



## Discussion

## Zero Accident Vision based strategies in organisations: Innovative perspectives



Gerard I.J.M. Zwetsloot<sup>a,\*,1</sup>, Pete Kines<sup>b</sup>, Jean-Luc Wybo<sup>c</sup>, Riikka Ruotsala<sup>d</sup>, Linda Drupsteen<sup>a,2</sup>, Robert A. Bezemer<sup>e</sup>

<sup>a</sup> Netherlands Organisation for Applied Scientific Research TNO, Schipholweg 77-89, P.O. Box 3005, NL 2301 DA Leiden, Netherlands

<sup>b</sup> National Research Centre for the Working Environment, Lersø Parkallé 105, 2100 Copenhagen, Denmark

<sup>c</sup> European University Cyprus, 6 Diogenous, Egkomi 2404, Cyprus

<sup>d</sup> Finnish Institute of Occupational Health, Topeliuksenkatu 41 a, P.O. Box 40, FI-00251 Helsinki, Finland

<sup>e</sup> Netherlands Organisation for Applied Scientific Research TNO, Van Mourik Broekmanweg 6, 2600 AA Delft, Netherlands

## ARTICLE INFO

## Article history:

Received 19 April 2016

Received in revised form 1 July 2016

Accepted 20 August 2016

## Keywords:

Vision Zero

Safety innovation

Safety management

Safety culture

Accident prevention

Safety strategy

## ABSTRACT

The Zero Accident Vision (ZAV) is a promising approach developed in industry, but not so much addressed by the safety science research community. In a discussion paper in Safety Science (2013) a call was made for more research in this area. Three years later is a good time to take status of developments in this field. A first set of empirical studies has been published, several authors see new perspectives with the vision, while misunderstandings still flourish with a focus on 'zero incidents' as a 'goal', rather than the 'vision' that all occupational incidents are preventable. This has thus given rise to fundamental criticism of ZAV with some authors seeing ZAV as an unjustified and misleading pretention that is counter-productive for safety. In this paper an overview is given of the knowledge developments in this respect, as well as on the discourse on the controversial aspect of ZAV.

There appears to be consensus that merely promoting traditional safety management or accident prevention will not lead to significant new improvements in safety. Six innovative perspectives associated with ZAV are identified and presented in this paper, which together offer a range of possibilities for both industry and for the safety science community to develop new practices and knowledge that may provide significant improvements in safety. The call for more empirical research into this challenging area is relevant for the advocates of ZAV as well as for its critics.

© 2016 Elsevier Ltd. All rights reserved.

## 1. Introduction

The Zero Accident Vision (ZAV) is based on the assumption that all (serious) accidents are preventable. ZAV is then the ambition and commitment to create and ensure safe work and prevent all (serious) accidents in order to achieve safety excellence. This is a high ambition and it often gives rise to several misunderstandings that focus on ZAV as a 'goal' of zero accidents, rather than as a 'journey' and a 'process' of creating safe work (safety excellence). ZAV gives rise to fundamental questions such as: Is it in reality possible to prevent all serious accidents, or is this some kind of

utopia? And if so, is it also possible (and desirable) to prevent all minor accidents? Don't we need the experience of incidents and accidents to attain knowledge on complex systems' vulnerabilities and remain motivated to safety leadership? How can such a bold ambition be realised, and what strategies are most promising? Etc.

Zwetsloot et al. (2013a) called for more research into this challenging area. The paper stated that ZAV was developed in industry, and needed more attention from safety researchers. The paper received a lot of attention, and was selected as the 'editor's choice' of the Safety Science journal and certainly did generate responses. Now, more than three years later, it seems to be a good moment to take status of developments in this field as some research has already been published within this field, with both positive responses as well as criticism and scepticism in some other papers.

The aim of this paper is to give an overview of the recent ZAV research published so far, to summarise and evaluate the ZAV criticism, to strengthen the scientific discourse on ZAV and to further clarify the innovative perspectives associated with ZAV.

\* Corresponding author.

E-mail addresses: [gz@gerardzwetsloot.nl](mailto:gz@gerardzwetsloot.nl) (G.I.J.M. Zwetsloot), [pki@nrcwe.dk](mailto:pki@nrcwe.dk) (P. Kines), [J.Wybo@external.euc.ac.cy](mailto:J.Wybo@external.euc.ac.cy) (J.-L. Wybo), [Riikka.Ruotsala@ttl.fi](mailto:Riikka.Ruotsala@ttl.fi) (R. Ruotsala), [ldrupsteen@windesheimflevoland.nl](mailto:ldrupsteen@windesheimflevoland.nl) (L. Drupsteen), [Robert.bezemer@tno.nl](mailto:Robert.bezemer@tno.nl) (R.A. Bezemer).

<sup>1</sup> Presently: Honorary Professor at the University of Nottingham and Director of Gerard Zwetsloot Research & Consultancy.

<sup>2</sup> Presently: Researcher at the Applied University Windesheim.

The paper comprises three parts: (1) the status of the scientific discourse, (2) a short section describing some important developments in policies and practices promoting ZAV (mainly at the level of national and international policy making), and (3) a section focusing on innovative perspectives of ZAV. The latter makes use of the authors' experiences while carrying out a two-year European research project on ZAV implementation in 27 companies, as well as other research findings presented in the first part of this paper.

## 2. The broader business context for the development of ZAV

In the previous ZAV paper (Zwetsloot et al., 2013a), ZAV was addressed as a member of the 'family of Vision Zero', e.g. zero defects, waste and traffic accidents. The industrial experience with the broader family of Vision Zero was thereby suggested to be an important reason to explain that ZAV was more easily recognised in industrial practice than it was in the safety science community. It actually implied that ZAV was part of a broader development, and that for a large part took place outside the research community. A basic understanding of this broader context wherein ZAV is developed and is still developing might therefore be very useful.

First, attention will be paid to this broader context, making use of a recently published book of a well-known business analyst of future trends (Singh, 2012), as well as an article in the business journal Forbes (Singh, 2014). The book as well as the paper focus on the ten 'Mega Trends' that in the coming decade are likely to have major impacts on the developments in business as well as society at large. Singh defines Mega Trends as "global sustained and macro-economic forces of development that impact businesses, economy, society, cultures and personal lives, thereby defining our future world and its increasing pace of change" (Singh, 2012, p. 4). Examples of the Mega Trends are 'smart is the new green' and 'eMobility', as well as 'innovating to zero'.

According to Singh, 'innovating to zero' is different from the other nine Mega Trends: it is a Mega Vision; it is more a concept than a real happening. It implies the desire for perfection in our society: a 'zero concept' world with a vision on zero carbon emissions, zero crime rates, zero accidents, carbon-neutral cities, etc.

*"Although this seemingly perfect world sounds almost impossible, the point is that governments and companies today are moving towards this 'picture perfect' vision of eliminating errors, defects and other negative externalities, and along that very journey creating for themselves huge challenges and opportunities. We might not achieve this goal in a decade or ever, in some cases, but we humans can make this as our ultimate goal. Even if we achieve half of the set objective – it will be huge progress. It will make a real difference to society".*

[Singh (2012, p. 46)]

Innovating to zero is not just a mere 'programme' but a way of running and innovating one's business (Singh, 2012, p. 57).

*"It is not a trend that is incorporated by individuals or companies overnight. It is a gradual process, a journey that will create opportunities, demand investments, and yield long-term returns. The most remarkable feature of this Mega vision is that the ultimate opportunity lies not in attaining the actual goal itself, but in capitalising on the opportunities that would lead to it (our underlining). Success in innovating to zero requires an innovation agenda that bravely talks of breakthroughs in the face of radical goals- goals that intend to create a better world, a zero concept world, which is free of unhelpful externalities and defects. It also needs a strong culture from people within that ecosystem".*

[Sing (2012, p. 59)]

The text above emphasises the innovative nature of ZAV, its close relationship with running business, and describes it as a journey generating many opportunities along the way to creating and ensuring safety, and the importance of the organisational culture. This sketches an important context for understanding and evaluating both the industrial experiences with implementing ZAV, as well as the responses to the ZAV 2013a paper. We address the innovative aspects in the last part of this paper.

## 3. An overview of responses to the ZAV paper and the broader literature

Google Scholar is a useful tool to attain an overview of the responses to scientific papers. In principle it includes all papers in international peer-review journals, but it also aims to include broader (scientific) literature. As of March 4, 2016, Google Scholar mentioned 23 unique citations of the ZAV paper (Zwetsloot et al., 2013a). Three of these publications present empirical research on practices of ZAV implementing companies (Koivupalo et al., 2015; Twaalfhoven & Kortleven, 2016; Young, 2014). We also take into account a recent report that we know of first hand (Zwetsloot et al., 2015). These four publications represent the type of empirical research we hoped to be triggered by the call for research into ZAV' (Zwetsloot et al., 2013a).

Five of the papers mentioned in Google Scholar, all with the same primary author, are critical to the call for ZAV research (Dekker, 2014a,b, 2015; Dekker et al., 2016; Dekker and Pitzer, 2015). We also take into account some other critical publications that were not identified by Google Scholar (Dekker, 2014c,d; Long, 2012; Sharman, 2014), though these do not refer to Zwetsloot et al. (2013a,b), and most of them are not published in peer-reviewed journals.

Apart from the empirical research and the critical publications, several other papers cite the ZAV paper, for instance by including it in review papers. These are respectively focused on the concept of prevention culture (Salminen and Lee, 2015), safety and learning (Drupsteen and Hasle, 2014), and values that support safety, health and well-being at work (Zwetsloot et al., 2013b). Some other papers refer to ZAV as an important development in the introduction or discussion of a research report (e.g. Runyan et al., 2013 and Kines et al., 2013 point out the potential relevance Vision Zero for the safety of young workers), or in non-peer-reviewed journals promoting the ZAV concept (e.g. Deniz, 2015 for Turkey, Aaltonen, 2013 for Africa). There are books promoting zero written by consultants with a wide range of experience in the industry (e.g. Duncan, 2012), and there are publications that, again in the introduction or discussion, address some dilemma's associated with ZAV, e.g. (Ju and Rowlinson, 2015 discuss ZAV in relation to safety for contractors in the Hong Kong construction industry; Nie (2015) shows that commitment to product safety in the Chinese industry may decrease the commitment to work safety).

## 4. Overview of the empirical findings so far

As the 2013 paper was a call for research, it seems appropriate to start with an overview of the empirical research on ZAV (already mentioned above) published so far. We will concisely summarise the main findings presented.

### 4.1. New Zealand Aluminium Smelter

Young (2014) described and analysed 25 years of experiences and interventions at the New Zealand Aluminium Smelters Limited (NZAS), where ZAV was introduced in 1990. NZAS has been named in 2007 as the safest aluminium smelter of its class in the world. In

that study, Young evaluated the activities and success factors of this sustained effort.

Automation, thereby eliminating hazardous work, was probably the most important successful intervention strategy over the years. Hazards were mostly ameliorated by long-term persistence following the principle of hierarchy of controls for injury prevention. The second most important factor was transformational leadership that enabled the application of resources towards goal-oriented interventions (Young, 2014). The transformational leadership was combined with an ergonomic strategy focussing on the hierarchy of controls. With respect to safe behaviour, the company focused on environmental conditions instead of trying to influence individual behaviour directly. There was a strong preference of interventions or measures that were eliminating hazards or risk scenarios (i.e. essential factors) and improving ergonomic system design; as a consequence, individual behaviour was generally regarded as less important.

The progress of NZAS towards their goal of having zero injuries on site was also assessed and found to be consistent with the established principles of goal-setting theory (Locke and Latham, 2002). According to this theory, specific difficult goals consistently lead more to higher performance than urging people to do their best. Another important finding was that worksites should not be regarded as static environments, where automation and ergonomic intervention are regarded as impractical or not feasible for safety improvement. Instead, it is important to see such innovations as opportunities for safety improvement – otherwise interventions are only manipulations of the existing plant and workforce (Young, 2014).

#### 4.2. A global steel company

Koivupalo et al. (2015) described and analysed health and safety management in a changing global steel company that was committed to preventing all accidents. The corporate safety vision was promoted around the theme “Safety First”, and the target was to build a safety culture where all accidents were preventable. There was a great emphasis on safety systems and processes, employee ownership, and safety leadership. Management commitment was seen as an important driver for the safety improvement process.

#### 4.3. Two Dutch ZAV companies (steel and construction)

In the largest steel and a large construction company in the Netherlands, both committed to ZAV empirical research was carried out by Twaalfhoven and Kortleven (2016). They focused on two strategies more or less regarded as incompatible: Implementing ZAV and Criminalising Human Error (CHE). CHE involves responding to people who err or violate safety rules by prosecuting or taking disciplinary action against them (Dekker, 2003, 2011). Twaalfhoven and Kortleven assessed how far and how ZAV and CHE were practiced, and whether the two strategies were related or not. They were especially interested in how the companies managed human errors, and whether these led to sanctions. If a sanction was taken, it could have two different meanings: it could be primarily a preventive action (to prevent reoccurrence, compatible with ZAV), or primarily be a punitive measure (a symptom of CHE).

Both companies had a three-step approach for dealing with unsafe behaviour, with the goal of stopping such behaviour. The ultimate purpose of their approach was to end unsafe behaviour (i.e. preventing reoccurrence, in line with ZAV). The attitude and behaviour of employees were perceived as important points of focus in achieving zero accidents. Employees were perceived to be individuals, who intrinsically want to work safely and who benefit most from doing so. The factors that caused them to exhibit

unsafe behaviour were perceived to be primarily external factors, and the responsibility of management. This is in line with ZAV.

Nevertheless, CHE was not eradicated completely. In these large organisations, not all managers behaved the same. In some situations the direct imposition of sanctions in response to unsafe behaviour was practiced only occasionally, even though this was not in agreement with the official company policy. There seemed to be a difference in punitive response between own personnel and personnel from contractors or subcontractors. Sanctions were used more frequently towards employees from external contractors, than towards their own personnel. It should be noted that the companies had selected, trained and coached their own personnel, which is not or to a lesser degree the case with personnel from the contractors and subcontractors.

#### 4.4. ZAV commitment and implementation in 27 companies in Europe

This research was carried out in 27 ZAV committed companies in seven European countries (Zwetsloot et al., 2015) in 2014–2015. A mixed method approach was used, combining a survey, company interviews and national workshops. The research focused on the roles, meanings and good practices of ZAV commitment, safety communication, safety culture and safety learning for ZAV implementation.

Each of the 27 companies had remarkably high ZAV commitments, both on the organisational and the individual (leader and worker) level. The organisational ZAV commitments were usually embedded in the companies' strategies. Safety communication, safety culture and safety learning were also very well developed, but to a significantly lower degree than the two types of commitment.

The safety climate items in the survey data were compared with the scores of 203 frontrunners in safety, based on 25 language versions used on all continents, and that had applied the Nordic Occupational Safety Climate Questionnaire (Kines et al., 2011). The ZAV committed companies had a more mature organisational safety climate; managers were to a greater degree perceived by workers to prioritise safety on a daily basis – even when working under production pressure. Managers were perceived to be much better at creating an open atmosphere for communicating about safety, and by empowering workers to take part in discussions and decisions regarding safety issues. The ZAV companies also had to a greater degree a ‘just’ culture in terms of dealing with accidents and incidents, investigating accidents for causes (not guilty persons), and treating accident victims fairly.

##### 4.4.1. Preliminary evaluation of empirical findings

From the four empirical studies presented above it can be concluded that they offer interesting and to some extent innovative insights and that ZAV research can indeed be valuable. The four studies form, however, only a very limited body of knowledge, and they also give rise to new research questions.

#### 4.5. ZAV criticism and response

In science, critique is an important contribution to the scientific discourse that may lead to improved understanding and scientific progress. It is therefore important to analyse such criticism, in order to bring the discourse to a higher level. In this section an overview is given of the argumentation of the ZAV critics, followed by reflection and response on these arguments. The critical statements can be clustered into five categories: (1) the ZAV concept as such, (2) the potential impact ZAV may have on a system-based approach to safety, (3) performance indicators, (4) safety culture, and (5) human behaviour (the latter four areas were also presented in Zwetsloot et al., 2013a).

#### 4.5.1. Criticism on the ZAV concept as such

Concerning the ZAV concept the criticisms are: ZAV is unrealistic and naïve, particularly the belief that all (serious) accidents can be prevented; ZAV denies the realities of risk (implying uncertainties, human limitation, and learning by mistake; stating that zero harm is ‘the only acceptable goal in safety’ is a fundamentalist ideology; and that ZAV is a dangerous idea (Long, 2012). Dekker et al. (2016) stated that ZAV suggests the pretention to eliminate all human suffering, and that ZAV uses quasi-religious means to achieve normative control. Furthermore, ZAV may give the impression that we need to abolish the causes of suffering, rather than alleviate its effects (Dekker et al., 2016).

#### 4.5.2. ZAV criticism and system-based improvements

With respect to system-based improvements of safety the critical statements are: ZAV is an activity of companies that pursue safety through bureaucratic safety systems (e.g. surveillance and measurement of incident and injury data, and the associated bureaucratic processes) and bureaucratic accountability (Dekker, 2014a,b,d). Furthermore ZAV is suggested to divert attention away from the big picture, to focusing on microscopic risks (Sharman, 2014), which is associated with overspending of investigation resources (Dekker, 2014b).

#### 4.5.3. ZAV criticism and the use of performance indicators

Not without reason ZAV is often seen as related to performance indicators; according to the critics ZAV is focused on lagging indicators (like injury rates) only. According to Dekker et al. (2016), Dekker and Pitzer (2015) and Dekker (2014b) ZAV invites much trickery and fraud with numbers. Long (2012) and Sharman (2014) argue that ZAV drives reporting underground. According to Dekker (2014b) the statistical probability of failure in a complex resource-contained world simply rules out zero – fraudulent manipulation of the dependent variable becomes a ‘logical response’ according to Dekker (2014b) and Sharman (2014); in Dekker and Pitzer (2015) the same phenomenon is called ‘suppression of bad news’; finally Sharman suggest that goal zero can never be a specific, measurable, achievable, realistic and time bound (SMART).

#### 4.5.4. ZAV criticism and safety culture

In relation to culture, the critics state that ZAV drives a safety culture characterised by scepticism, cynicism, underreporting, lack of debate, fear of openness and a non-learning climate (Long, 2012); according to Dekker (2014b) it leads to stigmatisation of workers involved in incidents, and Sharman (2014) warns of a culture of intolerance.

#### 4.5.5. ZAV criticism and human behaviour

Concerning human behaviour the arguments critical of ZAV are that it drives a punitive mind-set (Long, 2012), that there will always be all kinds of human errors (Dekker, 2014b), and that positive goals and targets are much more effective than avoidance goals such as zero accidents (Long, 2012; Sharman, 2014).

#### 4.5.6. Alternatives proposed by the critics

The critics do not all simply criticise ZAV, as in some of their publications ‘alternatives to ZAV’ are presented that they regard as better than ZAV or complementary to ZAV. Dekker (2014d) proposes the alternative of ‘going beyond zero’ by focusing on three key transitions: (1) a transition from seeing people as a problem to control to seeing people as a solution to harness, (2) a transition from seeing safety as a bureaucratic accountability *up*, to seeing it as an ethical responsibility *down*, and (3) a transition from seeing safety as an absence of negatives to seeing it as the presence of a positive capacity to make things go right (Dekker, 2014d). Long

(2012) states that goals and targets that speak about the ‘safety journey’, ‘harm minimisation’, ‘management of risks’, and gain-framed messages associated with family and welfare are much more effective than ‘avoidance goals’ that prime the mind on (avoidance of) negative failure.

In their remarkable discussion paper Dekker et al. (2016) go further. They criticise ZAV for its strong focus on prevention (which they associate with Christian protestant religion). According to them, there is not very much to win anymore with a research focus on prevention. In complex situations accidents will continue to emerge in unpredictable ways, even “after we have implemented all safety measures we know we should, there remains an unremitting residue of harm”. Dekker et al. (2016) therefore propose to extend the ZAV commitment from its focus on prevention to a commitment to compassion (another Christian value) to alleviate the suffering that remains inevitable.

## 5. Evaluating and responding to the ZAV criticism

The concept of ZAV triggers very critical reactions. It turns out to be difficult to address ZAV in an objective way (addressing the strengths and weaknesses of ZAV), as the responses are often only radically against or idealistically in favour. In our view, more (empirical) research into the practices of ZAV will be helpful to achieve and share a more realistic understanding of the strengths and weaknesses of ZAV.

The belief that ‘all (serious) accidents are preventable’ is a focal point of the critics. They state that this belief is by definition not feasible, naïve and utopian in nature, and therefore should not be taken seriously by any scientist (they see fraud with numbers as the only way to achieve zero). Some critics ask questions about the exact nature of this belief, or even state that zero is not a number with any real meaning (Long, 2012).

As researchers, we are of the opinion that the exact nature of the beliefs behind ZAV are *not* very interesting, nor whether they are 100% feasible or not. We are interested in the *consequences* of ZAV: the commitments that generate actions and programmes to develop greater safety, often using or developing innovative means. Table 1 illustrates the commitments of the more than 300 companies that are a member of the Finnish Zero Accident Forum (and similar commitments are made by the members of the German and Dutch Zero Accident Fora) – notice that they focus on processes and not numbers.

The quote of Singh (2012, p. 59) that was included in the introduction was to clarify that we are much more interested in the processes of ‘innovating to zero’ than in the beliefs underlying ZAV. We consider the ZAV companies as companies that are ‘innovating’ their safety approaches with the intention to achieve safety excellence.

The ZAV critics underline the importance of positive goals, while they regard ZAV as ‘only trying to avoid the negative’. We fully agree with the importance of positive goals. In the ZAV committed companies where we have done our research, ZAV clearly comprised elements of both ‘avoiding the negative’ and ‘developing the positive’. As a consequence we defined ZAV in the introduction in a slightly different way compared to the 2013 paper, as ‘the ambition and commitment to create and ensure safe work and prevent all (serious) accidents in order to achieve safety excellence’. This definition better clarifies that ZAV includes the serious ambition to increase safety and develop safety excellence (the positive aim).

We also recognise the importance of the three transitions that are proposed by Dekker (2014d) as alternatives to ZAV (seeing people as part of the solution, seeing safety as an ethical responsibility, and seeing safety as the presence of a positive capacity to make

**Table 1**  
Commitments of the member organisations of the Finnish Zero Accident Forum.

---

We commit ourselves to sharing information on best practices with other workplaces
We will improve our workplace safety in co-operation with our employees and management
Health and safety are an integral part of our workplace's successful business operations
We commit ourselves to annually providing the Zero Accident Forum's project team with information on occupational safety

---

things go right). In our research these are, however, not alternatives to ZAV, but transitions that help the ZAV companies to be innovative in safety.

It seems to us that part of the criticism is based on the assumption that some ZAV committed companies are trying harder to do the same old safety things, i.e. to make more safety procedures (systems associated with greater bureaucracy) and to be stricter and more punitive towards unsafe behaviour. We agree with the critics that this would not make much sense, and we cannot exclude that such simplistic strategies exist in some companies, perhaps with greater frequency in some jurisdictions or cultures than in others. But we do not recognise any of this in the good practices that are shared among ZAV companies in the Finnish, German or Dutch Zero Accident Fora, nor did we find this as a characteristic in any of the 27 ZAV companies in Europe, where we did our empirical research. We observed that the ZAV committed companies explored innovative ways to improve safety (see also Young, 2014), and endeavoured to develop a learning-driven safety culture. Instead of stricter control and more sanctions towards unsafe behaviour, we found more empowerment than in other safety frontrunner firms. We observed that managers asked questions in order to trigger reflection and dialogue, instead of giving orders and referring to existing procedures (compare also with the findings of Kortleven and Twaalfhoven (2016).

It is important to note that the critics are not based on empirical research published in peer-reviewed journals. They are based on anecdotal evidence and some publications in non-peer-reviewed journals. They mainly criticise the suggestion that ZAV is a useful concept, and do not explicitly respond to the main issue in the discussion paper: the call for more research into ZAV; instead they seem to pretend to already know that ZAV is 'a dangerous idea' (Long, 2012) or that "we have to implement all safety measures we know we should" (Dekker et al., 2016). The argumentation that a given tool, methodology or vision (in this case ZAV) is wrongly understood or can be used wrongly (as illustrated by anecdotes) is from a scientific point of view a very weak reason to say that such a tool, method or vision is of no value.

In Zwetsloot et al. (2013a) reference was made to ZAV as a commitment strategy for safety, in analogy with commitment strategies developed in human resource management (see Walton, 1985; Beer, 2009). Such commitment strategies are developed precisely as an alternative to hierarchical and bureaucratic controls, and are quite successful in realising high performance through high commitments. Dekker et al. (2014a,b,d) do not refer at all to these sources, thereby deviating from the valuable tradition to study and refer in a scientific discourse to the original sources. Instead they simply suggest that ZAV commitment will result automatically in more bureaucracy. It is also clear that many of the critical statements belong to what Zwetsloot et al. (2013a) termed 'the traditional criticism' (seeing zero as an accountable target, associated with the risk of underreporting).

The four empirical studies mentioned above give a totally different picture than the critics' sketch. Their suggestion that ZAV leads to stricter bureaucratic control, a punitive culture, and fraud with numbers is not what ZAV committed companies, according to the empirical studies mentioned above, are experiencing. The empirical results so far show that ZAV implementation often leads to significant safety improvements (e.g. Young, 2014; Zwetsloot

et al., 2015), thereby being keen to make use of technical and social innovations (Young, 2014). Companies and their personnel see ZAV as a journey driven by genuine long-term commitment (Young, 2014; Twaalfhoven and Kortleven, 2016; Koivupalo et al., 2015; Zwetsloot et al., 2015) that does not lead to more bureaucracy. Instead, it leads to higher worker commitment and more empowerment (Zwetsloot et al., 2015), to managers giving safety a very high priority in daily practice, to the encouragement of participation and learning, and a culture that has more characteristics of a 'just culture' than is found in non-ZAV frontrunner firms (Zwetsloot et al., 2015). The empirical findings also show that the ZAV companies already put into practice several of the ZAV 'alternatives' suggested by the critics, while keeping a strong focus on incident prevention.

The overall picture seems to be that the ZAV critics do not have a strong scientific case; there is a need for good empirical research, which is designed to confirm or falsify their critical statements. The empirical findings presented so far give good reasons to state that the assumptions upon which much of the criticism is based, are not well-justified. This is not to say that misunderstandings (misuse) and poor examples of the use of the ZAV label do not exist. The criticisms of ZAV give us reason to believe that misunderstandings of ZAV as a goal rather than as a vision are widespread – so there is still need for empirical studies in this field. In any case the criticism should not overshadow the many good practices found in the empirical studies so far. All in all, an evaluation of the criticism published so far underlines the earlier Zwetsloot et al. (2013a) call for more research into the industrial practice of ZAV implementation.

## 6. Vision Zero policy developments

National and international policies form an important context for the industry, and we therefore pay some attention to recent developments related to ZAV. 'Vision Zero' (broader than just accidents) is not only an issue for research and industrial practice, but has also developed into a major issue in policies for promoting occupational safety and health (OSH) in national and international political arenas, directly or indirectly addressing many workplaces. A very concise overview of the main policy developments is given before focusing at the development of a deeper understanding of ZAV.

In Germany the national social accident insurance adopted Vision Zero in 2008; they explicitly refer to Vision Zero as the basis for their strategy for accident prevention (at work, in schools and on the road) as well as the prevention of occupational diseases and work-related illnesses (DGUV, 2008). They were also the organiser of the second OSH Strategy Conference focusing on a Preventive Occupational Safety and Health Culture (2nd Strategy Conference, 2011), where representatives from governments, European and international organisations, multinational companies, associations and the scientific community defined 'Vision Zero' as the foundation for strategies to develop a culture of (OSH) prevention.

While several industry associations developed ZAV strategies independently, Vision Zero is increasingly recognised as a strategic vision underlying OSH strategies. In 2012, the executive board of

the International Social Security Association (ISSA) section on Mining decided to place their global OSH strategy under the guiding principle of Vision Zero. After pilot testing in companies of a great variety of sectors, all ISSA sectors, including SMEs and developing countries, ISSA recently published generic guidelines for implementing Vision Zero, comprising seven golden rules for OSH prevention (ISSA, 2016; Ehnes, 2016). Vision Zero was also adopted in Singapore, where in 2012 a guide for business leaders – “Towards Vision Zero” was published as part of a broad OSH programme (WSH, 2012). Both in the ISSA and Singapore materials, the importance of leadership is strongly emphasised. This is illustrated by a quote: “Leadership is the capacity to translate vision into reality” (Warren Bennis, quoted in WSH, 2012). Another interested development in the field occurred at the end of 2015 when the Swedish Government adopted a Vision Zero strategy with a zero tolerance for fatal occupational accidents (which supplements their ongoing Vision Zero for fatal traffic accidents) with increased investments in research, education and inspection (Swedish Government, 2015).

In the US, NIOSH has a type of Vision Zero approach with their ‘Total Worker Health’ programme, which includes a focus on safety, well-being, leadership and empowerment (NIOSH, 2016).

In June 2015 OSH was for the first time put on the agenda of the world leaders at the G7, the summit of the heads of state of the seven leading industrial nations. Vision Zero was thereby the leading concept, and was confirmed to be an area where joint political action is needed (G7, 2015a). The G7 established a ‘Vision Zero Fund’ (VZF) for more joint prevention around the world, with the goal of seeing as few serious work-related accidents as possible, or none at all (ILO, 2015a). The VZF is to stimulate appropriate action in low-income producing countries by governments, business, social partners and NGOs (G7, 2015b). The VZF is to be implemented through the International Labour Organisation (ILO); to start with, seven million euro were made available. The VZF intends to mobilise additional voluntary resources e.g. from other countries and from multinational corporations (ILO, 2015b).

### 6.1. ZAV: beyond traditional safety management and accident prevention

Let’s now return to ZAV and safety science. In the ZAV discussion paper (Zwetsloot et al., 2013a) several reasons were given for why ZAV is important and also interesting from a research point of view. The discourses on ZAV, both in safety science and industrial practice, underline the importance of clarifying how ZAV differs from good traditional safety management or excellent traditional accident prevention. The key question thereby is: What are the ‘new promising perspectives’ offered by ZAV? And what theoretical or conceptual frameworks might be useful for future research into this challenging area? The next section in this paper reflects the deeper understanding of ZAV that the authors developed while being involved in the ZAV research project in the seven European countries (Zwetsloot et al., 2015). In particular, the qualitative aspects of the research (interviews and workshops with representatives of the ZAV-committed organisations, and dialogues with the projects advisory board and among the members of the research team) contributed to a deeper understanding of ZAV (the ZAV survey results are reported in an upcoming article). From a scientific point of view the status of this deeper understanding is that of hypotheses (which need further research to be confirmed, or not).

In order to be successful, ZAV requires an innovative perspective on several issues or aspects of safety. Many of these innovative aspects are not completely new, and have been practiced, researched or suggested occasionally. However, ZAV can serve as

both an umbrella for such developments, and as the vision that may unite isolated innovations into a consistent framework. In this way ZAV can serve as a coherent framework for processes and practices that contribute to transforming the vision into measurable safety improvements. Table 2 gives an overview of the elements of such an innovative framework, which we have clustered into six themes that are explained below.

Table 2 is not only of theoretical relevance, but also can be used to review existing safety policies – both at a company, sector and national level. The table (and the associated innovative perspectives mentioned below) can serve as a source of inspiration for companies to enrich their existing approaches to safety management with innovative elements. Companies that are already on the ZAV journey are also likely to find new perspectives in Table 2 that they find inspiring, but were not pursued seriously so far. Macro-level policy makers and authorities could also use the table to review their existing policies and intervention strategies: e.g. would it make sense to trigger some of the more innovative perspectives for safety improvement through their policies and interventions? For safety experts and practitioners, the table presents ideas which can form a start for meaningful dialogue in the companies they work for, and also imply opportunities for further professional development.

Finally, Table 2 focuses on ZAV and therefore is aiming at innovative ways of safety improvement. As we have seen earlier in the paper, Vision Zero is broader than ZAV and also addresses the prevention of work-related illnesses and the promotion of work-related health and well-being. It is beyond the scope of this paper to fully explore the opportunities for broader OSH policies implied by Table 2 here; instead we invite others to explore such broader innovative perspectives.

The various elements of Table 2 are closely linked with six innovative perspectives that are discussed below.

### 6.2. Six innovative perspectives opened up by ZAV

We do not discuss each of the elements of Table 2 individually, as in practice combinations thereof are important for making a difference. Instead we discuss six innovative perspectives of ZAV, each building on several of the elements mentioned in Table 2. Each of these six perspectives is important for ZAV, as they are mutually compatible, and probably synergetic. In the 2013a paper most of these perspectives were already – mostly implicitly – addressed, but without the explicit attention that they deserved.

#### 6.2.1. ZAV: A commitment strategy for safety

The first innovative perspective is the concept of a ‘commitment strategy’ for safety. Commitment strategies – as opposed to control strategies – have been applied in human resource management since the mid-eighties (Beer, 2009), and are characterised by high commitment and high performance. Commitment and engagement require empowerment, and allow for a minimum of administrative or hierarchical controls. Related concepts are intrinsic motivation and self-regulation, which can theoretically be supported by e.g. the self-determination theory (Ryan and Deci, 2000; Deci and Ryan, 2008). Interesting is also the paper of Edwards and Jabs (2009) that demonstrates that a safety culture that promotes greater commitment and empowerment is not compatible with traditional bureaucratic controls. This doesn’t preclude all controls; ZAV is a combination of shared knowledge about a dynamic environment and willingness to anticipate and keep the system safe. Therefore methods and resources are needed such as leading indicators and flexible communication means to support an efficient sharing of information among people.

**Table 2**  
OSH Vision Zero compared to traditional OSH management (elaborating on Zwetsloot et al., 2015).

ZAV Theme	Traditional safety management (accident prevention)	Zero Accident Vision
Commitment strategy	Safety <b>control</b> strategy Safety is a priority Safety (0 accidents) is an (unrealistic) goal Focus on risk assessment and control Safety and health are in practice two distinct worlds	Safety <b>commitment</b> strategy Safety is a value Safety is a process, a journey Long-term commitment is the basis for safety improvements Zero accidents and zero harm are ethically and practically closely interconnected
A way of doing business	Safety improvements stem from safety programs Safety is mainly a tactical and operational challenge Risk management Transactional management Safety is perceived as a cost factor Safety is only relevant internally (and for the authorities)	Safety is an integrated part of doing business Safety is a strategic challenge Safety leadership and business excellence Transformational leadership Safety is perceived as an investment Safety is also relevant for business partners and external stakeholders
Innovation	The workplace is more or less a static environment wherein safety management will lead to continuous improvement	The workplace is a dynamic environment wherein technological and social innovations are important for significant improvements
Prevention culture	Preventing accidents Compliance – ‘We have to’ (external motivation) Incidents are failures Safe behaviour is desirable Workers’ behaviour (human error) is part of the problem  Safety is designed or prescribed by experts  Focus on management systems Safety culture is important	Creating safety Participation – ‘We want to’ (intrinsic motivation) Incidents are opportunities for learning Safe behaviour is the norm Workers are empowered to come up with solutions – they are part of the solution Safety is co-created by experts and all members of the organisation (having a questioning and learning attitude) Focus on culture and learning A safety and ‘just’ culture are important
Ethics and CSR	Safety management is always rational Safety is associated with prescriptions, paper work, and owned only by a few champion	Safety management is rational but also founded on ethics Safety is inspiring, ‘alive’ and ‘owned’ by all members of the organisation
Networking and co-creation	Safety improvement is triggered by internal processes (Plan, Do, Check, Act) Benchmarking on lagging indicators (like injury rates) Safety improvement is triggered by best practices in the sector	Safety improvement is triggered also by learning from the experiences of others Benchmarking on leading indicators and good practice Safety improvement is triggered by good practices from other (ZAV) companies and sectors

### 6.2.2. ZAV is a way of doing safe business

The second innovative perspective implies that ZAV is not a safety programme, but a way of doing safe business, a safety programme being a resource. It presupposes transformational leadership and is often closely connected with other members of the ‘Vision Zero family’, e.g. zero defects, etc. It implies opportunities for synergy with good business and the areas of the other zero ambitions. Theoretically, ZAV can build on the goal setting theory (Locke and Latham, 2002), on theories of transformational leadership (e.g. Barling et al., 2002), and on more applied knowledge such as on ‘mainstreaming’ (EU OSHA, 2010).

### 6.2.3. ZAV triggers innovation

A third innovative perspective is that the processes involved in ZAV cannot be realised sustainably with existing good practices only: innovative practices are needed. Young’s (2014) paper clearly demonstrates a good example, whereby it is important that this is not only innovation in safety, but certainly also in production technology. A very relevant concept here is that of workplace innovation (Eeckelaert et al., 2012). It may be interesting to elaborate on the theories of socio-technical (re)design, and on theories of resilience engineering (Hollnagel et al., 2006), high reliability organisations (Roberts, 1990; Weick and Sutcliffe, 2007), the concept of inherently safer production (Zwetsloot and Ashford, 2003), and the diffusion of innovation theory (Rogers, 1993).

### 6.2.4. ZAV as the basis for the development of a prevention culture

A fourth innovative perspective is the importance of ‘Vision Zero’ for the development of a ‘prevention culture’, which is usually defined as a culture fostering prevention in the area of OSH. This perspective can elaborate on a lot of research in the area of

safety culture and climate, and can also address prevention of work related diseases and illnesses (see e.g. Eichendorf and Bollmann, 2014; Salminen and Lee, 2015). As already described above the concept of prevention culture is also important in international OSH policy agendas (2nd Strategy Conference, 2011; WSH, 2012). In particular, a ‘ZAV-driven’ preventive culture emerges from shared values and practices like vigilance and shared awareness, questioning attitude and willingness to make sense of safety procedures and devices.

### 6.2.5. ZAV implies business ethics and corporate social responsibility

A fifth innovative perspective is the ethical perspective: zero is the only goal that is ethically sustainable (Aaltonen, 2007), and Vision Zero is in line with modern corporate social responsibility (CSR), and the growing attention to business ethics; relevant theories are e.g. institutional theory (Powell and Di Maggio, 1991) and ‘normative management’ (Bleicher, 2009). From a CSR perspective, accidents and the resulting injuries are ‘externalities’ that should be prevented; setting a goal in terms of a number of accidents per year can be interpreted as a consent of failure. Another characteristic of CSR is the active involvement (dialogue, cooperation) of stakeholders, both external and internal. This implies recognising that non-traditional safety stakeholders such as social or private insurers, local communities, families, NGO’s, employment agencies, shareholders etc. have interests in prevention and may contribute to it (compare Jain et al., 2011).

### 6.2.6. ZAV requires networking and co-creation

The sixth innovative perspective is that exchanging inspiration and good practices with other ZAV committed companies supports each of them attaining safety excellence over time, and therefore

the use of ZAV networks are important. Theoretically this can build on network organisations and learning (e.g. Knight, 2002), on the combination of organisational learning and system improvement (Senge, 1990), and on learning and soft systems methodology (Checkland and Poulter, 2006). For theory on co-creation see Payne et al. (2008), and Prahalad and Ramaswamy (2004).

## 7. Overall conclusion

The ambition and commitment to all (serious) accidents being preventable implies the need for innovation. ZAV differs from more traditional safety management or accident prevention approaches. It offers a range of innovative perspectives for the industry and for the safety research community. Building on empirical research the differences of ZAV with traditional safety approaches have been analysed, and six compatible and probably synergetic 'innovative perspectives' for ZAV were presented. It is suggested that each of these six perspectives implies links with theories and concepts that were developed outside the domain of safety science. Some of the few empirical studies presented so far indeed build on one or several of these innovative perspectives and have contributed to the further understanding thereof. If the business analysts who see 'innovation for zero' as a Mega Trend for the coming decade are right, ZAV has the potential to become very important in safety leadership. This underlines the call for more empirical research into this challenging area that was made in 2013. Empirical research into the practices, potentials and dilemmas associated with ZAV seems just as relevant for the critics of ZAV as for its advocates.

## Acknowledgements

This paper could not have been written without the many dialogues and discussions we had with our research colleagues who participated in the European research on the implementation of ZAV (Zwetsloot et al., 2015) and the leaders and workers of the 27 companies participating in the project. The project was sponsored by the German Social Accident Insurance (Deutsche Gesetzliche Unfallversicherung, DGUV) under grant FF-FP 0352, and to a limited extent by the seven individual participating research institutes (CIOP-Poland, FIOH-Finland, HSL-UK, IFA-Germany, NRCWE-Denmark, Prevent-Belgium, and TNO-Netherlands). We would like to thank them for their support. We would also like to specifically thank the members of DGUV Advisory Board from the above mentioned project for their positive thinking and their challenging remarks, questions and suggestions. Finally we would like to thank Dr. Markku Aaltonen for his initiatives and ideas to promote ZAV and this current study.

## References

- 2nd Strategy Conference, 2011. Five Pillars for a Culture of Prevention in Business and Society – Strategies on Safety and Health at Work, 3–4 February 2011, DGUV Academy Dresden. Available at: <<http://www.dguv.de/iag/veranstaltungen/strategiekonferenz/2011/index-2.jsp>> (accessed 26–6–2015).
- Aaltonen, M., 2007. The Zero Effect Model. In: *The Quality of Working Life: Challenges for the Future*. Liber Amicorum for the 10th Anniversary of Prevent. Brussels, pp. 166–170.
- Aaltonen, M.P.V., 2013. The Finnish Zero Accident Forum, the African newsletter on. *Occup. Health Saf.* 23, p31.
- Barling, J., Loughlin, C., Kelloway, K.E., 2002. Development and test of a model linking safety-specific transformational leadership and occupational safety. *J. Appl. Psychol.* 87 (3), 488–496.
- Beer, M., 2009. *High Commitment, High Performance – How to Build a Resilient Organization for Sustained Advantage*. Jossey-Bass, San Francisco.
- Bleicher, K., 2009. *Normatives Und Strategisches Management*. Christian Abegglen, St Gallen Switzerland.
- Checkland, P., Poulter, J., 2006. *Learning for Action: A Short Definitive Account of Soft Systems Methodology and Its Use, for Practitioners, Teachers and Students*. John Wiley and Sons Ltd, Chichester.
- Deci, E.L., Ryan, R.M., 2008. Self-determination theory: a macro theory of human motivation, development and health. *Can. Psychol.* 49 (3), 182–185.
- Dekker, S.Z.W., 2015. The psychology of accident investigation: epistemological, preventive, moral and existential meaning-making. *Theor. Issues Ergon. Sci.* 16 (3), 202–213.
- Dekker, S.Z.W., Long, R., Wybo, J.L., 2016. Zero vision and a western salvation narrative. *Saf. Sci.* 88, 219–223.
- Dekker, S.Z.W., Pitzer, 2015. Examining the asymptote in safety progress: a literature review. *Int. J. Occup. Saf. Ergon.* (published on line 14 December 2015).
- Dekker, S.Z.W., 2014a. The bureaucratization of safety. *Saf. Sci.* 70, 348–357.
- Dekker, S.Z.W., 2014b. Employees: a problem to control or solution to harness? *Insurance newsnet.com*. Newswires, 22 August 2014.
- Dekker, S.Z.W., 2014c. The psychology of accident investigation: epistemological, preventive, moral and existential meaning-making. *Theor. Issues Ergon. Sci.* 16 (3), 202–213.
- Dekker, S.Z.W., 2014d. The problems of Vision Zero in Work Safety. *Malaysia Labour Rev.* 8 (1), 25–36.
- Dekker, S.Z.W., 2011. The criminalization of human error in aviation and health care: a review. *Saf. Sci.* 49, 121–127.
- Dekker, S.Z.W., 2003. When human error becomes a crime. *Human Factors Aerosp. Saf.* 31 (1), 83–92.
- Deniz, V., 2015. Sifir Kaza Hayal mi? (Do you dream of zero accidents?), *Önlem*, 21 December 2015 <<http://www.onlemdergisi.com.tr/6037-2/#respond>> (accessed 27 January 2016).
- Drupsteen, L., Hasle, P., 2014. Why do organizations not learn from incidents? Bottlenecks, causes and conditions for a failure to effectively learn. *Accid. Anal. Prevent.* 72, 351–358.
- Duncan, C. (Ed.), 2012. *The Zero Index – A Pathway to Sustainable Safety Excellence*. BST, Ojai, California.
- DGUV, 2008. *Prävention lohnt sich: Die Position der Selbstverwaltung der gesetzlichen Unfallversicherung zur Prävention – Leitlinien und Umsetzung – Mitgliederversammlung 2/08 der DGUV*, Fulda.
- Edwards, M., Jabs, L.B., 2009. When safety culture backfires: unintended consequences of half-shared governance in a high tech workplace. *Soc. Sci. J.* 46 (2009), 707–723.
- Eckelaert, L., Dhondt, S., Oeij, P., Pot, F.D., Nicolescu, G.I., Webster, J., Elsler, D., 2012. *Review of Workplace Innovation and Its Relation with Occupational Safety and Health*. EU-OSHA, Bilbao.
- Ehnes, H., 2016. Seven Golden Rules, Presentation at the 4th International Strategy Conference on Safety and Health at Work, Dresden, 22 March 2016.
- Eichendorf, W., Bollmann, U., 2014. Future approaches to a culture of prevention. In: *From Risk to Vision Zero – (Selected) Proceedings of the International Symposium on Culture of Prevention – Future Strategies*. FIOH, Helsinki, pp. 43–53.
- EU-OSHA, 2010 (Pawlowska Z, Eckelaert L editors). *Mainstreaming OSH into Business Management*, European Agency for Safety and Health at Work, Bilbao.
- G7, 2015a. Vision Zero Found Launched, Press and Information Office of the Federal Government, 13 October 2015 <[https://www.g7germany.de/Content/EN/Artikel/2015/10\\_en/2015-10-13-g7-arbeitsminister\\_en.html?nn=1282190](https://www.g7germany.de/Content/EN/Artikel/2015/10_en/2015-10-13-g7-arbeitsminister_en.html?nn=1282190)> (accessed 28 January 2016).
- G7, 2015b. Action for Fair Production, Ministerial Declaration. 16 pages (including 1 annex) <[http://www.bmz.de/g7/includes/Downloadarchiv/G7\\_Ministerial\\_Declaration\\_Action\\_for\\_Fair\\_Production.pdf](http://www.bmz.de/g7/includes/Downloadarchiv/G7_Ministerial_Declaration_Action_for_Fair_Production.pdf)> (accessed 28 January 2016).
- Hollnagel, E., Woods, D.D., Leveson, N., 2006. *Resilience Engineering: Precepts and Concepts*. Ashgate.
- Ju, C., Rowlinson, S., 2015. Institutional determinants of construction safety management strategies of contractors in Hong Kong. *Constr. Manage. Econ.* 32 (7–8), 725–736.
- ILO, 2015a. *Our Goal: Vision Zero*, Published by Federal Ministry of Labour and Social Affairs, G7 Project Group, October 2015, Berlin <[http://www.ilo.org/wcmsp5/groups/public/-europe/-ro-geneva/-ilo-berlin/documents/genericdocument/wcms\\_414171.pdf](http://www.ilo.org/wcmsp5/groups/public/-europe/-ro-geneva/-ilo-berlin/documents/genericdocument/wcms_414171.pdf)> (accessed 28 January 2016).
- ILO, 2015b. Vision Zero Fund: Questions and Answers, ILO Geneva <[http://www.ilo.org/safework/whatsnew/WCMS\\_423672/lang-en/index.htm](http://www.ilo.org/safework/whatsnew/WCMS_423672/lang-en/index.htm)> (accessed 28 January 2016).
- ISSA, 2016. Safety 7.0 – 7 Golden Rules to Vision Zero <<https://www.issa.int/-/safety-7-0-7-golden-rules-to-vision-zero>> (accessed 12 February 2016).
- Jain, A., Leka, S., Zwetsloot, G.I.J.M., 2011. Corporate social responsibility and psychosocial risk management in Europe. *J. Bus. Ethics* 101 (4), 619–633.
- Kines, P., Framke, E., Salmi, A., Bengtson, E., 2013. Young workers' occupational safety and health risks in the Nordic countries. *Nordic Council of Ministers, TemaNord* 2013:569.
- Kines, P., Lappalainen, J., Mikkelsen, K.L., Olsen, E., Pousette, A., Tharaldsen, J., Tómasson, K., Törner, M., 2011. Nordic Safety Climate Questionnaire (NOSACQ-50): a new tool for measuring occupational safety climate. *Int. J. Ind. Ergon.* 41, 634–646.
- Koivupalo, M., Sulasalmi, S., Rodrigo, P., Väyrynen, S., 2015. Health and safety management in a changing organisation: case study global steel company. *Saf. Sci.* 74, 128–139.
- Knight, L., 2002. Network learning: exploring learning by interorganisational networks. *Hum. Relat.* 55 (4), 427–454.
- Locke, E.A., Latham, G.P., 2002. Building a practically useful theory of goal setting and task motivation: a 35-year odyssey. *Am. Psychol.* 57 (9), 705–717.



- Long, R., 2012. The Zero Aspiration – The Maintenance of a Dangerous Idea <<http://www.humandimensions.com/images/images/The%20Zero%20Aspiration%20the%20Maintenance%20of%20a%20Dangerous%20Idea.pdf>> (accessed 28 January 2016).
- Nie, P.-Y., 2015. Product guarantee commitment: based on Game theory approaches. *Econ. Comput. Econ. Cybern. Stud. Res.* 49 (2), 291–306.
- NIOSH, 2016. What is Total Worker Health, National Institute for Occupational Safety and Health <<http://www.cdc.gov/niosh/TWH/default.html>> (accessed 30–6–2016).
- Payne, A.F., Sorbacka, K., Frow, P., 2008. Managing the co-creation of value. *J. Acad. Mark. Sci.* 36, 83–96.
- Powell, W.W., DiMaggio, P.J., 1991. *The New Institutionalism in Organisational Analysis*. University of Chicago Press.
- Prahalad, C.K., Ramaswamy, V., 2004. Co-creation experiences: the next practice in value generation. *J. Interactive Market.* 18 (3), 1–14.
- Roberts, K.H., 1990. Some characteristics of high-reliability organizations. *Organ. Sci.* 1, 160–177.
- Rogers, E.M., 1993. *Diffusion of Innovations*. Free Press, New York.
- Runyan, C.W., Lewko, J., Rauscher, K.R., 2013. Setting an agenda for advancing youth worker safety in the U.S. and Canada. In: Runyan, C., Lewko, J., Rauscher, K., Castillo, D., Brandspigel, S. (Eds). *Health and Safety of Young Workers – Proceedings of a U.S. and Canadian series of symposia*. DHHS (NIOSH) Publication No. 2013-144. 190–199.
- Ryan, R.M., Deci, E.L., 2000. The self-determination theory and the facilitation of intrinsic motivation, social development and well-being. *Am. Psychol.* 55 (1), 68–78.
- Salminen, S., Lee, J., 2015. A concept of a culture of prevention: a review of literature. *Occup. Med. Health Aff.* 2, 154.
- Sharman, A., 2014. *From Accidents to Zero*. Maverick Eagle Press, Great Britain.
- Senge, P., 1990. *The Fifth Discipline. The Art and Practice of the Learning Organisation*, Doubleday.
- Singh, S., 2012. *New Mega Trends – Implications for Our Future Lives*. Palgrave Macmillan, Hampshire (UK), New York (US).
- Singh, S., 2014. The Ten Mega Social and Tech Trends that Could Shape the Next Decade, *Forbes*, 12 May 2014.
- Swedish Government, 2015. *A Work Environment Strategy for Modern Working Life 2016–2020*, Government Communication 2015, 16/80, Stockholm.
- Twaalfhoven, S.F.M., Kortleven, W.J., 2016. The corporate quest for zero accidents: a case study into the response to safety transgressions in the industrial sector. *Saf. Sci.* 86, 57–68.
- Walton, R.E., 1985. From control to commitment in the workplace. *Harvard Bus. Rev.* 63 (2), 77–84.
- Weick, K.E., Sutcliffe, K., 2007. *Managing the Unexpected*. Jossey-Bass, San Francisco.
- WSH, 2012. *Towards Vision Zero – A Guide for Business Leaders*. WSH Institute, Singapore.
- Young, S., 2014. From zero to hero, a case study of industrial injury reduction: New Zealand Aluminium Smelters Limited. *Saf. Sci.* 64, 99–108.
- Zwetsloot, G.I.J.M., Kines, P., Ruotsala, R., Drupsteen, L., Bezemer, R., 2015. Success factors for the implementation of a Zero Accident Vision (ZAV), Report to the DGUV, Netherlands Organisation of Applied Scientific Research TNO, Report R11506, 27 November 2015, Leiden, The Netherlands.
- Zwetsloot, G.I.J.M., Aaltonen, M., Wybo, J.L., Saari, J., Kines, P., Op De Beeck, R., 2013a. The case for research into the zero accident vision. *Saf. Sci.* 58, 41–48.
- Zwetsloot, G.I.J.M., van Scheppingen, A.R., Bos, E.H., Dijkman, A., Starren, A., 2013b. The core values that support health, safety and well-being at work. *Saf. Health Work* 4, 187–196.
- Zwetsloot, G.I.J.M., Ashford, N.A., 2003. The feasibility of encouraging inherently safer production in industrial firms. *Saf. Sci.*, 41, 2, 219–240.