be controlled by designing people out of the system or providing procedures and training to minimize human error” (Carroll, 1998, p. 706).

However, the human influence can also be positive. Reason (2008), gives a lot of attention to ‘heroic recoveries’ as a natural complement to the attention for unsafe acts and accidents. Indeed, the impact of human behavior of safety, both individually and collectively, can be both positive and negative. Safety can also be understood as resulting from decision-making and acting by key agents, and safety management as process of co-creation safety (or unsafety) (Zwetsloot et al., 2007).

While top managers’ attitudes and behavior may drive the safety performance of organisations, the middle managers form another category of personnel that play an important role in safety and organizational change. At their level, they may feel close to their operators, contributing to a local micro-culture, or close to the management, playing the role of a transmission belt of objectives and constraints to operators.

“Organizational change gets enacted through middle managers who mediate the sense-making between top managers and employees on the frontline to affect both cognitions and actions” (Maitlis and Sonenshein, 2010, p. 559).

Finally, it is important that the personnel on the shop floor are involved in the generation of safety. Participation of the workers and/or their representatives is relevant for several reasons (see also Kristensen, 2011 and Frick, 2011). The workers have a clear interest in (personal) safety, are much more than managers involved in the hazardous activities, and they have first-hand, often tacit, knowledge about the hazardous processes, relevant risk factors and practicalities of safety solutions (Podgorski, 2010).

Safety management, especially in complex and dynamic situations, is therefore nowadays a complex challenge, wherein plan-

ning is complemented by resilience and ‘managing the unexpected’. Risk awareness and safety culture are essential complements to safety management systems. Managers at all levels, workers and safety experts, are all key agents in a collective process of creating safety (or unsafety). In this situation ZAV, can be instrumental in sharing the belief that all accidents can and should be prevented, and that this is a challenge that cannot be realized without the commitment (active support) and contributions of all relevant agents.

8. Developments of ‘Vision Zero’ in industrial practice and in policy

To this day, the DuPont group is considered a global leader in matters of employee safety and health. One key element of this DuPont safety culture has been the creation of an error-forgiving workplace environment, which is a key constituent of ‘Vision Zero’ (Eichendorf, 2011). Over the last decades other companies have reduced their accident rates to close to zero. They are often large internationally operating companies, such as Shell, which reported 0.3 lost time injuries per million working hours (employees and contractors) for the year 2010 (Shell, 2011). There are excellent examples of safety performance in other industries as well, especially in aviation and the nuclear industries where safety is essential for their ‘license to operate’.

In the early 1990s, the US Construction Institute established a ‘Making Zero Accidents a Reality’ project team, who were charged with finding out how worker injuries in construction could be eliminated. The team surveyed 106 of the 400 largest construction companies in the United States, and conducted extensive interviews at 38 construction projects, before they identified nine best practices for achieving zero accidents (Hinze, 2002).

In Finland, a ‘Zero Accident Forum’ has been active since 2003. The Forum is a voluntary network of Finnish workplaces, and is open to any workplace, regardless of its size, field or level of occupational safety. Members of the Forum share a common ‘vision’ of becoming leaders in safety, and are willing to share their experiences for the benefit of other members. The Forum provides examples of good practices from other workplaces, promotes success stories, and motivates and encourages workplaces to strive for a proactive and high level of safety. The Forum also provides national and regional seminars and materials and tools to promote ZAV. Materials include campaigns, websites and a newsletter. More than 280 organizations all over Finland have joined the Forum by February 2012. These workplaces employ more than 300,000 people, which is more than 10% of the Finnish working population. In the Netherlands a similar forum/network has been started up in early 2012.

It is often common for these high achievers that they adopt ZAV and explicitly communicate it (Gudworth, 2010). These good achievements are not directly a result of research, but rather a result of practical efforts. At the same time we notice that safety research is almost completely neglecting this development. Indeed, ZAV was developed by industries and does not stem directly from safety theories.

9. The zero accident vision

Companies that want to eliminate workplace accidents increasingly adopt the zero accident vision (ZAV) because they feel their identity does not allow for accidents. ZAV is based on a belief that all accidents are preventable. If accidents are not preventable right away, then this should be feasible in the longer run. The aim of ZAV is to encourage people to think and act in a manner that supports the vision that all accidents are preventable. Often people tolerate accidents because they believe they simply cannot be prevented, or that a certain number are inevitable. It is stated that promoting

ZAV is an important weapon in the battle against common fatalism. Higher safety goals in organizations are thus a step towards greater adoption of ZAV (Saari, 2001).

ZAV provides an ethically sustainable basis for accident prevention (Aaltonen, 2007). It is estimated that if all ILO Member States would use the best accident prevention strategies and practices that are already easily available worldwide, some 300,000 deaths and 200 million accidents could be prevented annually (Takala, 2002). In the second Strategy Conference of the Preventive Occupational Safety and Health Culture (Dresden, 3–4 February 2011), representatives from governments, European and international organizations, multinational companies, associations and the scientific community agreed on a statement of five pillars for a safe and healthy culture. 'Vision Zero, Reducing work accidents and occupational diseases' was defined as pillar No. 1 that establishes the foundation (the strategy) and forms the roof (the objective) for a culture of (accident) prevention. This pillar was considered to be most relevant for, and closely related to, the next pillar No. 2 'Raising awareness, developing competencies and capacity building' (2nd Strategy Conference, 2011).

10. The traditional criticism

The ambition to achieve accident free workplaces is often confused with an accountable zero accident 'goal'. Such a goal is then criticized for being unrealistic and not feasible; for several professionals of various disciplines, including safety engineers; it can be the reason to regard 'zero accidents' as utopic nonsense. Production without accidents does not exist, at least not over time, they argue. Moreover they say that when managers are made accountable, and perhaps even get a bonus for reaching the goal zero, you may see zero accidents, but only because accidents are then no longer reported and documented. When 'zero accidents' is used as target in a safety control strategy, linked with accountability and management by objectives, it can easily lead to false safety.

However, in our opinion, and that of many industrial leaders, it is most important to emphasize the innovative nature of the zero accident vision. Unfortunately, nowadays the dominant way to look at safety strategies is to see them as risk control strategies. This approach starts with the identification of hazards and risks, and is followed by planning and implementation of control measures for those risks that are regarded as unacceptable. In this approach, safety experts have to convince managers of the value of the necessary safety measures, in order to attain their commitment and support for the proposed measures, and to have them implemented. Not surprisingly, many authors have identified management commitment (or safety leadership) as a crucial factor for effective strategies to control risks (e.g. Grabowski et al., 2007; Barling et al., 2002; Cox et al., 1998). However, management commitment is not self-evident in many industries. Indeed, the implication of the risk control strategy seems to be that safety or occupational safety and health management is a 'problem solving' activity – the commitment can then be expected only as long as the problem is unacceptable (severe or urgent). When the safety problem is solved, management commitment often vanishes, resulting in problematic conditions for any future accident prevention activity.

11. Zero accident vision: the commitment strategy for safety and implications for safety culture

ZAV implies a need for a generative safety culture, wherein risks are not only controlled, but unforeseen risks are also anticipated, recognized, and adequately dealt with (Weick and Sutcliffe, 2007), and where there is a continuous desire to improve safety. Top management commitment and leadership is a basic character-

istic – which is known to be an important success factor for any safety improvement, and involves each manager and worker.

ZAV starts with the ambition to create accident free workplaces. Indeed it should be realized that without the personal commitment of every individual person in the company, ZAV cannot be realized. Another consequence is that simply doing the same things better than before, is not a successful ZAV strategy. Both technical and social innovations are needed, as well as out-of-the-box thinking for solving existing safety problems.

Even in the 'third age of safety' wherein safety culture and behavior are key components (Hale and Hovden, 1998), and individual and collective behavior are essential for creating safety (Zwetsloot et al., 2007), 'commitment strategies' are usually not regarded as a serious safety option. This is totally different in the area of human resource management, a discipline we regard as of crucial importance for influencing safety behavior and culture. The strengths of a 'commitment strategy', as opposed to a 'control strategy' in human resource strategies were first advocated in the Harvard Business Review (Walton, 1985). Especially for professionals dealing with complex processes, commitment of every manager and worker is nowadays regarded as essential for successful and resilient companies (Beer, 2009).

Indeed, ZAV is not a risk control strategy, but a *safety commitment strategy*. It is an ambition the company commits itself to in order to achieve better safety performance. In the generally accepted 'control' vision to safety (which is dominant in safety research), commitment (and leadership) is frequently identified as a major prerequisite; but it is not regarded as the starting point for safety improvement. In company practice, commitment to safety creates better risk reduction and control strategies, not the other way around (Zohar, 2002; Locke et al., 2009). ZAV provides a clear safety message from the top management within and outside a company, and it can boost the safety culture.

12. The family of zero visions

ZAV and the prospect of zero accidents are not unique concepts. In fact it is part of a family of 'zero visions' that has existed for almost half a century. Many leading companies have committed themselves to several of these zero visions, such as zero defects, zero emissions, zero traffic accidents, zero wastes or zero economic waste. As commitment to zero occupational accidents is both rationally and ethically closely related to these other members of the 'zero vision family', we provide here a short overview of other relevant zero visions.

The first example of a zero vision was the 'zero defects' approach, developed in the mid-1960s by Halpin in the Martin Marietta Corporation (now part of Lockheed Martin) as part of the Titan Missile program (Halpin, 1966). Halpin emphasized that a change in corporate culture is essential for a zero defects program. He criticized the 'double standard' that almost every consumer expects products without defects when they buy them, while the same persons as an employee may see it as 'normal' that they make some 'human errors' in their work, implying that they accept defects in the products they make. Halpin also emphasized the importance 'that workers can be proud of their work' and see their work as meaningful. According to him, if you produce products with defects, you cannot be proud of your job. Therefore, 'zero defects' contributes to the well-being of the worker (Halpin, 1966).

The zero defects movement was further inspired and strengthened by Crosby's book 'Quality is Free' (Crosby, 1979). In an era where delivering high quality was regarded as a cost factor, Crosby demonstrated that the hidden costs of low quality were actually much higher than those for generating better quality: products with defects often require rework before they can be sold. Defect products also generate dissatisfied and disloyal customers, imply-

ing extra costs for marketing and sales. In this way, Crosby clarified that there is a clear business case for zero defect strategy.

In the same period, a similar development took place in Japan led by the Toyota Corporation. In Toyota and several other Japanese companies 'Kai Zen' (Imai, 1986) formed the basis for the involvement of all employees in processes for continuous incremental improvement of production processes and products. Imai described how Toyota developed an 'improvement suggestion system' in their company, expecting suggestions for improvement from every single employee. This resulted in over a million suggestions annually. Each of these suggestions was evaluated carefully, while the workers received positive feedback, also when their suggestions were not implemented. Another striking characteristic from the Toyota system is that each worker is entitled to stop the production line, in case a quality problem is identified (Womack et al., 1990). Production is restarted only when the problem is solved. The Toyota system is also an example of lean production. The central idea of lean production is to eliminate all wastes (production, stock, transportation, motion, time, etc.), another zero goal. Again, the business case is clearly here.

With the exception of the zero accident vision in road traffic policy (Tingvall and Haworth, 1999), each member of the family of zero visions originated from industrial practice and visionary leaders, and not from research traditions. In the beginning, each of these visions was criticized for being unrealistic, or too expensive. In fact, their introduction triggered inspiring developments that led to significant improvements, while business cases proved to be realistic.

The family of zero vision fits very well into the increasing importance of Corporate Social Responsibility (CSR) (Zwetsloot, 2003). An important principle in CSR is that of 'inclusive thinking and acting', i.e. to reflect on – and take responsibility for – the impacts in and outside the company. This is associated with the principle of prevention of undesirable external impacts (zero externalities). Occupational accident prevention is important in this respect, as accidents have negative consequences not just for the company, but also for workers, and often for their families, as well as society at large (costs for social security and health care). From the perspective of avoiding externalities, zero accidents is the only logical safety goal. Likewise CSR is an important driver and framework for the zero waste and emissions visions (the ecological issues, see e.g. Pauli, 1997). The combination of the rationalities of prevention with the values of business ethics is an important characteristic of CSR (Zwetsloot, 2003). Though safety is often regarded as mainly a rational issue, safety in-itself is a value-laden concept, and relevant for business ethics. Indeed, a unique strength of ZAV is that it combines the rationalities of accident prevention with the only ethically sustainable safety goal: accident free workplaces.

13. Triggers to move towards a zero accident vision

ZAV is a logical step for companies that have adopted other zero visions. Even completely apart from the specific value of safe production and accident free workplaces, every occupational accident implies defects in production processes and often in products. It often implies an uncontrolled and sudden release of energy or products, while the economic costs of accidents are clearly economic wastes. It can therefore hardly be a surprise that industries that have adopted other zero visions, also began to include ZAV.

There are more traditional drivers for safety improvement as well, which may well go together with the adoption of vision zero. Awakening to unsatisfactory safety situations may occur due to (relatively or absolutely) high accident rates of a company that cause unwanted costs and disturbances in the production. A great number of accidents in a workplace may also lower the morale of

personnel. The integration of safety values to daily business activities is a natural goal. Oil drilling in the North Sea is an example of an operation, which initially had quite high accident rates, and which subsequently has reduced its accidents considerably (Haukelid, 2008). Another driver can be when a company gets a new owner and new occupational safety policy is thereby introduced. Global companies often implement similar safety management procedures in all countries where they are active. These changes can have a radical impact on safety practices at their sites. Increasingly procedures are influenced by CSR and the adoption of zero visions. A third driver is formed by requirements from customers or from supply chain partners that may influence attitudes towards safety. If a company cannot fulfill the safety requirements, it may lose business opportunities. Similar effects may be produced when the competitors of a company are implementing more effective safety procedures. New safety statements within an economic sector can also trigger higher safety ambitions. As an example the Confederation of Finnish Construction Industries has stated that 'zero work accidents' is the goal in Finnish construction sites by 2020. This is very likely to impact safety attitudes at Finnish construction firms. CSR and changes in ethical codes may also have an effect on the safety policy of a company. Similar effects can be attained through e.g. participating in safety competitions or implementing new requirements in quality and productivity management systems (new goal settings).

Standard-based safety management systems (SMSs) have been a strong trend in safety. They emphasize formal safety processes and the anticipation of risks. The US Occupational Safety and Health Administration (OSHA) would like to make some kind of SMS compulsory in all work places. However, formal processes are not enough. A recent meta-analysis does not give strong support for SMS (Robson et al., 2007). Hasle and Zwetsloot (2011) give several reasons for the ambiguous outcomes of SMS. One of them is that such systems can be understood as a tool for management, yet in contrast to ZAV, using SMS tools does not imply anything about the management's ambitions or OHS objectives. Indeed, high levels of safety require deep internal commitment to safety at all organizational levels.

14. The way ahead: call to the research community

Generally, it can be said that not enough is known with regard to successful strategies that lead to long-term, on-going improvements in safety performance. Many initiatives to reduce accident rates are not realized, and accident investigations do not always lead to the prevention of reoccurrence of the same or similar types of accidents (Drupsteen et al., 2013). There is still a lack of scientific evidence on how such goals can be realized. Knowledge in the field of occupational safety can be developed through theory-based research, but also through the evaluation and analysis of technical and social innovations by companies – regarded as practical experimentation. Practical experiments and innovations associated with ZAV should be connected with safety research, in order to contribute to scientific knowledge and to support innovative practices with scientific evaluations.

We therefore want to make a call to the community of safety researchers, to pay explicit attention to the relevant and exciting issues associated with ZAV. As we were not able to carry out a full research programming effort, we want to give an indication of possible aims of such research efforts. This comprises on the one hand research that is explicitly focused on ZAV related practices and relevant safety theories, and on the other hand research topics that are not explicitly aiming at ZAV, but can be regarded as vital for the further development and success of zero accident strategies.

- To identify success and failure factors in the implementation of ZAV strategies.

- To evaluate practical experiences with safety improvements, in companies or company networks that are committed (not only in words) to ZAV.
- To research the impact of business ethics on safety leadership and commitment to ZAV.
- To develop and analyze business cases for ZAV.
- To clarify the meaning of ZAV commitments, for coping with variance in production, and developing resilience to unplanned events and developments.
- To clarify how ZAV can contribute to safety leadership and CSR.
- To clarify the cultural and contextual factors influencing ZAV effectiveness.
- To identify opportunities for synergy between the family of zero visions, and their potential impacts on safety.
- To analyze how generative learning from incidents, accidents and other experiences can be developed.
- To further develop our understanding of commitment strategies for safety improvements (making connections with commitment strategies in human resource management).
- To address the interactions and potential mutual benefits between safety and social and technical innovations.
- To reduce the vulnerability for human error of production processes.
- To study the compatibility of risk control and commitment strategies to safety.

We argue that not only in industrial practice, but also in safety science, the time has come to seriously consider safety commitment strategies, and especially those associated with ZAV. With this discussion paper, we hope to spark new research initiatives in the above mentioned directions.

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