Safety management at road work zones

Best-practice recommendations.

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Safety management at road work zones – Current practices and best-practice recommendations

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Abstract

Accidents nearby work zones are a persistent road safety problem in many European countries. The Conference of European Directors of Roads (CEDR) has initiated and finances the IRIS project (Incursion Reduction to Increase Safety in road work zones) with the aim to collect and share information about best practices in temporary traffic management at road works. An analysis of work zone accidents and a review of best practices were made. Psychological issues to improve safety at work zones were studied by a literature review. Interviews with stakeholders were carried out in eight European countries to gather information on guidelines, standards and procedures in temporary traffic management. Best practice findings cover organizational/management issues, work zone safety reviews, establishment/de-establishment of a road work zone, informing/warning and guiding road users through work zone areas, speed management, protecting devices for road workers' and road users' safety and incursion warning systems.

Keywords: Road work zone; Safety; Best practice; Review

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1. Introduction

Accidents at work zones are a persistent road safety problem in many European countries. In most cases road work zones are located close to the traffic, with limited space available creating risks for both road workers and road users. Hence, it is important for road authorities, work environment authorities and construction companies to minimize these risks. Still, work zones are hazardous for both road users and road workers as can be seen regarding the numbers of incidents collected in various countries (see e.g. Trafikverket, 2016, Slootmans & Daniels, 2017; Statens Vegvesen, 2011).

The Conference of European Directors of Roads (CEDR) initiated and finances a multinational project IRIS – (Incursion Reduction to Increase Safety in road work zones) with the aim to collect and share information about best-practices in temporary traffic management of road works. A great amount of work and research had been done on the topic already – e.g. within the CEDR-projects BRoWSER - Baselining Road Works Safety on European Roads (2015), including the EuRoWCas database, and ASAP - Appropriate Speed Saves all People (2015).

The aim of this paper is to present findings from the IRIS project, such as principles that should be considered during planning, establishment and maintenance of work zones, as well as procedures and guidance for road safety reviews, including work zone road safety audits and inspections.

Best practices can be of regulatory/management or technical kind. Incorporating them into the regular activities of road authorities and contractors can contribute to making work zones safe for both road workers and road users.

2. Method

2.1. Accident data analysis

Work zone related accident data from various sources was collected. A first source was the IGLAD-database. IGLAD (Initiative for the Global harmonization of Accident Data, www.iglad.net) had developed a database containing accident data according to a standardised data scheme that enables comparison between datasets from different countries. Secondly, data was collected via the CEDR-network (Trafikverket, 2016, Slootmans & Daniels, 2017; Statens Vegvesen, 2011). The collected data was used to provide a descriptive overview of factors that are related to work zone accidents.

2.2. Review of psychological issues

Psychological trends and attitudes to improve safety at work zones were studied by a literature review related to psychology of perception and attention (e.g. unintentional blindness, useful field of view, etc.), environmental psychology (e.g. automatic behavioural change) and traffic psychology (e.g. human factors with impact on traffic behaviour).

2.3. Literature review on temporary traffic management

An inventory of best practices to prevent incursions into work zones as well as a review of best practices in work zone road safety audit and inspection requirements was made. The literature search in the transport database TRANSGUIDE gave 68 references of relevance published in 2007 to 2017. Besides the systematic literature search, other available sources through knowledgeable experts in the field were used.

2.4. Interviews with practitioners

To gather information on guidelines, standards, strategies and procedures, interviews with stakeholders have been done in eight European countries: Austria, Belgium, Germany, Ireland, the Netherlands, Slovenia, Sweden and the UK. These interviews resulted in a detailed overview of current practices in the selected countries.

3. Findings

3.1. Accidents

The IGLAD accident database currently contains 3100 cases in total. For the analysis of crashes near work zones only the cases from EU countries were considered, resulting in a subset of 2150 cases from Austria, Czech Republic, France, Germany, Italy, Spain and Sweden. The selection based on specific search terms resulted in 13 relevant crashes where a total of 33 vehicle occupants or pedestrians were involved. Six accident scenarios could be distinguished but only two of them occurred more than two times: 'rear-end crashes in congestion at work zones' (3 times) and 'wrong manoeuvres in changed traffic situation' (3 times).

Other sources were national studies from Belgium (Slootmans & Daniels, 2017), Norway (Statens vegvesen, 2011) and Sweden (Trafikverket, 2016). Slootmans & Daniels (2017) report that 13% of all fatal accidents (20 out of 158) on motorways in Belgium took place in or nearby a work zone. The most frequent accident types at work zones are single-vehicle accidents and rear-end collisions. Rear-end collisions at work zones often happen in emerging traffic jams upstream the work zone. Traffic jams at work zones usually are the consequence the work zone traffic management measures such as a reduction of the number of lanes, narrowing lanes or compulsory lane changes. Furthermore, some of the reported accidents in the mentioned sources are collisions with safety devices (e.g. shock absorbers, guardrails) that are put in place to protect the work zone area. A large majority of all work zones accidents occur in daylight and good weather conditions.

From the perspective of the road workers, work zone incursions (i.e. vehicles entering the work zone) are of importance. Work zone incursions are separately monitored in some countries, e.g. by Highways England (http://www.highwayssafetyhub.com/traffic-management-incursions.html). Incursions can be either intentional or unintentional. In absolute numbers, most incursions are intentional (e.g. a road user seeks refuge due to vehicle breakdown, a road users seeks information, a roads uses seeks some benefit such as a shorter distance to a service or destination). However, the most severe accidents happen in case of unintentional incursions such as road users following a works vehicle into the works in error, road users entering the works area as a result of confusion or road users entering the works area as a result of a collision or to avoid a collision).

3.2. Psychological issues

The output from the review of psychological factors is a list of major principles that influence road user behaviour in and around work zones. Important principles are those related to attention, inattention, cognitive workload and the effects of emotions. Ullman et al. (2017) analysed work zone related accidents and the relationship between several predisposing factors, like environmental, human and vehicle variables that influence the crash occurrence. As far as the human variables could be analysed from the description of the accidents, the following human factors are involved:

- Physical condition of the driver (health problems, fatigue, driving under influence of alcohol/drugs)
- Distraction of the driver (due to physical condition, use of devices, passengers, distraction by events outside the car)
- Confusion/uncertainty about the situation (which lane/direction to take, restricted overview of the situation, distance challenges)

Also the perspective of road workers should be taken into account. A basic principle that already was described in early psychological works as 'habituation' (Rankin et al., 2009) comes into play. The first time a worker is exposed to traffic nearby its work zone, he will be aware of the risk. Exposed daily to this risk, the worker will get familiarized and after some time, he will probably not notice the risk anymore, except in exceptional circumstances (Sharot et al., 2011). Some other cognitive processes, like illusions and emotions, could limit people's understanding of the different risks. In this context, self-overestimation can lead to neglecting problems or risks and encourage dangerous or risky behaviours (Baumeister et al., 2003). Surprisingly, people share a realistic view on the (in)security of others whereas they develop a too optimistic view on their own risk-related activities.

Workload is also an essential element to consider. Workers experiencing a certain pressure to work faster or to reach a deadline are more likely to neglect safety procedures. This phenomenon of risk willingness in the work environment can be explained by two factors:

- Most people want to be a good and performant worker. Working faster can be perceived (even just by the worker) as an indicator of good performance. People therefore might neglect safety procedures as such

negligence often allows to work faster and most of the time does not lead to negative consequences: accidents are rare events, even when preventive measures are not applied.

- 'Loss aversion': if people can avoid losing something (time, success, money, friendship, …), they are prepared to take more risks (Kahneman, 2012). Deadlines for contractors are often very sharp and governments are sometimes willing to pay more for a work to end earlier. This can lead to a company culture in which fast work becomes part of the social norm at the detriment of an orientation towards safety.

3.3. Regulatory/management issues

3.3.1. Standardisation of design and work sequence

Work zone design is usually done based on national guidelines and regulations. These documents typically include example layouts for distinct types of work zones, covering markings, signing and infrastructural elements to be used. A detailed description of practices in road work signing and equipment and an analysis of several national performance standards and guidance documents has been conducted within the BRoWSER-Project (2015).
In Germany (Hessen) standard plans for work sequences have been developed, e.g. describing in detail the procedure to establish a work zone. These plans are considered as a help for construction companies and workers on site and shall help ensuring a desired quality level during works.

3.3.2. Safety related issues in the tender

Procedures differ between countries, but generally, contractors are obliged to follow national laws, rules and regulations, which usually include safety aspects. To emphasise the importance of safety, safety issues should be a part of contracting, thus making safety an assessment criterion.

3.3.3. Work Zone Safety Examinations

For ensuring a successful work zone safety process the practitioners involved should "see the big picture", i.e. how the various components of Work Zone Safety Examinations interrelate (see Figure 1). To achieve this, the agency must have (ATSSA, 2013):

- Overarching policies that clearly spell out responsibilities and competencies for individuals involved in the work zone inspection program from agency to project levels;
- A monitoring program that regularly evaluates the effectiveness of agency policies and project-level actions;
- A standardized procedure for program and project deficiency identification and follow-up;
- A process that folds feedback on performance back into the program as a whole.

The agency should develop guiding principles, procedures, and resources that form the basis upon which the program operates. Once established, these guiding principles should be updated through process reviews and self-assessments performed at a regular basis. Detailed documentation of all relevant aspects of the process, program or project being inspected is important. Documentation across all levels of inspection and review activities should be maintained.

An effective Work Zone safety process involves two basic levels of reviews:

- Agency level review activities, which deal mainly with process related elements over longer periods of time and involve review and response to policies and processes.
- Project level activities, which involve a more 'real-time' look at conditions specifically within the project.

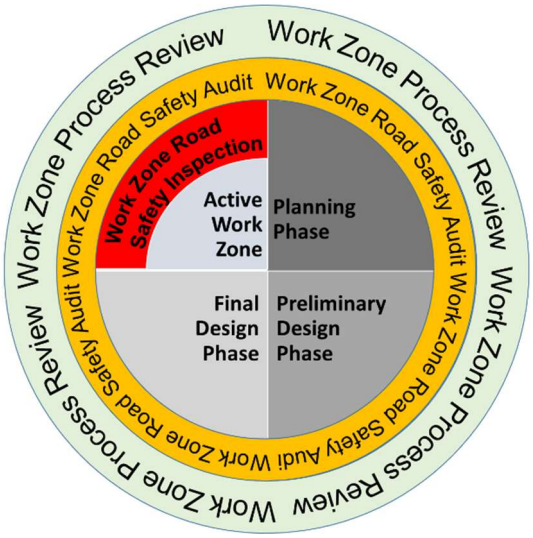

Figure 1. Types of Work Zone Safety Examinations. Based on ATSSA (2013).

Agency level review activities include:

- Work Zone Process Review guiding an agency through an assessment of the functionality and effectiveness of practices and procedures used to audit or inspect work zones. Process reviews can assess whether operational processes are consistent with established standards and expectations, performing effectively and efficiently, and if the practices are adequately captured and applied within the program, or across other programs at an agency.
- Work Zone Self-Assessment can help road agencies to manage their work zone program. WZSA looks at the following areas: leadership and policy, project planning, project design, project construction and operation, communications, education, program evaluation.
- Work Zone Crash Data Trend Analysis involves analysis of aggregated work zone crashes with an emphasis on crash contributory factors and discussion of countermeasures.
- Regional Work Zone Reviews are a higher-level, multi-project assessment of inspection practices across the agency regions. This review may take the form of quarterly meetings of project inspectors with notes being compared as to satisfaction with or issues related to inspection processes and their outcomes.

Project level activities include:

- Crash and Mobility Data Analysis evaluating crash events and mobility issues in or near work zones.
- Work Zone Road Safety Audits (WZRSA), which are formal safety performance evaluations performed at any stage of a planned work zone by an independent, multidisciplinary team, and considers methods of improving safety in a work zone. The difference between an RSA and a WZRSA is in the tailored RSA approach incorporated into the unique challenges of work zones. A WZRSA assesses a project's temporary elements that will eventually be removed once the active work zone phase is completed. Hence, a WZRSA team should focus on work zone safety, design, and operations; it should not focus on permanent geometric design elements. WZRSAs can be done during all project phases – from planning through an active work zone. Due to the temporary nature of work zones, the WZRSA team must record its findings and submit recommendations to the road owner in a timely fashion (ATSSA, 2013). The individual phases of WZRSA, with their own particularities are shown in Figure 2.
- Work Zone Road Safety Inspections (WZRSI) which are formal reviews of temporary traffic control devices and safety/mobility strategies deployed according to an approved plan, standards and specifications in active work zones. Work zone inspections are done during the active work zone phase. Compliance and deficiencies are documented formally, using a work zone inspection sheet. Work zone inspection sheets can vary in complexity and categories, but typically identify criteria deemed most critical to the work zone (e.g. signing quality/location, whether the work zone set-up matches design plans, presence of flaggers, safety/mobility concerns, etc.) (ATSSA, 2013). Each country should define its own national regulatory and administrative framework, as well as procedures for WZRSI. Legal competences of road operators and of the ordering entity should be clearly specified.

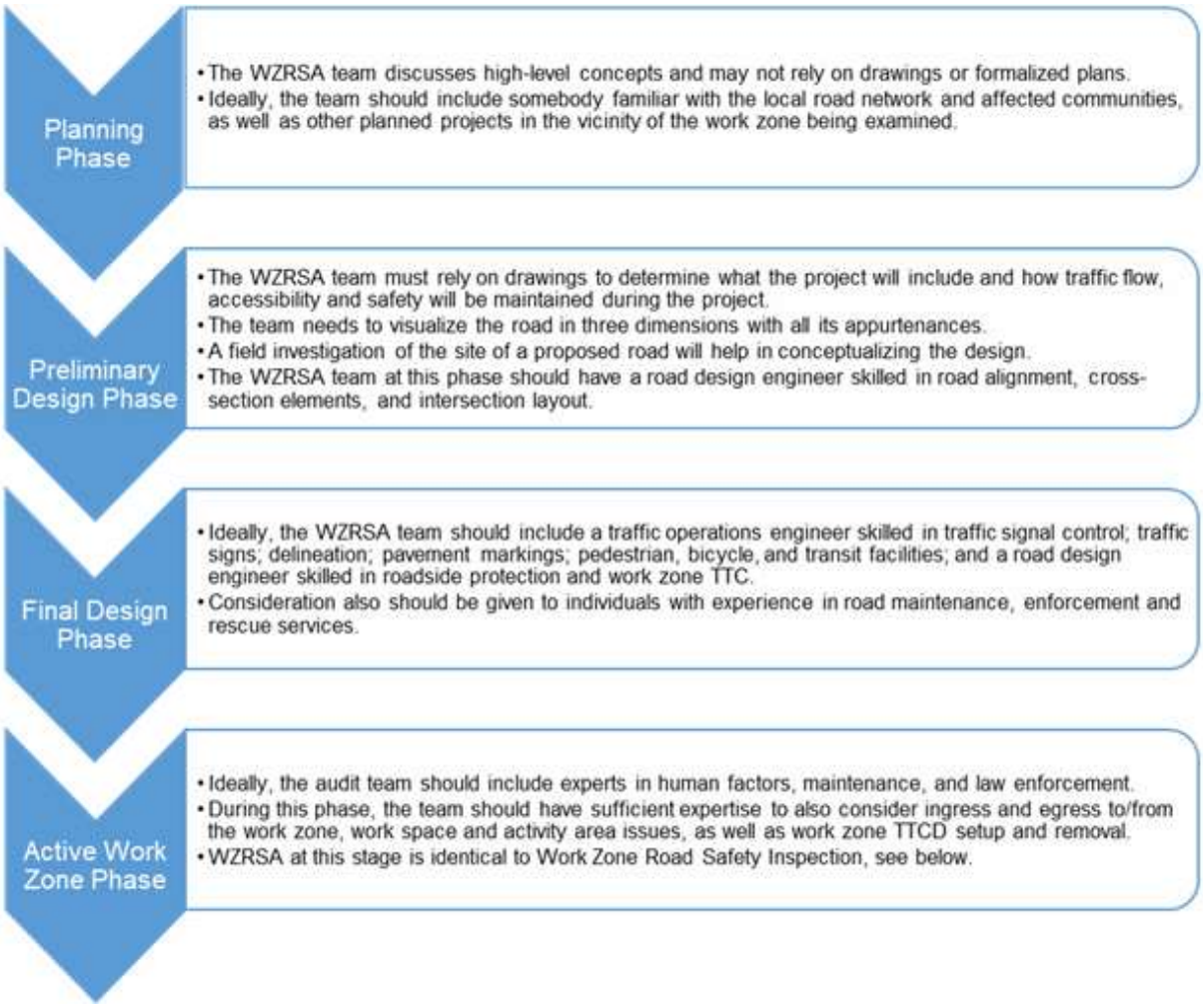

Figure 2. The individual phases of WZRSA.

3.3.4. Raising safety awareness

A prominent issue is to ensure that all parties involved in designing and operating work zones see safety as a top priority. This includes designers, employees of road authorities and road operators, construction companies, contractors and subcontractors, and the workers on the site. Measures to raise awareness among these people are:

- training courses, qualification, accreditation/certification of contractors/subcontractors,
- guidelines for road workers with e-learning and approval,
- internal educational measures for employees of road authorities to raise awareness of safety aspects at work zones.

Risk-sensitivity and risk-understanding are two parameters to influence the safety attitude and behaviour of the road worker. Instructions to the road worker and on-site prevention and mitigation measures need to be repeated and need to be an evidence-based response to the risk and its possible consequences. This response should be strictly followed by the road worker with limited habituation, emotions or illusions to interfere. This will allow the risk not to be under- or over-perceived by the road worker. These topics ideally should be covered in safety awareness trainings of road workers.

To improve the road user's understanding of safety related issues education at driving schools and work zones campaigns are at stake. To tackle the problem that road users seem to have difficulties in understanding signage and fail to behave accordingly, pictures of road work zone issues should be used for education in driving schools, thus raising awareness for the significance of traffic regulations in road work zones.

3.4. Technical issues

A basic principle to prevent vehicles from intruding into work zones is to physically separate the road user from the work zone. In long term work zones physical barriers (mostly steel or concrete), that comply with the obligations according to EN 1317, should be used whenever possible. For short term work zones this is often not feasible. Generally, devices used in work zones should be as "collision friendly" as possible. This applies especially for temporarily applied signs, lampposts, etc. Putting obstacles in place that are not "collision friendly" (like blocks of concrete) to prevent incursions should be avoided due to the possible injuries of drivers colliding with these obstacles.

The establishment of work zones is a phase that poses many risks – devices must be put in place, the situation for the drivers changes, workers are even more exposed to oncoming traffic than under regular work zone conditions. Reducing the exposure of the workers improves their safety situation. This can be done by stopping or slowing down traffic during the establishment of a work zone, use of protection measures, use of automated vehicles for works in work zones or automation of deployment and dismantling of devices needed in work zones.

To inform, warn and guide road users, various technical devices are available. Modern technology can provide information like estimated travel times, appropriate or recommended speed, display of variable speed limits, alternative routes or end-of-queue warnings.

Enforcement of speed limits generally has a positive effect on traffic safety. In work zones speed cameras and average speed control can contribute to lower speeds and a harmonisation of traffic flow.

4. Discussion and recommendations

The findings presented correspond to the current situation. They do not cover probable future problems of autonomous vehicles. These vehicles might pose a problem at work zones in the future, as autonomous vehicles, at current state, have difficulties in detecting road works where signage and road marking have not been sufficiently changed to reflect the layout during the work zone. On the other hand, remotely controlled vehicles and automation can be used to reduce exposure of road workers are included in possible measures to improve work zone safety.

The topics of best practices cover organizational/management issues, establishment/de-establishment of a road work zone, informing/warning road users, ITS solutions, guiding road users through work zone areas, speed information/feed-back/enforcement, protecting devices for road workers' and road users' safety and incursion warning systems as well as best practices in work zone road safety audit inspection requirements

Based on the findings from the various activities in IRIS, the following recommendations can be made:

- In the tender call, the contractor should be requested to propose procedures for regular checks (e.g. driving through the work zone every two hours to verify the integrity of the infrastructure and signalisation).
- Shift from "cheapest offer" to "best offer", wherein safety, as a broad topic, is an integral part of the offer.
- In the contract, procedures for regular checks should be documented. The contract also should specify the duties of the contractor, most importantly:
  - responsibility for the work to be carried out according to the Traffic Management Plan,
  - to produce a Health and Safety Plan with defined measures,
  - to appoint a work zone coordinator / a foreman on the site,
  - to look to that road workers make daily controls in the course of their work,
  - after the work is completed, to check if everything is restored "back to normal".
- Reduce time stress – when setting deadlines attention should be put on the fact that time stress may drive workers to start activities on the road before every necessary prevention or mitigation measure is fully deployed since they do not want to lose time by waiting until everything is located correctly.
- Improve skills and knowledge of workers – special skills for working on roads are necessary, regarding application of barriers, safety awareness, appropriate equipment and also health and safety training.
- Inspections should be made not only at the beginning of the work, but also later, since experience shows that safety arrangements may deteriorate over time.

- If deviations from the road work design are detected, notifications, instructions and/or warnings can be issued and targets to eliminate deviations can be set. It is very important to maintain the integrity and independence of the Inspectors – if not they might become reluctant to issue fines, to avoid making "enemies" among their possible future employers. It seems that a good relationship with the contractor and "good spirit" allows that any deviations are solved promptly.
- Besides on-site controls according to formal work zone RSIs, the contractor's documentation of its performance concerning the prescribed daily checks of the work zone should be controlled.
- Collect data on incidents and accidents in work zones – research on the topic is still needed. The EuRoWCas database was developed specifically for this aim.
- Consider basic psychological rules – keep the driver in mind when arranging and designing a work zone, keep the cognitive workload low, avoid surprises; consider the 4C's concept of PIARC – keep the work zone conspicuous, clear, consistent and credible.
- Reduce speeding – enforcement, average speed control, appropriate speed levels at different times to enhance the acceptance, providing information on current driving speed.
- Keep the signing clear – enough and early enough information, but only the information necessary; guide the drivers through the work zone.
- Use symbols, images, pictograms – to make it clear and understandable for everyone throughout Europe (and harmonise these signs all over Europe…).
- Keep adaptation needs of the eye in mind – illumination of critical zones and use of LEDs can improve safety, but there are limits for the eye… regulations regarding light intensity must be considered.
- Use vehicle restraint systems – whenever possible, keeping in mind EN 1317.
- Use collision friendly devices – whenever new devices are used they should not be obstacles themselves.
- Each country should define its own national regulatory and administrative framework, as well as procedures for Work Zone Road Safety Audits and Work Zone Road Safety Inspections.
- Instigate Work Zone Process Reviews - periodic evaluation of work zone policies, processes, and impacts that systematically monitors the process of managing the safety and mobility impacts of work zones. Such reviews can contribute to achieving long-term improvements in road safety work.
- Include behaviour and signalisation related to work zones in driving education.

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5. References

ASAP (2015) Towards a European Guideline for Speed Management Measures in Work Zones. Deliverable 5.1 of the CEDR 2012project "Speed Management in Work Zones".

ATSSA (2013) Work Zone Road Safety Audit Guidelines and Prompt Lists. American Traffic Safety Services Association, USA. https://www.workzonesafety.org/training-resources/fhwa_wz_grant/atssa_wz_rsa_guide/

Baumeister, R.F., Campbell, J.D., Krueger, J.I. & Vohs, K.D. (2003). Does high Self-esteem cause better performance, interpersonal success, happiness or healthier lifestyles? Psychological Science in Public Interest, Vol.4, n°1

BRoWSER (2015) http://www.cedr.fr/home/fileadmin/user_upload/en/Thematic_Domains/Strat_plan_3_2013-2017/TD1_Innovation/I1_Research/TGR_TPM/Transnational_calls/CEDR_Call_2012/CEDR%20Call%202012%20Safety/BROWSER/cedr%20call2012_safety_browser.pdf

Highways England (2016) The Delivery Hub health, safety and environment. Raising the bar 27. Managing temporary traffic management incursions. https://www.gov.uk/government/publications/health-and-safety-for-major-road-schemes-managing-temporary-traffic-management-incursions Downloaded 11/11/2017

IRIS (2019) Best Practice in Temporary Traffic Management at Work Zones – Final report. D3.2 of the IRIS - Incursion Reduction to Increase Safety in road work zones – project.

Kahneman, D. (2012) Thinking, fast and slow. Penguin Books Ltd,

Rankin, H.A., Abrams, T., Barry, R.J., Bhatnagar, S., Ckayton, D.F., Colombo, J. & Thompson, R.F. (2009) Habituation revisited: An updated and revised description of the behavioral characteristics of habituation. Neurobiology of Learning and Memory 92(2), p.135-138

Sharot, T., Korn, C.W. & Dolan, R.J., (2011) How unrealistic optimism is maintained in the face of reality. Natural Neuroscience, 11-09

Slootmans, F. & Daniels, S. (2017) De dodelijke tol op autosnelwegen. Analyse van de dodelijke verkeersongevallen op de Belgische autosnelwegen in de periode 2014-2015. (The deathly toll of motorways. Analysis of fatal accidents on Belgian motorways 2014-2015, in Dutch/French). Brussels, Belgium. Vias institute.

Statens vegvesen (2011) Temaanalyse av trafikkulykker i tilknytning til vegarbeid. Basert på data fra dybdeanalyser av dødsulykker i vegtrafikken 2005-2009. (Thematic analysis of traffic accidents associated with roadworks based on data from in-depth analyses of road accidents in road traffic 2005-2009, in Norwegian). The Norwegian Public Roads Administration.

Trafikverket (2016) Trafikolyckor vid vägarbeten 2003-2015. (Traffic accidents at road works, in Swedish). Publication: 2016:122. Swedish Transport Administration.

Ullman, G.L., Pratt, M., Geedipally, S., Dadashova, B., Porter, R.J., Medina, J. & Fontaine, M.D. (2017). Analysis of Work Zone Crash Characteristics and Countermeasures. National Cooperative Highway Research Program, Transportation Research Board, Washington DC – Web-Only Document 240.