



The importance of commitment, communication, culture and learning for the implementation of the Zero Accident Vision in 27 companies in Europe



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ABSTRACT

In this paper the findings are presented of a multinational study involving 27 companies that have adopted a 'Zero Accident Vision' (ZAV). ZAV is the ambition that all accidents are preventable, and this paper focuses on how companies implement ZAV through ZAV commitment, safety communication, safety culture and safety learning. Managers and workers took part in a survey (8,819 respondents), company interviews and national workshops in seven European countries. A common characteristic of all the companies was the high ZAV commitment of their managers and workers, which often were embedded in the companies' business strategies. It is very likely that this commitment is the main driver for long-term safety improvements. This research supports the importance of safety communication for ZAV implementation, especially of: specific ZAV or safety promotion programmes, constant and updated communication on functional tools, and effective supervisor communication. Successful communication must ensure 'relevant' information to respective organisational levels (not a one-size fits-all strategy), and allow for 'decentralised' initiatives. This research also highlights the importance of safety culture for ZAV implementation, with ZAV companies having high survey scores on management safety priority, safety empowerment and safety justice. The results also support the importance of safety learning (incidents and good-practice) for ZAV implementation. Additional success factors were top management support and an 'open atmosphere', systematic communication and dialogue on incidents, and a focus on things that go right. We conclude that ZAV is the basis for inspiring and innovative approaches to improve safety, as an integrated part of doing business.

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1. Introduction

There has recently been an increasing political and research interest in the Zero Accident Vision (ZAV): the vision that all accidents are preventable. Or, as Zwetsloot et al. (2017) explained it "ZAV is the ambition and commitment to create and ensure safe

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work and prevent all (serious) accidents in order to achieve safety excellence" (p. 260). Some of the recent research literature emphasises the potential benefits of ZAV as a concept (e.g., Salminen and Lee, 2015; Runyan et al., 2013), whereas others are critical about the concept (e.g., Dekker, 2014a,b, 2015). These are however mainly papers about the ZAV concept as such, and there is only a limited number of empirical studies available.

There are, however, a few of such studies: Virta et al. (2009) demonstrated that the member-organisations of the Finnish Zero Accident Forum were substantially improving their safety performance (in terms of loss time incidents) over time, while the average company safety performance in Finland remained stable. Young (2014) analysed the major safety improvements over time in a New Zealand aluminium smelter company that was committed to ZAV, and showed that innovation of work processes,

especially automation, and transformational leadership where the main enablers for a successful strategy. [Twaalfhoven and Kortleven \(2016\)](#) analysed dilemmas in dealing with sanctions on human error in two ZAV committed companies (steel and construction) in the Netherlands, and concluded that sanctions were dominantly regarded as a preventive action (to prevent reoccurrence, compatible with ZAV), not as a punitive measure. Employees were perceived to be individuals who intrinsically wanted to work safely and who benefited most from doing so. The causes of unsafe behaviour were therefore regarded as primarily external factors, which were the responsibility of management.

Critical reflections and statements on ZAV have also been published. Particularly from Australia stem several publications suggesting counter-productive effects of ZAV (e.g., [Dekker, 2014a,b](#); [Long, 2012](#)). One of the main critiques is that ZAV denies the realities of risk (implying uncertainties, human limitation, and learning by mistake) ([Long, 2012](#)). Another argument is it diverts attention to microscopic risks ([Sharman, 2014](#)), which is associated with overspending of investigation resources ([Dekker, 2014b](#)). Although there are several publications criticising ZAV, so far no empirical research on negative effects have been published, and the main focus of the critical papers is not on implementation ([Zwetsloot et al., 2017](#)).

It is, however, certainly relevant to know more about the strategies and success factors of companies that have committed themselves to ZAV. The safety divisions of several leading European research institutes cooperating in the Partnership for European Research on Occupational Safety and Health (PEROSH) were involved in a call for more research in this area ([Zwetsloot et al., 2013](#)), and thereafter initiated a European research project involving 27 companies in seven EU countries and seven research institutes ([Zwetsloot et al., 2015](#)).

In this paper we present the findings of this European research project. The research is part of a larger study, which was presented in a non-scientific report to the funding agency ([Zwetsloot et al., 2015](#)), and which has also generated a few other papers ([Zwetsloot et al., 2017](#)). The aim of this project is to identify strategies for safety promotion and accident prevention that are typical for companies that have adopted ZAV. Of course, merely the desire to achieve zero accidents can in itself never be sufficient to achieve substantial safety improvements. To understand the success factors behind ZAV, it is inevitable to look more in-depth into the strategies, and activities of the companies that pursue ZAV. It is thereby important that ZAV is not a (quantitative) target, but the ambition to make work safe, which will always require a long-term journey and sustained efforts.

In the research we adopted the idea that such strategies start with a genuine commitment of the organisation to ZAV, to initiate a 'commitment strategy for safety' as [Zwetsloot et al. \(2013\)](#) suggested. This implies that it should start with an active commitment and involvement of senior management with ZAV (which would imply several aspects of good safety leadership). The primary focus of the research presented here was on four main concepts: safety commitment, communication, culture and learning associated with the implementation of ZAV.

1.1. Research question

The central research question in this paper is: What are the factors that contribute to successful implementation of the 'Zero Accident Vision' (ZAV)?

Four sub-research questions cover the four key areas mentioned above:

- What are the factors that make 'commitment' to ZAV a driver for ZAV implementation and safety improvement?

- What are the factors in 'safety communication' that contribute to successfully implementing ZAV?
- What are the specific characteristics of the 'safety culture' in ZAV committed companies?
- What are the factors in ZAV companies that contribute to successful 'learning' from incidents and 'learning' from good (safety) practices?

1.2. Commitment

Commitment to ZAV was regarded as a crucial factor in the design of the project. Organisational safety commitment is the extent of engagement with safety promotion and accident prevention in an organisation. Factors include strong belief and acceptance of the organisation's goals and values, willingness to exert considerable effort on behalf of the organisation, and a strong desire to maintain membership in the organisation. ZAV encompasses the idea of the commitment-based approach to safety (management), in which safety leadership is motivated by concern and respect for the employees, in contrast to a compliance based approach, where the motivation comes from following legislation and cost consciousness (compare [Barling and Hutchinson, 2000](#)).

[Zwetsloot et al. \(2013\)](#) suggested that the implementation of ZAV requires a 'commitment strategy': the idea being that ZAV provides a clear safety message from top management within and outside a company, which can boost safety culture and performance. Commitment is hereby not regarded as a formal (written) commitment (only), but as active and visible support, particularly from senior managers, or in Small and Medium sized Enterprises (SMEs, not involved in this research) from the owners/directors. The concept of a 'commitment strategy' was originally developed in the area of human resource management ([Walton, 1985](#); [Beer, 2009](#)). Contrastingly to what [Dekker \(2014a,b\)](#) suggests, commitment strategies are developed as alternatives for strategies of hierarchical and bureaucratic control ([Walton, 1985](#)), and are characterised by shared goals and values, flat organisations, empowerment of the personnel, high engagement of the personnel, and by high performance ([Beer, 2009](#)).

1.3. Communication

Important as genuine commitment of senior management is, the success of any safety strategy cannot depend only on the active commitment of senior management, as it has to be translated into concrete actions of the personnel: this implies that the organisation has to communicate the organisational ZAV commitment in order to share it with all of its personnel. When a company commits itself to ZAV it requires communication of the vision and processes of sharing the belief that 'all (serious) accidents are preventable'; without good communication processes, ZAV cannot be expected to impact the safety behaviour of all members of the organisation ([Cudworth, 2009](#)).

Communication climate is often described as a subset of organisational climate that refers to the relationships and interactions in the workplace ([Keyton, 2011](#)). Communication climate contains for instance superior-subordinate communication, quality and accuracy of downward information, upward communication, and perception of reliability ([Guzley, 1992](#); [Allen, 1992](#)). Communication is also recognised and often considered as a contributing factor to a healthy safety climate (e.g., [Griffin and Neal, 2000](#); [Dejoy et al., 2004](#); [Real and Cooper, 2009](#); [Kines et al., 2011](#)).

1.4. Culture

We assumed that the ZAV commitment of personnel can only be sustained when the commitment towards 'all (serious)

accidents being preventable' becomes a key characteristic of the organisational culture. "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" (Rollenhagen, 2010, p. 269). ZAV implies a need for a 'generative' or at least a 'proactive' safety culture (Zwetsloot et al., 2013; Parker et al., 2006), wherein risks are not only controlled, but unforeseen risks are also anticipated, recognised, and adequately dealt with (Weick and Sutcliffe, 2007), and where there is a continuous desire to improve safety. This implies strongly shared safety values and involvement and 'ownership' by all members of the organisation (owners, managers and employees). There has recently been a shift in focus from measuring safety culture to safety climate, the latter being described as the surface manifestation (a snapshot) of the underlying culture, and as such, are observable directly using a combination of psychometric and qualitative approaches (based on the work of Zohar (e.g., 2002), see for a recently validated method Kines et al. (2011)).

1.5. Learning

Our final assumption is that individual and collective learning processes are likely to play a key role in on-going safety improvement processes, which are needed to make substantial steps towards zero accidents. ZAV requires both individual and collective learning processes for enabling safety improvements. This implies not only adequate education and training of managers and workers in order to ensure their safety competences, but also collective learning from experiences, from planned safety actions, incidents and accidents, as well as from unexpected situations and events. This requires a learning attitude and climate in the organisations (Drupsteen and Wybo, 2015), which is also likely to foster the development and adoption of safety relevant innovations (Littlejohn et al., 2014).

2. Materials and methods

The research design applied in the study is an example of a 'mixed methods' approach, combining a quantitative survey with qualitative interviews and workshops. The quantitative methodology (11 ZAV topics, 72 item survey) was entitled the PEROSH ZAV Survey, and was used to generate data for statistical analyses (27 companies, 8819 respondents). The qualitative methods included interviews (in 22 companies), and national workshops in 7 countries (23 companies participating). This allowed the exploration of new perspectives that are difficult to assess with a survey (e.g., good practice), as well as to gain a better understanding and interpretation of the survey topics and the underlying processes and factors. The combination of quantitative and qualitative methods generated added value by providing complementary insights. The recruitment and data collection processes took place in 2014.

2.1. The 27 ZAV companies

The research partners in each of the seven participating EU countries recruited 3–5 companies each using convenience sampling. All the companies had explicit ZAV commitments or 'ZAV-like' principles and ambitions (yet may have used different terminology). The total of 27 companies were comprised of 13 manufacturing companies, 7 construction companies and 7 'other organisations' (including two public agencies). For the survey, we required a minimum of 40 respondents per company (both managers and workers), and thus only companies with more than 100 employees were recruited. The companies were not represen-

tative for their country. Apart from potential biases due to different cultures and histories, this did not make it meaningful to compare the survey data between the countries.

Background information from each company was collected, with companies ranging in size from 100 to over 10,000 employees and having 1–11 years of experience with ZAV. Companies reported having either decreasing injury rates (sometimes with fluctuation), or low and stable injury rates in comparison to sector norms. Unfortunately, there is not a European or global standard for the registration of incident frequencies. As a consequence, it is not possible to find reliable incident frequency data on a European level. Fortunately, for a proactive safety policy as ZAV implementation, lagging indicators like incident frequencies have only limited relevance.

Table 1 provides an overview of the main characteristics of the participating companies.

2.2. Participants/respondents

Participants in the survey and interviews, managers (leaders and supervisors) and workers, were identified dependent on selection from and by the companies, and therefore the participant selection process varied greatly between the 27 companies. In some companies all managers and workers were invited to participate in the survey, whereas in other companies convenient sampling was used by inviting at least around 100 potential respondents in order to be reasonably sure that the minimum limit of 40 respondents with completed surveys would be achieved. It was therefore not possible to calculate the participation rate for all 27 companies.

The data from one Belgian company could not be differentiated into responses from managers and workers: the company had a very flat hierarchical structure, and only wanted to participate in the research when this distinction was not made: They argued 'we have different roles in this company, but equity is one of our core values and we do not have bosses or subordinates – to make the distinction in our company would be artificial and would not be recognised or regarded as useful'.

2.3. The PEROSH ZAV survey

The PEROSH ZAV Survey consisted originally of 72 items across 11 ZAV topics, and was developed by the project partners (in English) by using or adapting items from existing validated survey dimensions, and by creating new items. In the analyses one of the items provided unreliable results and was removed, so the research made use of 71 items. The surveys were collected either through an internet survey system or using a paper and pen method, after which results from the latter were manually entered into a database, and subsequently combined with the electronic survey data for analyses in SPSS. The ZAV topics covered ZAV commitment, safety communication, safety culture/climate and safety learning, as well as an additional topic regarding safety resilience. In the three companies in Germany one additional scale comprising five items was included, addressing the interactions of ZAV implementation with preventing occupational disease and work-related illness.

2.3.1. Survey topics

In the survey we measured both *organisational ZAV commitment* and *individual ZAV commitment* as experienced or perceived by each survey-respondent. Broader 'zero' commitments were assessed in the interviews and workshops. The two communication topics covered *ZAV communication on the management level* and *the individual level*. The management communication items reflected the different aspects of communication quality,

Table 1
Characteristics of the 27 'Zero Accident Vision' companies.

Country	Company ID	Sector	Size	Start ZAV – commitment	Development of incident frequencies in the last few years
Belgium	BE1	Manufacturing	100–249	2008–2010	Decreased with fluctuations
	BE2	Other	100–249	2008–2010	Decreased
	BE3	Other	100–249	2010–2012	Decreased
Denmark	DK1	Other	>1000	2013–2014	Decreased
	DK2	Manufacturing	250–499	2010–2012	Very low, stable
	DK3	Construction	<100	2010–2012	Very low, stable
Finland	FI1	Manufacturing	100–249	2003–2004	Decreased
	FI2	Construction	>1000	2005–2006	Decreased
	FI3	Manufacturing	500–999	2007–2008	Decreased
	FI4	Other	100–249	2003–2004	Stable
Germany	GE1	Manufacturing	100–249	2010–2012	Very low, stable
	GE2	Other	500–999	2008–2010	Decreased
	GE3	Manufacturing	>1000	2010–2012	Decreased
Netherlands	NL1	Manufacturing	250–499	2010–2012	Low, stable
	NL2	Construction	>1000	2010–2012	Decreased with fluctuations
	NL3	Construction	>1000	2013–2014	Decreased
	NL4	Construction	>1000	2013–2014	Decreased
Poland	PL1	Manufacturing	500–999	2008–2010	Decreased
	PL2	Manufacturing	>1000	2008–2010	Decreased
	PL3	Manufacturing	500–999	2008–2010	Decreased
	PL4	Manufacturing	>1000	2004–2008	Decreased
	PL5	Other	>1000	2004–2008	Low, stable
UK	UK1	Manufacturing	>1000	2004–2006	Decreased
	UK2	Construction	>1000	2000–2002	Decreased
	UK3	Manufacturing	100–249	2013–2014	Decreased
	UK4	Other	>1000	2013–2014	Low, stable
	UK5	Construction	>1000	2008–2010	Decreased

communication on vision and safety goals, and providing feedback on safety performance. The individual communication items covered aspects of how individual workers receive safety information and feedback, as well as their perceptions of talking with and giving feedback to peers and management regarding safety matters.

The survey included four safety climate scales related to culture. *Management safety priority* refers to perceptions of management behaviour; to actions that clearly demonstrate that they give priority to safety, even in times of production pressure; they are knowledgeable about safety and also actively support safety initiatives from the respondents. *Management safety justice* refers to an open and fair reporting culture, wherein accidents and near-misses' can openly be discussed and analysed, and there is no fear of blame. *Safety empowerment* addresses management actions that actively include the respondents in decisions regarding safety and to support safety initiatives from the respondents. *Safety climate-group* level addresses the priority of safety in the respondents' workgroup, demonstrated through behaviour and actions. It deals with whether respondents are also knowledgeable about their own safety, and whether they actively support each other to take safety initiatives.

The survey included twenty items from the Nordic Occupational Safety Climate Questionnaire (NOSACQ-50; Kines et al., 2011). Four of these items were slightly adapted, actually simplified, while their meaning remained the same; one was included in the scale communication management, the others in the safety climate scales. To guarantee compatibility of the twenty items with NOSACQ 50 and its international database, it was ensured that the official NOSACQ translations (available in all seven languages) were used. At the time of our analyses (January 2016), the NOSACQ-50 international database comprised 203 studies/sites from around the world in 25 different languages on six continents. The 203 companies/sites were comprised of many front runners in safety with active OSH organisations, and many of the NOSACQ companies are very proactive, with a few having adopted ZAV. The NOSACQ database was therefore not representative for 'non

ZAV companies'. It is not known however, to what degree the companies involved in the NOSACQ studies aspire to ZAV.

Two topics for safety learning were used. *Learning actions* involved taking action following observations, near-misses and incidents (accidents/injuries) according to a 'learning from incidents' process model of: reporting and registration, investigation and analysis, translation of findings into action plans, acting and evaluating (Drupsteen et al., 2013). *Learning conditions* measured organisational conditions that facilitated safety learning, i.e., that there is a generic openness for improvements, and that ideas are shared and reflected upon (Drupsteen, 2014). *Safety resilience* was measured due to the growing attention for managing safety in complex situations, acknowledging that variation and interaction are common phenomena in many work situations (Hollnagel et al., 2006; Hollnagel, 2011). Jointly with attention for high reliability organisations, it implies new perspectives to further advance safety improvements. In the three German companies a 12th topic was added regarding ZAV and the interactions with prevention of work-related disease and illness.

2.3.2. Survey items

In the survey different organisational levels were addressed: Items using the term 'our organisation' (e.g., 'In our organisation suggestions from workers are used to improve safety') refer to issues that go beyond the workplace level, in the organisation. Safety culture is typically an issue at this level. Items using the term 'our work place' were used to address issues that were common and/or shared at the workplace, but not the behaviour of individuals (e.g., 'Our workplace is committed to a Zero Accident Vision (preventing all accidents - injury to people and damage to objects)'). Items with the term 'I' were used to address the behaviour or opinion of the individual respondent – be they a worker or a manager (e.g., 'I can openly give feedback to my peers about safety issues'). The full list of items used in the PEROSH ZAV Survey can be found in Zwetsloot et al. (2015, pp. 74–78).

A four-point response scale was used ranging from 'Strongly disagree', 'Disagree', 'Agree' to 'Strongly agree', and for some items a 'Don't know' option was also included. The principal researcher from each of the seven countries then coordinated translation of the English language survey into the native language of each respective country. To make it attractive for the companies to participate in the survey (what's in it for us?), the option was offered to include a maximum of five additional questions that were not directly relevant for the research, but could provide the company with information relevant for the development of their safety policy. Some companies made use of this option, adding questions on e.g., the division or the department of the respondents or on the evaluation of recently implemented specific safety activities.

2.4. ZAV interviews and national workshops

Twenty-two of the 27 companies participated in the semi-structured interviews that were carried out with a selection of company representatives (3–5 interviews per company - e.g., a senior manager, a worker representative, a line manager or supervisor and the safety expert). The interviews were also meant to explore the diversity of good practices and challenges in ZAV companies. The interviews were not always recorded, but the researcher made notes. An integrated summary of the interviews was made for each company using a standardised format, and these reports were sent to the company contact person for verification. The interviews and reports of the interviews comprised the following areas: (1) interpretations of the company specific survey results, (2) good practices - perceived as success factors related to ZAV commitment, communication, culture and learning, (3) involvement in networking or benchmarking safety activities, (4) broader commitments to zero (e.g., zero defects, zero emissions, zero bullying), (5) main ZAV challenges for the (near) future, and (6) a company 'ZAV story'. These six topics were also used in the analyses of the interviews across the companies. Details on the interview findings cannot be given here due to limitations in the length of the paper, but the most important ones are presented in the project report (Zwetsloot et al., 2015).

The national workshop with the participating companies focused on: (1) providing a short feedback and discussion of the national and international survey results (of all 27 companies), (2) discussion about the interpretation and meaning of the survey and interview data, (3) sharing success stories per company (of that country), and (4) discussion of good practices and lessons learned. A total of 23 companies participated in the national workshops, and a report from each national workshop was made using a standardised format. These were sent to the participants of the workshops for their approval. As we were mostly interested in the interpretation of the analysis of the quantitative data by the companies and possible other factors relevant for successful ZAV implementation, recording, transcribing and analysing the data with software was not regarded as practical, timely or useful.

2.5. Data analyses

Coordination and analyses of the data were carried out jointly by the research coordinators and partners at a number of face-to-face meetings and teleconferences. Survey data were analysed using the Statistical Package for the Social Sciences (SPSS-20). Statistical analysis of the internal consistency of the items that operationalised the 11 topics revealed that the 11 topics (dimensions) proved to have good or acceptable statistical reliability for both manager and worker respondents, see Table 2. Differences between groups, e.g., managers and workers were analysed using an independent samples T-test.

The ZAV and commitment to disease and illness prevention items, which were used in the three German companies only, had high reliability (Cronbach Alpha = 0.90 when all 2068 German respondents were taken together).

Initial explorative analyses of interview and workshop data were carried out in a workshop with representatives from all seven research institutes. The complementarity of the interview and workshop data with the survey analyses was important. A qualitative data matrix was defined, which was used to analyse all available interview and workshop data. The qualitative data matrix was again focused on the main topics of ZAV commitment, safety communication, safety culture and safety.

3. Results

3.1. Overview of the PEROSH ZAV survey data

A total of 9423 survey responses were initially received, and 604 predominantly empty responses were removed because they did not include at least half of the items in at least one of the 11 dimensions. After cleaning the available responses a total of 8819 survey responses were available from the 27 companies, of which around 30% were from managers and 66% from workers. The seven construction companies accounted for 51% of the respondents (Table 3).

In Table 4 the results are shown of the average of the company averages (wherein all company averages are weighed equally, i.e., independent of the number of respondents per company) for the 11 ZAV survey dimensions per sector.

The survey results are relatively similar for managers and workers (see Table 4 and Fig. 1), although managers have significantly higher ($p < 0.001$) average scores than workers on 10 of the 11 dimensions, with the greatest differences in scores seen in regards to safety justice and safety communication - individual. There is less disagreement between the groups in regards to safety resilience. Detailed results by country, sector, company and respondent position are provided in Zwetsloot et al. (2015, p. 79).

Most of the companies have relatively lower scores on two dimensions: Safety resilience: only 22% of companies had scores of 3 or more (average score for the 27 companies = 2.86; scale 1–4). Individual safety communication: 52% of the companies have scores of 3 or more (average of 2.98). For individual safety communication the average scores given by the workers are considerably lower than those from the managers. Interview and workshop data confirm these results, and several companies see these two topics as areas where improvements can and should be made.

The next section focuses on the roles of safety commitment, communication, culture and learning as well as success factors for ZAV implementation, hereby complementing the survey results with the findings from the interviews and workshops.

3.2. Commitment

3.2.1. Survey results

In the survey, both organisational and individual commitment to ZAV were very high. Twenty-five of the 27 companies (93%) had an average score of 3 or more (scale 1–4) on organisational commitment to ZAV, and 100% had a score of 3 or more on individual commitment to ZAV. Both managers and workers had their highest dimension 'scores' in this ZAV survey in regards to the organisational and individual commitment to ZAV (see Fig. 1).

The analyses of the data on the interaction of ZAV commitment with the prevention of work-related disease and illness (German data only) showed that according to the experience or perception of the respondents, there was a positive interaction between the

Table 2
The PEROSH Zero Accident Vision (ZAV) survey dimensions and reliability.

No.	ZAV dimensions	Number of items	Reliability ^a managers (n = 2,672)	Reliability ^a workers (n = 5,854)	Reliability ^a all respondents (n = 8,819)
1	ZAV commitment – organisational	2	0.76	0.76	0.76
2	ZAV commitment – individual	5	0.71	0.69	0.71
3	ZAV communication – organisational	8	0.92	0.92	0.92
4	ZAV communication – individual	8	0.85	0.84	0.85
5	Safety climate – organisational	9	0.84	0.87	0.86
6	Safety climate - safety justice ^b	3	0.72	0.72	0.73
7	Safety climate - safety empowerment	6	0.89	0.89	0.89
8	Learning actions	5	0.85	0.90	0.88
9	Safety climate – group	15	0.86	0.88	0.88
10	Learning conditions	8	0.87	0.87	0.87
11	Safety resilience	2	0.72	0.74	0.73
1–11	All dimensions	71	0.97	0.98	0.98

^a Cronbach's Alpha: Results over 0.67 acceptable, results over 0.8 are good (Nunnally, 1978).

^b One problematic item removed.

Table 3
PEROSH Zero Accident Vision survey – respondent position and sector.

		Respondents	%
Position	Managers (leaders & supervisors)	2672	30
	Workers	5854	66
	Not provided ^a	293	3
	Total	8819	100
Sector	Manufacturing companies (n = 13)	2491	28
	Construction companies (n = 7)	4495	51
	Other (n = 7)	1833	21
	Total (27)	8819	100

^a One Belgian company did not provide data about management versus worker responses.

two. The average value for this additional scale was 3.11. As for the other scales, the average scores from management respondents were somewhat higher than from workers (3.21 and 3.06 respectively).

3.2.2. Qualitative findings on commitment

In the interviews and workshops organisational commitment to ZAV turned out to be closely related to company strategies, including the companies' core ambitions, their mission and vision and/or broader commitments to zero. Embedding the ZAV commitment in the company was seen as very important, which also meant

making it clear to all members of the organisation that the commitment was not hype, but that it was there to stay, even in times of production pressure, change and/or difficulties. The companies that participated in the project used various strategies in this respect.

They emphasised that organisational safety commitment was (and had to be) more than merely words and paperwork. As many companies were decentralised – with departments in various geographical locations – it was also essential for them to allow and develop buy-in at local levels.

The congruency of work safety and the moral philosophy of management turned out to be important, and were frequently demonstrated in daily management activities. It implied showing safety leadership and developing a proactive or 'generative' safety culture, wherein the importance of safety was always clear (especially in decisions and actions), and wherein the mind-set of managers and workers was focused on creating safety.

Several of the 27 companies had formulated broader zero commitments which included ZAV (e.g., Zero Harm) or existed in parallel to ZAV, e.g., commitments for zero defects (production and quality), for environmental issues, violence, or for psychosocial topics such as bullying and substance use (alcohol and drugs). This is illustrated by one company that had a comprehensive 'zero' company strategy covering four key areas: health (long and short term), safety, environment and security (e.g., aggressive and/or political incidents in global markets). There was great synergy

Table 4
Average Zero Accident Vision survey dimension scores of company averages per sector differentiated for managers and workers – dimension numbers same as in Table 2.

Sector and position	Dimension										
	1	2	3	4	5	6	7	8	9	10	11
Construction managers (7 companies)	3.65	3.55	3.26	3.14	3.31	3.34	3.25	3.23	3.23	3.28	2.90
Construction workers (7 companies)	3.47	3.37	3.08	2.92	3.08	3.11	3.01	3.11	3.07	3.13	2.88
Construction average (7 companies)	3.52	3.43	3.13	3.00	3.14	3.17	3.08	3.14	3.12	3.17	2.88
Manufacturing managers (13 companies)	3.44	3.59	3.29	3.20	3.32	3.36	3.26	3.22	3.19	3.28	2.94
Manufacturing workers (13 companies)	3.40	3.35	3.14	2.98	3.11	3.06	3.03	3.19	3.13	3.18	2.89
Manufacturing average (13 companies)	3.41	3.39	3.16	3.02	3.14	3.10	3.08	3.20	3.13	3.19	2.89
Other managers (6 companies) ^a	3.34	3.43	3.10	3.03	3.14	3.25	3.13	3.24	3.18	3.15	2.85
Other workers (6 companies) ^a	3.19	3.32	2.98	2.88	2.97	3.03	2.98	3.10	3.08	3.11	2.85
Other sectors average (6 companies)	3.22	3.35	3.03	2.89	3.00	3.06	3.00	3.12	3.09	3.09	2.81
All sectors-managers (26 companies)	3.47	3.54	3.24	3.15	3.28	3.33	3.23	3.23	3.20	3.25	2.91
All sectors-workers (26 companies)	3.37	3.35	3.09	2.94	3.07	3.07	3.01	3.15	3.10	3.15	2.88
All sectors. all respondents (27 companies)	3.39	3.39	3.12	2.98	3.11	3.11	3.06	3.16	3.12	3.16	2.86

^a Manager/worker position not provided in one company Survey scale: '1 Strongly disagree' (very poor), '2 = Disagree' (poor), 3 = 'Agree' (good) to 4 = 'Strongly agree' (very good).

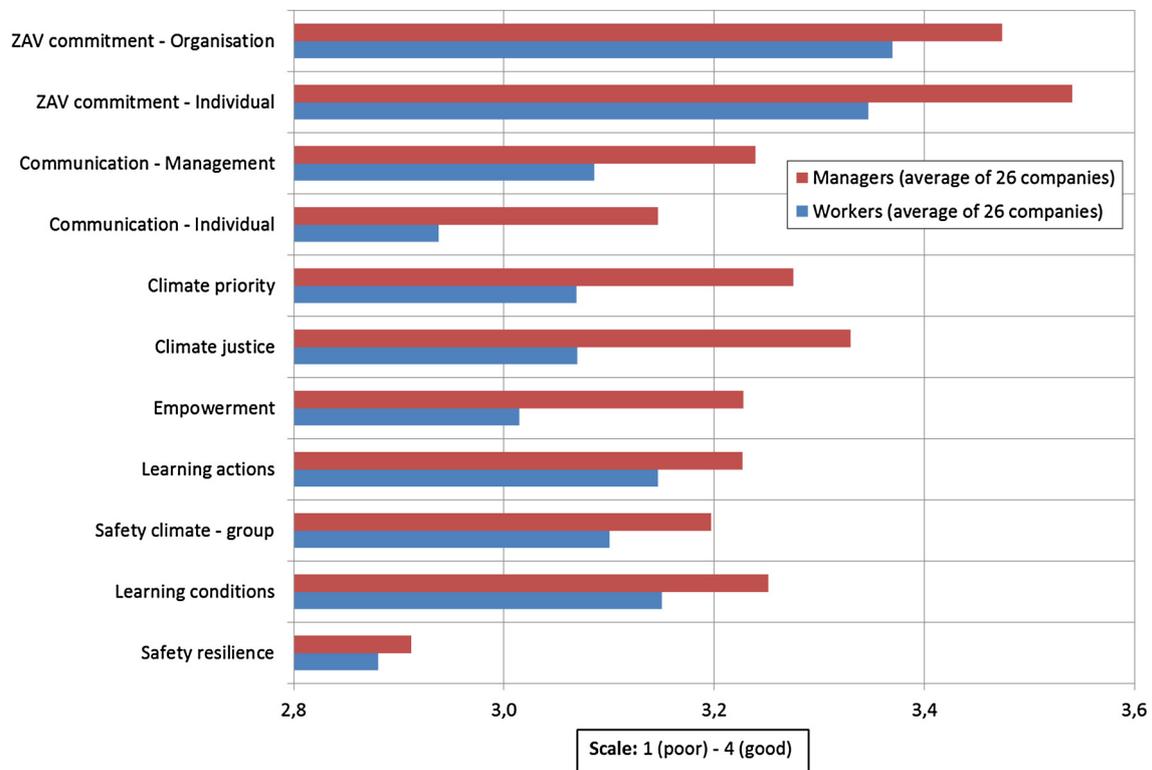


Fig. 1. Zero Accident Vision survey – dimension means for managers and workers (position not provided for one of the companies) (modified from Zwetsloot et al., 2015).

between the four areas with some acting as leading indicators for initiatives in other areas. Such an approach also ensured that safety was fully integrated with operational efficiency – instead of something additional or separate from operational performance.

The Finnish companies emphasised the importance of their ZAV strategies for well-being at work, which was regarded by them as a comprehensive strategy that also included safety and health. Several other ZAV companies saw it as an up-coming challenge to broaden their ZAV commitment, in order to include ensuring healthy work conditions, or to develop a broader generative culture.

3.3. Safety communication

3.3.1. Survey results

The survey results (Table 4) emphasised the vital role of safety communication for ZAV implementation. Particularly the management safety communication (average at company level 3.12; management 3.24; workers 3.09) scored relatively high. The scores for communication on the individual level were however, relatively lower (average at company level 2.98; management 3.15; workers 2.94). Companies in the manufacturing sector scored higher on both management and individual communication than their peers in construction and in ‘other’ sectors. There were two companies in which workers gave higher scores for individual communication than their managers.

3.3.2. Qualitative findings on communication

Based on the interviews and workshop data, three relevant success factors were recognised: specific ZAV or safety promotion programmes; constant and updated communication and functional tools; and effective supervisor communication. Many of the companies had launched and branded a specific ZAV or safety promotion programme for introducing or strengthening a ZAV mind-set. These programmes functioned as an important way for top man-

agement to communicate the company’s safety vision and express their personal commitment to ZAV. Besides being part of formal company communication, the programmes also aimed at encouraging informal communication and bottom-up initiatives.

To put the programmes and strategies into action the importance of constant and updated communication and functional tools was underlined. The ZAV companies utilised a wide variety of different media and means, e.g., safety briefings, newsletters, info screens, videos, safety days and events, monthly safety themes, and mobile apps. In addition to the functional tools, supervisors’ active role in communicating safety matters and empowering workers was stressed. Effective supervisor communication was considered to be more than giving one-way feedback. Dialogue-based communication practices, such as morning meetings, toolbox talks, safety walks and workshops, were considered to create dialogues and contribute to the feeling of openness and trust within the company. In some companies supervisors were trained in dialogue-based communication and to act as safety facilitators.

3.4. Safety culture

3.4.1. Survey results

In general the scores on each of the four safety climate scales were high, with averages above 3.0, but lower than the scores for the two ‘commitment’ scales. There were quite large differences between companies in regards to ‘safety justice’, where some companies have very high scores (potential for sharing) and others rather low scores (potential for learning). These results indicate that safety justice issues are a particular area that the ZAV companies should continue focusing on in sharing and learning.

There were relatively large differences between manager and worker survey results on three of the four safety climate dimensions. The two dimensions with the greatest differences in this respect were ‘safety justice’ and ‘empowerment’. Interestingly, the company where safety justice was scored highest by managers

Table 5

Safety climate items in the Zero Accident Vision (ZAV) survey and NOSACQ-50 internal benchmarks (ranked by difference in scores for workers). Scores for 'negated' items are reversed – a high score indicates a positive safety climate. Differences between ZAV and NOSACQ-50 workers or managers are all statistically significantly different at the 99.9% confidence level ($p < 0.001$), except where noted: * 99.0% ($p < 0.01$); ** 95.0% ($p < 0.05$); or # not significantly different.

Scale	Safety climate item	ZAV workers n = 5,854	NOSACQ workers n = 24,777	ZAV managers n = 2,672	NOSACQ managers n = 6,062
(3) Communication management	Management ensures that everyone receives the necessary information on safety	3.10	3.04	3.25#	3.27#
(5) Management safety priority	Management accepts employees taking risks when the work schedule is tight	3.12	2.85	3.29	3.22
	Management puts safety before production	3.01	2.77	3.23	3.04
	Management looks the other way when someone is careless with safety	3.27	3.06	3.36#	3.33#
	Management listens carefully to all who have been involved in an accident	3.07	3.02	3.25**	3.22**
	Management encourages employees here to work in accordance with safety rules - even when the work schedule is tight	3.10	3.07	3.35#	3.36#
(6) Management safety justice	Management treats employees involved in an accident in a fair way	3.20	2.95	3.40	3.18
	Management looks for causes, not guilty persons, when an accident occurs	3.04	2.86	3.22	3.09
	Management blames employees for accidents	3.11	2.99	3.24#	3.27#
(7) Safety empowerment	Management makes sure that each and everyone can influence safety in their work	3.00	2.92	3.23	3.16
	Management involves employees in decisions regarding safety	2.81	2.77	3.04#	3.02#
(9) Safety climate group	We who work here consider minor accidents (injury-people & damage-objects) as a normal part of our daily work	3.06	2.91	3.18	3.10
	We who work here try hard together to achieve a high level of safety	3.23	3.17	3.36	3.29
	We who work here always discuss safety issues when such issues come up	3.04	3.00	3.23	3.14
	We who work here try to find a solution if someone points out a safety problem	3.19	3.16	3.32	3.28
	We who work here take joint responsibility to ensure that the workplace is always kept tidy	2.99#	2.99#	3.06#	3.05#
	We who work here have great trust in each other's ability to ensure safety	3.05*	3.08*	3.16#	3.14#
	We who work here help each other to work safely	3.12	3.20	3.21*	3.25*
	We who work here seldom talk about safety	2.77	2.88	2.91	3.20
	We who work here break safety rules in order to complete work on time	2.81	3.02	2.89	3.30

(4.00, the maximum score) was also the company where this aspect was scored lowest by the workers (2.73). Obviously this company needs to look further at the discrepancy and improving its two-way communication.

Workers also had relatively much lower ratings of management safety priority than managers had. This pattern is similar to what is seen in other safety perception surveys (e.g., NOSACQ-50, see below), and may reflect different points of reference, where managers base their perceptions within their own group of leaders, and more in regards to policies, procedures and idealised practice, whereas workers base their perceptions on everyday practice with their managers and colleagues. There was greater agreement as to the level of group safety climate within both the manager-group and the worker-group.

3.4.2. The ZAV survey compared with NOSACQ-50

The ZAV-survey safety climate results are similar to NOSACQ-50 with managers having consistently higher scores than workers. When comparing the responses of the 5854 workers in the 27 ZAV companies with the 24,777 workers in the 203 NOSACQ-50 companies/sites (benchmark status as of January 2016), the ZAV companies have statistically significantly higher results on all of the 'management safety priority' items found in both surveys (5 items), the three safety justice items, both safety empowerment items, and a communication management item. On the other hand there were no clear patterns in regards to differences on the nine group safety climate items, with the ZAV companies having lower (4 items), same (1 item) or higher (4 items) worker scores compared to the NOSACQ-50 companies/sites (see Table 5).

ZAV companies clearly differentiate themselves from the NOSACQ-50 companies on three of the four safety culture/climate topics, having a 'richer' (more mature) organisational safety climate where managers/leaders to a greater degree are perceived by workers to prioritise safety on a daily basis – even when working under production pressure. In addition, the managers are perceived to be more competent in dealing with daily safety issues. Thirdly, managers are perceived to be much better at creating an

open atmosphere for communicating about safety, ensures that everyone has the necessary information on safety, and by empowering workers to take part in discussions and decisions regarding safety issues. Finally, they have to a greater degree a just ('no blame') culture in terms of accidents and incidents, investigating accidents for causes – not guilty persons, and treating those involved in accidents fairly.

3.4.3. Qualitative findings on safety culture

Interview and workshop results revealed that safety empowerment and safety justice were seen by companies as two key areas that potentially have a great impact on ZAV. Some described the role of sincere top management's mandate and support for a strong safety culture, e.g., with empowerment to stop production, and an atmosphere where colleagues can be open about mistakes in order to learn from them. Participative improvement processes were often standard practice: leaders asked questions instead of giving answers, they reached out to workers, to discuss and to encourage them to be involved, and to challenge them to think for themselves. In addition, leaders strived to build trust and an open atmosphere to discuss and deal with safety dilemmas. Submitting proposals for safety improvements was also common, but what made them a success was when workers saw that they actually had *influence* on safety decisions (they were not just *involved*). One company statistic showed that company action was taken on 92% of suggestions, which was perceived as helping to build trust between the workers and leaders. The workers saw that their opinions and suggestions mattered, and that the company really cared for them.

3.5. Safety learning

3.5.1. Survey results

The results from the survey (Table 4) show high scores on the two learning dimensions for both managers and workers. However, there were seven individual companies where the workers' score on learning actions were below 3; for managers this was in three

cases. This indicates great differences between the companies for learning actions. The results for learning conditions were less diverse, with workers in four companies, and managers in only one company, having scores below 3. Generally, a high score on organisational commitment was associated with a high score on learning conditions. This could be explained by the fact that learning conditions and organisational commitment both referred to organisational aspects of safety.

3.5.2. Qualitative findings on learning

The interviews supported that learning actions were generally well performed in the ZAV companies. If incidents occurred they were registered, communicated throughout the organisation in news bulletins or a similar approach, and discussed to see if lessons could be learned and applied. Although follow-up was not always clearly visible, most interviewees assumed that follow-up actions were implemented in their organisation.

The interviews and workshops showed many examples of safety learning and demonstrated the width of the two learning dimensions. There were several examples of where skills were improved through learning by doing. The success factors mentioned for safety learning partly referred also to training methods. Some examples: approach the workers during their work tasks and closely refer to their daily work activities (instead of taking them into an office and pelt them with paper and power points); select scenarios of the employees' work place; illustrate scenarios with sketches, photos, videos, real documents and equipment, motivate employees to discuss and describe the situation, get the employee actively involved in activities; choose external group moderation and train supervisors and foremen as moderators for theme-based safety discussions.

4. Discussion

The research triggered a range of broader reflections and discussions on ZAV and the innovative aspects of ZAV implementation. To limit the length of this article, these broader reflections were presented in a separate paper (Zwetsloot et al., 2017).

ZAV companies are, of course, not a uniform group. The 27 participating companies varied greatly in many respects. They had different organisational cultures; they may have recently committed themselves to ZAV, or had already had such commitments over a range of years. Their safety performance may be world-class or (in the beginning) only average. This great variety made it very interesting to identify common aspects of how companies implement ZAV, as these common aspects seem to be relevant for a broad group of (potentially) ZAV committed companies. An important characteristic is that the ZAV committed companies were proactive and strategic in developing safety. While the critics (e.g., Dekker, 2014a,b) suggest that ZAV committed companies are obsessed with (manipulating their) incident frequencies, the focus in the 27 companies was strongly on the vision (not the zero), and on improvement activities and associated leading indicators, and much less on the incident frequencies (they realise these might be fluctuating and mirror the past rather than being predictors of future performance).

The implementation strategies of the various companies were certainly not uniform either, in fact each company, sometimes each location a company had, to some extent, its own implementation strategy. Several factors were seen as important for choosing and developing the ZAV strategy: company history, the nature of the primary process, the company structure (centralised or decentralised), the personal convictions of top managers, being part of a multinational organisation, or being an independent family business, etc.

The PEROSH ZAV Survey was carried out in large and medium-sized enterprises. This was a consequence of the survey design, wherein it was important to have at least 40 respondents per company; consequently only companies with more than 100 employees were involved. Nevertheless, ZAV implementation is also important for SMEs. Most of the ZAV companies saw ZAV as part of how they did business, which implies consequences for their business partners (often SMEs): suppliers, (sub)contractors, even customers. Some of the ZAV companies also required their contractors (usually small and medium enterprises - SMEs) to embark on a journey towards ZAV. Several ZAV companies that were still focussing on the safety of their own activities only, saw the involvement of contractors as one of their main challenges for the near future. In this way, more and more SMEs who do business with larger companies are likely to be triggered by business incentives to implement ZAV. Innovation theory shows that a relatively small group of 'front runners' often pave the way for a much broader group of 'followers' (Rogers, 1993). The ZAV companies can be regarded as such 'innovators', while many of the SMEs are likely to be 'followers'.

There are several other limitations of this research. First of all we were focussing on the factors that contributed to successful implementation of ZAV, and thereby did not focus on potential downsides.

Furthermore, the factors safety commitment, communication, culture and learning, although presented as separated concepts, are in fact interrelated. This can be illustrated by the interdependencies of safety learning: management commitment is important for supporting safety learning; structural attention for incidents in communication and dialogues connects learning with communication, whereas sharing information is conditional for safety learning. An 'atmosphere where colleagues can be open about mistakes in order to learn from them', connects the conditions for learning with aspects of culture: leadership, empowerment, and justice.

None of the 27 companies explicitly referred to the concepts of resilience engineering or high reliability organisation as part of their practices or inspiration, though some did mention these as one of their future challenges. However, the 27 companies developed their capabilities in terms of monitoring, anticipation, and learning, which are three of the four abilities for resilience according to Hollnagel et al. (2006) and Hollnagel (2011). The relatively low scores on the safety resilience dimension in the survey, (focussing on the capability to be prepared to respond in case of unexpected events), indicate a clear opportunity to further improve in this area.

The companies also increased several capabilities known to be relevant for High Reliability Organisations (HRO), as mentioned by Weick and Sutcliffe (2007): High 'individual commitment to zero' is likely to be associated with *preoccupation with failure*; *The alertness to hazards and risks* seems associated with *sensitivity to operations*; the high scores for 'safety empowerment' in the ZAV companies correspond to some extent with *deference to expertise*; The HRO characteristic of *reluctance to simplify* could also be recognised in some of the ZAV companies, e.g., in the good practices where people were 'invited to challenge their supervisors', or where training is provided through new innovative perspectives on already known activities. It is therefore justified to hypothesise that the ZAV companies tend to develop in a direction of more resilient companies, which enjoy higher reliability.

5. Conclusion

In this section the answer to the main research question is presented, taking into account all findings and discussions mentioned earlier. The central research question was: *What are the factors that*

contribute to successful implementation of the 'zero accident vision' (ZAV)? A common characteristic of all ZAV companies was the high commitment to ZAV of their managers and of their workforce. It is very likely that this is, combined with other factors, the main driver for long-term safety improvements. Companies that implement ZAV are serious in their strategies and practices to improve safety, and realise that it will be an on-going effort.

The research confirmed that in ZAV committed companies accident prevention is often not the only 'zero' commitment for the companies. Many companies have broader commitments to zero. Synergies between the various zero commitments were frequently mentioned. The relevance of ZAV for health promotion was shown in three German companies, where ZAV tends to impact positively on health promotion and the prevention of work-related disease. It was also clear that broadening ZAV to include the prevention of ill health (zero harm) was identified as a future challenge in several companies, where this currently was not yet the case.

There is no blueprint for implementing ZAV. Companies differ in their business context, primary processes, history, structure, culture and people, implying that a tailored implementation strategy is to be preferred. Irrespective of the implementation strategy, it is crucial to show the sustainability of the commitment and the zero ambition. The success of the implementation is also influenced by the style of leadership both at the senior and supervisor level.

We conclude that ZAV is the basis for inspiring and innovative approaches to improve safety, with a high commitment of all members of the organisation. Safety commitment, communication, culture and learning all play a key role in ZAV implementation processes.

6. Recommendations for future research

This research project was the first (to our knowledge) to systematically explore the opportunities and challenges implied by the implementation of ZAV. The results provide a good impression of the relevance of such research, though there is still a lot to do to fully understand what makes these strategies and practices successful, and under what conditions they are useful. Clearly, there is still a need for more research in this innovative area. We provide a few suggestions here:

- A longitudinal ZAV implementation study could enrich the data and lead to better scientific evidence of the benefits and pitfalls of ZAV. Other useful options would be to evaluate the development and implementation processes, including e.g., leadership style and group dynamics, the role of management systems, and clarifying how networking leads to in-company safety initiatives, etc. These activities would also help to further improve the guidance for companies that implement ZAV.
- The study presented in this paper was conducted in North-West Europe. A similar study in other countries and continents could probably create new insights. Are there differences in ZAV implementation per country or continent?
- Another option is to perform a somewhat similar study on the implementation of ZAV in SMEs. The principles, challenges, and good practices of ZAV implementation seem also relevant to SMEs; they may also be triggered by larger companies that follow ZAV, and promote or even require commitment to ZAV from their suppliers and contractors. On the one hand, it is known that long-term strategies are often problematic for SMEs, yet on the other hand decision making is faster, and communication channels are shorter, jobs have more decision latitude, etc.
- Given the variety in ZAV companies, future ZAV implementation studies could look at the relevance of differences in company structure, culture, history, size, etc.

- In the interviews and workshops it became very clear that for ZAV implementation leading indicators were used for monitoring and steering continuous safety improvement processes. Lagging indicators (like incident frequencies) were dominantly used to monitor whether the companies were still on the right safety track. Future research into the nature and use of leading indicators in ZAV committed companies is recommended.
- The synergies of ZAV implementation with other 'zero ambitions' is another very relevant area for further exploration. Particularly the relevance of ZAV for the prevention of occupational disease and illness, as well as the promotion of well-being at work.

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