



LUND UNIVERSITY

Tools for Road Safety Audits and Road Safety Inspections at Work Zones

Varhelyi, Andras; Strnad, Bernd; Temmerman, Philip

2019

[Link to publication](#)

Citation for published version (APA):

Varhelyi, A., Strnad, B., & Temmerman, P. (2019). *Tools for Road Safety Audits and Road Safety Inspections at Work Zones*. (Deliverable of the Project IRIS - Incursion Reduction to Increase Safety in road work zones project within the CEDR Transnational Road Research Programme <https://www.cedr-iris.eu/>).

Total number of authors:

3

General rights

Unless other specific re-use rights are stated the following general rights apply:

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

Read more about Creative commons licenses: <https://creativecommons.org/licenses/>

Take down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

LUND UNIVERSITY

PO Box 117
221 00 Lund
+46 46-222 00 00

CEDR Transnational Road Research Programme

Call Safety

Funded by Belgium-Flanders, Ireland,
Netherlands, Slovenia, Sweden, United Kingdom



Conférence Européenne
des Directeurs des Routes
Conference of European
Directors of Roads



Incursion Reduction to Increase Safety in road work zones

Tools for Road Safety Audits and Road Safety Inspections at Work Zones

Deliverable N° D2.2

Date 24/04/2019

Final version

Partners

KFV Kuratorium für Verkehrssicherheit, Austria

Lund University, Sweden

Vias institute, Belgium



LUND
UNIVERSITY



CEDR Call 2016: Safety

Incursion Reduction to Increase Safety in road work zones

Tools for Road Safety Audits and Road Safety Inspections at Work Zones

Start date of project: 01/09/2017

End date of project: 30/06/2019

Authors of this deliverable:

András Várhelyi (Lund University)

Bernd Strnad (Kuratorium für Verkehrssicherheit)

Philip Temmerman (Vias institute)

PEB Project Managers:

Veerle Schoutteet (Agency for Roads and Traffic, Flanders)

Niels Janssen (Agency for Roads and Traffic, Flanders)

Gavin Williams (Highways England)

Table of contents

1	Introduction	6
2	Current situation concerning RSA/RSI at work zones in some European countries	7
2.1	Formal RSA procedures for work zones:	7
2.2	Formal RSI procedures or on-site controls of road works	7
2.3	Consequences in case of deviations	9
2.4	Conclusions	10
3	Best practices in Work Zone Safety Examinations.....	11
3.1	Work Zone Process Review	12
3.1.1	Agency level reviews.....	13
3.1.2	Project level activities	13
3.2	Work Zone Road Safety Audit.....	14
3.3	Work Zone Road Safety Inspection.....	15
3.3.1	Good practice guidelines.....	15
3.3.2	Checklists.....	16
3.3.3	Electronic tools.....	17
4	Recommendations	21
5	References.....	22
Annex 1	Links to examples of Work Zone Safety Examinations and Inspection forms	23
Annex 2	Work Zone Checklist (PIARC).....	24

Abbreviations

RSA	Road Safety Audit
RSI	Road Safety Inspection
TMP	Traffic Management Plan
TTC	Temporary Traffic Control
TTCD	Temporary Traffic Control Device
TTCP	Temporary Traffic Control Plan
TTM	Temporary Traffic Management
WZRSA	Work Zone Road Safety Audit
WZRSI	Work Zone Road Safety Inspection
WZSA	Work Zone Self-Assessment

Glossary of Terms

Road Safety Audit (RSA): A formal safety performance examination of a road or traffic project by an independent audit team. It qualitatively estimates and reports on potential road safety issues and identifies opportunities for improvements in safety for all road users

Road Safety Inspection (RSI): A systematic, on site review, conducted by road safety expert(s), of an existing road or section of road to identify hazardous conditions, faults and deficiencies that may lead to serious accidents.

Traffic Management Plan (TMP): A formal plan defining project-specific strategies to minimize the safety and mobility impacts from the work zone on roadway users. For all projects, a TMP requires a temporary traffic control plan that addresses traffic safety and control through the work zone. For significant projects, the TMP must also contain both transportation operations and public information components.

Temporary Traffic Control (TTC): Regulating, warning, or guiding traffic through a road segment where road user conditions are changed because of a work zone or incident.

Temporary Traffic Control Device (TTCD): A sign, signal, marking, or other device used to regulate, warn, or guide traffic; placed on, over, or adjacent to a street, road, pedestrian facility, or shared-use path by authority of a public agency having jurisdiction.

Temporary Traffic Control Plan (TTCP): A plan or set of plans detailing the contracting/construction techniques, strategies, and use and location of all temporary traffic control devices that will facilitate traffic flow and safety through and around work zones.

Temporary Traffic Management (TTM): Placing, maintaining and removing of temporary traffic control devices for work zones to ensure safe, efficient and effective movement of all road users and the safety of all those working on or in the work zone.

Work Zone: A segment of roadway where activity of either a short- or long-term duration, which can include a stationary or moving operation is being performed, including maintenance to existing roadways, construction of new elements, or other non-roadway work (e.g., utility installations).

Work Zone Inspection Program: Work zone safety examination involving agency level reviews and project level inspections

Work Zone Process Review: Periodic evaluation of work zone policies, processes, procedures, and impacts of work zones that aids in the process of addressing and managing the safety and mobility impacts of work zones. The process review helps to assess the effectiveness of a program or a set of processes and procedures.

Work Zone Road Safety Audit (WZRSA): A formal safety performance evaluation that can be performed at any stage of a planned or existing work zone (project planning and design, or in active work zones) by an independent, multidisciplinary team. It qualitatively estimates and reports on potential work zone safety issues, identifies opportunities for improvements in work zone safety for all road users and workers, and culminates in the development and presentation of a final report citing work zone safety enhancement recommendations.

Work Zone Road Safety Inspection (WZRSI): A formal review of temporary traffic control devices and safety/mobility strategies deployed according to an approved plan, standards and specifications in an active work zone.

Work Zone Self-Assessment (WZSA): A tool consisting of a set of questions designed to assist those with work zone management responsibilities in assessing their policies, programs and procedures against many of the good work zone practices in use.

1 Introduction

Road Safety Audits (RSA) and Road Safety Inspections (RSI) are effective means of Road Infrastructure Safety Management (Elvik, 2006). They are preventive tools, consisting of systematic, safety assessments, carried out by trained, independent safety expert teams, resulting in a formal report on detected road hazards and safety issues, requiring a formal response by the relevant road authority. Yet, current regulations, procedures and protocols vary considerably between countries (Cardoso, et al. 2005). The prerequisites for a good RSA/RSI practice are a number of defined regulatory, administrative, financial and technical issues. The EU directive 2008/96/EC requires the establishment and implementation of procedures relating to, among others, RSAs, and RSIs by the Member States (EC, 2008). The directive applies, however, only to roads, which are part of the trans-European road network. A recent amendment of the Directive 2008/96/EC (EC, 2019) expands the requirement to all primary roads, however, there is no specific demand for RSA or RSI concerning road work zones. Since road work zones represent elevated hazards, running systematic and effective RSA/RSI procedures is vital to provide safe environments for both road users and road workers.

2 Current situation concerning RSA/RSI at work zones in some European countries

Interviews with practitioners/experts in eight European countries (Austria, Flanders in Belgium, the Netherlands, Germany, Ireland, Slovenia, Sweden, and United Kingdom) were carried out. The main corresponding questions concerning this issue were as follows:

- Are there formal Road Safety Audit / Road Safety Inspection procedures for work zones?
- Are checks undertaken to determine if the works are implemented in accordance with the work zone plans?
- Are road works controlled on-site?
- Are there any consequences (e.g. fines) if deviations are detected?

The compilation of answers is presented in the following sections.

2.1 Formal RSA procedures for work zones:

- A: RSA is not compulsory, but ASFINAG, the Austrian motorway operator, has an internal regulation that important long-term work zones are audited by external auditors.
- B: RSA is not compulsory, but checks are carried out by contractors internally.
- D: RSA is not compulsory, but in the course of approval by the authorities the design is discussed, and it may be changed.
- Irl: According to the new guideline documents, from March 2018 TII (2017a), RSA is required for complex TTM schemes by the Road Authority.
- NL: RSA is not compulsory, but usually part of the contracting. The authorities and the contractor agree on the RSA process.
- Slo: RSA is only done for long-term road works. Usually, a designer designs the road works, then RSA is done by external experts. After that, the construction company, winning the tender, is contracted. The contractor often changes the details of the work zone plans due to constructional/organisational, etc. reasons. Thus, a new situation emerges, but the external RSA already has been done. The project, then is audited again internally by people from the Slovenian motorway operator (DARS) before the design is approved by the authority.
- S: There are no formal RSA procedures for work zones.
- UK: There are no formal RSA procedures for work zones.

2.2 Formal RSI procedures or on-site controls of road works

- A: Formal RSI is only carried out at bigger work zones. The contractor should make daily controls. Also, road workers should make controls daily in the course of their daily work. The work zone coordinator is responsible for controlling the Health and Safety Plan. From the authorities, labour inspectors rarely are involved. AUVA (Austrian Workers' Compensation Board) has an advising function. In case of grossly negligent behaviour (i.e., if there is a work zone accident and the construction company neglected regulations in a gross way, claims can be made by AUVA, since AUVA is usually responsible for compensation and rehabilitation of injured workers).
- B: No formal RSIs are carried out, but contractors must make checks daily and at every modification. Inspectors perform random checks (e.g. if signals are kept clean).

- D: No formal RSIs are undertaken. Controls, such as after installation inspection and acceptance are made by the authority. Employed material is also inspected by the authority. The contractor checks the work zone two times per day, and the authority controls if that is done (i.e. checking the documentation). According to the legal requirements (Baustellenkoordinationsgesetz), there must be a Health and Safety Plan with defined measures as well as a work zone coordinator. Road workers and police do controls in the course of their daily work.
- Irl: The Road Authority and the contractor will undertake inspections, as outlined in the regulatory document (TII, 2017). For large contracts, Transport Infrastructure Ireland (TII) visits the site and documents the frequency of inspections. If the work is more than 1 year (full time), each work is to be inspected 4 times per year. If the work is between 6 and 12 months (full time) each work is to be inspected 2 times per year. If the work is between 1 and 6 months, (full time) 50% of works is to be inspected once. If the work is between 12 hours and 1 month (full time) 10% of works to be inspected once. For intermittent works (only on site for up to 12 hours), the frequency of inspections is determined according to the overall contract length. If contract length is 6 months or more, then four random inspections are made. If contract length is 3 to 6 months, then two random inspections and if contract length is less than 3 months, then a single random inspection is made. Checks, to determine if the works are implemented in accordance with the work zone plans are done at installation stage by qualified supervisors (employed by the contractor), and daily (usually morning and evening) for each day of the contract. Health and safety recording at the contractor are made on a monthly basis.
- NL: Contractors verify their construction zone according to their own procedures. Road Auditors inspect in detail whether everything is according to specifications and report irregularities. Their visit is unexpected or on demand. They can visit everywhere but they also can be sent to special cases, complex situations, etc.
- Slo: There is no formal RSI procedure as such, but there are numerous inspections of various types. The safety coordinator of the Slovenian motorway operator (DARS) controls regularly (in total 9 people in Slovenia are qualified to inspect and enact measures). For short-term work zones: a checklist is in use to verify if the work zone is implemented in accordance with regulations. The state traffic inspector exercises control once per day (monitoring includes plan and site inspections). The safety coordinator of the contracting company does controls regularly. Internal coordinators of DARS are controlling three times a day (inspection regarding workers' safety, current placement of cones and traffic signs). The police checks regularly during patrolling. Labour inspectors also carry out controls.
- S: No formal RSIs, according to international standards, are practiced. Both the contractor and the Swedish Transport Administration have their own checks. It is called work place control. Inspections should be done regularly by the contractor, randomly by Transport Administration inspectors and sometimes by the authority for workers' health and safety. Site inspections are performed by personnel from the Swedish Transport Administration. The inspectors have checklists to assist them in their work. The checklists are based on the applying regulations and the contract. However, the Swedish Transport Administration has only five inspectors, so they only can make sample tests of a limited number of the total road works. The foreman on the site is responsible for the work to be carried out according to the Traffic Management plan. The city councils show great variation, from no inspections to regular inspections. The police only come to the site when there has been an incident or accident.

UK: The contractor proposes a layout of all elements as well as procedures to check regularly whether everything is in place. It can for example propose to drive through the work zone every two hours to verify the integrity of the infrastructure and signalisation. This procedure, as well as the inspection rounds, must be documented in the contract. The contractor checks the construction site with the agreed frequency. On top of that, Health & Safety inspectors, randomly check construction sites all over the country. They evaluate the situation and notify the contractor of the result. A 'RAG' ('Red', 'Amber', 'Green') profiling is used. Improvements based on goodwill and reputation.

2.3 Consequences in case of deviations

- A: In Vienna, fines are sometimes issued in the case when night time lane closures exceed a defined time (usually 5:00 a.m.). In case of grossly negligent behaviour regress can be claimed by AUVA (Austrian Workers' Compensation Board).
- B: At first, the contractor is notified about the deviations. Usually, the contractor corrects the situation. Ultimately, in severe cases, the road works can be shut down.
- D: If deviations are detected, notes and setting of targets to eliminate deviations are made, but there are no fines.
- Irl: If deviations are found, Transport Infrastructure Ireland issues a direction/instructions or if there are severe deficiencies, it might stop the work. There are no fines, but notifications. The contractors are experienced and any deviations are figured out and solved immediately. It is a liability issue if accidents occur.
- NL: If contractors do not comply, they are warned. If the situation does not improve, the contract can be cancelled.
- Slo: In case of small deviations the Road Inspector would remind the contractor to keep to the work zone plan. In case of large deviations, the Inspector can demand prompt actions to make corrections but he also can issue a fine or even close the work site.
- S: If deviations are detected, there are established fines, based on the number of deviations in the checklist, but they are very seldom executed (may be due to the interdependency between the person in charge at the Swedish Transport Administration and the responsible person at the contractor).
- UK: If deviations are detected, there are no formal penalties or consequences.

2.4 Conclusions

The interview answers revealed that there are no general compulsory RSA procedures for work zones in most of the 8 reviewed countries. Only in Ireland, RSA is required for complex TTM schemes by the Road Authority. In some of the countries, the contractor carries out internal checks or the authority may discuss the design with the contractor. Even if designs of long-term road works are audited by external experts, the construction company winning the tender often might change the details of the work zone plans (due to constructional/organisational, etc. reasons) and this creates the need of a new RSA process. Regarding on-site inspections, there is a pressing organisational issue, i.e. the far too low number of inspectors at road authorities not allowing to inspect a satisfactory number of sites.

The following issues were identified as duties of the contractor:

- 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) - these procedures are documented in the contract.
- to perform checks of the work zone with the agreed frequency,
- to appoint a work zone coordinator / a foreman on the site, responsible for the work to be carried out according to the Traffic Management Plan,
- to produce a Health and Safety Plan with defined measures,
- to control that the Health and Safety Plan is followed,
- to look to that road workers make daily controls in the course of their work,
- after the work is completed, perform checks if everything is restored "back to normal".

Regarding on-site controls of road works, no formal RSIs are carried out in the majority of the reviewed countries, but various types of inspections are done:

- after installation of the work zone, it is to be inspected and approved by the authority,
- checks to verify if the work zone is implemented in accordance with regulations, specifications and work zone plans,
- inspection of the employed material,
- control of documentation of the contractor about its performance of the prescribed daily checks of the work zone,
- inspection on workers' health and safety,
- the police can do checks during patrolling.

When it comes to fines if deviations are found the following was revealed:

- fines are issued rarely - only in Sweden there are established fines, based on the number of deviations, but they are very seldom executed,
- some form of notifications, instructions, issuing warnings, or target setting to eliminate deviations are practiced in some countries,
- if there are severe deficiencies or grossly negligent behaviour, the work can be stopped or the contract can even be cancelled,
- a good relationship with the contractor and the fact that the contractors are experienced allows that any deviations are solved immediately.

3 Best practices in Work Zone Safety Examinations

To improve the safety of workers and road users, work zone safety examinations may be performed at various project phases and can be done at any time. Examinations of work zone safety are of various types, see Figure 1 (ATSSA, 2013a):

- Work Zone Process (or Policy) Review – a periodic evaluation of work zone policies, processes, procedures, and work zone impacts that aids in the process of addressing and managing the safety and mobility impacts of work zones. The process review helps to assess the effectiveness of a program or a set of processes and procedures.
- Work Zone Road Safety Audit (WZRSA) is a formal safety performance evaluation performed at any stage of a planned work zone by an independent, multidisciplinary team, and considers methods of improving safety in a work zone.
- Work Zone Road Safety Inspection (WZRSI) is a formal review of temporary traffic control devices (TTCD) and safety/mobility strategies deployed per an approved plan, standards and specifications in an active work zone.

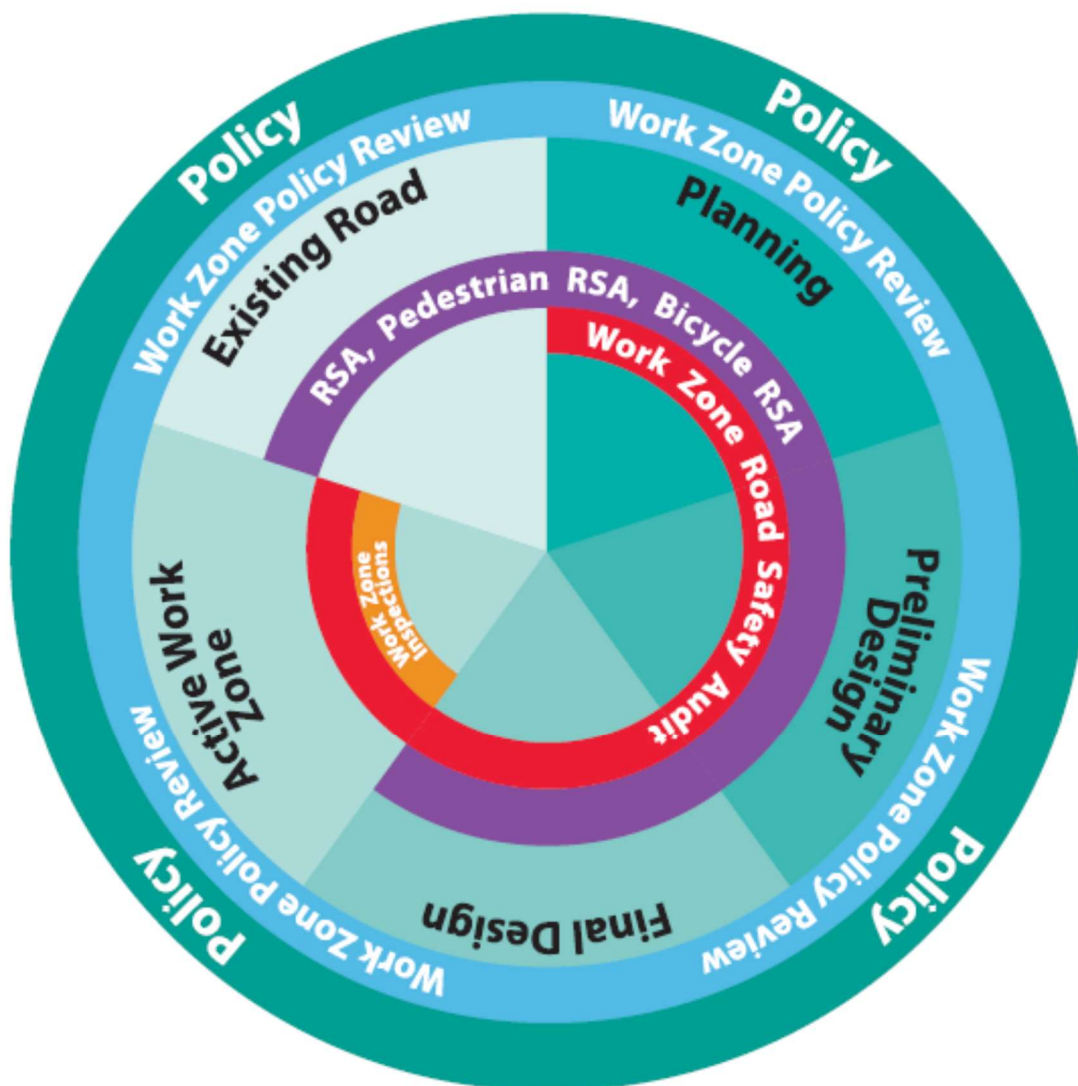


Figure 1. Types of Work Zone Safety Examinations (ATSSA, 2013a).

3.1 Work Zone Process Review

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. To achieve this, the agency must have (ATSSA, 2013b):

- 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.

An effective Work Zone Inspection Program involves two basic levels of inspections and reviews: agency level and project level (see Figure 2). Agency level inspection activities deal mainly with process related elements over longer periods of time and involve review and response to policies and processes. Project level activities involve a more ‘real-time’ look at conditions specifically within the project. The outcomes of both levels of inspections should be evaluated and feedback should be provided into the respective processes. (ATSSA, 2013b).



Figure 2. Agency - and project level inspection/review activities (ATSSA, 2013b).

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. To be effective, a program must have instruments in place that provide a guiding framework for operation of the program. These instruments include the following (ATSSA, 2013b):

- **Supportive agency policies, procedures, and specifications** at the agency level, that hold the agency to high safety standards.
- **Program charter** – a guiding document that identifies agency level work zone inspection program goals, structure within the organisation, specific roles of various players within the organisation, and resources available to accomplish the goals.
- **Program database** for storing both agency and project level inspection results.
- **Feedback mechanism** – a process by which inspectors and others with roles in the program are able to identify weaknesses and/or strengths and provide feedback to improve the overall agency program and inspection processes.
- **A comprehensive training program** for inspectors and engineers.

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.

3.1.1 Agency level reviews

Agency level reviews provide a continuum of information on performance of work zone inspection related policy. Agency level review activities include (ATSSA, 2013b):

- **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, within a work zone inspection program, 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. The outcome should be a continuous improvement in the safety and mobility aspects of each work zone. States in the USA are required to perform a process review at least every two years.
- **Work Zone Self-Assessment** - The WZSA tool can help road agencies to manage their work zone program. Agency and project level inspection policies and procedures are part of this self-assessment and these can be strengthened as the assessment looks at the following areas:
 - a) Leadership and policy;
 - b) Project planning and programming;
 - c) Project design;
 - d) Project construction and operation;
 - e) Communications and education;
 - f) 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. The outcome of such reviews should be a scheduled report, which informs policy and process adjustments at both the agency and project levels on a regular basis.

3.1.2 Project level activities

Project level inspections focus on areas pertaining to the operation of one project and deal with the aspects of work zone safety, device deficiencies, etc. An important aspect of project level inspections is an effective deficiency correction process. Project level work zone inspection activities include (ATSSA, 2013b):

- **Work Zone Road Safety Audits**
- **Crash and Mobility Data Analysis** that evaluates current or real-time crash events and mobility issues in an active work zone.
- **Work Zone Road Safety Inspections.**

3.2 Work Zone Road Safety Audit

Work Zone Road Safety Audit (WZRSA) is a formal safety performance evaluation 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. WZRSA's 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, 2013a).

The individual phases of WZRSA have their own particularities (ATSSA, 2013a):

- Planning Phase - the WZRSA team discusses high-level concepts and may not rely on drawings or formalized plans. Ideally, the team should include somebody familiar with the local road network and affected communities, as well as other planned projects in the vicinity of the work zone being examined.
- Preliminary Design Phase - the WZRSA team must rely on drawings to determine what the project will include and how traffic flow, accessibility, and safety will be maintained during the project. The team needs to visualize the road in three dimensions with all its appurtenances. A field investigation of the site of a proposed road will help in conceptualizing the design. The WZRSA team at this phase should have a road design engineer skilled in horizontal and vertical road alignment, cross-section elements, and intersection layout.
- Final Design Phase – ideally, the WZRSA team should include a traffic operations engineer skilled in traffic signal control; traffic signs; delineation; pavement markings; pedestrian, bicycle, and transit facilities; and a road design engineer skilled in roadside protection and work zone TTC. Consideration also should be given to individuals with experience in road maintenance, enforcement and rescue services.
- Active Work Zone Phase – ideally, the audit team should include experts in human factors, maintenance, and law enforcement. During this phase, the team should have sufficient expertise to also consider ingress and egress to/from the work zone, work space and activity area issues, as well as work zone TTCD setup and removal. WZRSA at this stage is identical to Work Zone Road Safety Inspection, see below.

The Work Zone RSA Guidebook (ATSSA, 2013a) provides WZRSA prompt lists for Planning Phase, Preliminary Design Phase, Final Design Phase and Active Work Zone and a WZRSA Report Template, as well as case study examples. Printable and electronic prompt lists are downloadable from the National Work Zone Safety Information Clearinghouse website (www.workzonesafety.org). The Florida Department of Transportation (FDOT) has created an RSA tracking database, which can be accessed at <http://safety.fhwa.dot.gov/rsa/sampledb/>.

3.3 Work Zone Road Safety Inspection

Work Zone Road Safety Inspection (WZRSI) is a formal review of temporary traffic control devices (TTCD) and safety/mobility strategies deployed according to an approved plan, standards and specifications in active work zones. Compliance and deficiencies are documented formally, using a work zone inspection sheet. Work zone inspection sheets can vary in complexity and categories, but typically, they enumerate criteria deemed most critical to the work zone (e.g. signing quality/location, whether the work zone set-up matches design plans, possible presence of flaggers, safety/mobility concerns, etc.) (ATSSA, 2013a).

3.3.1 Good practice guidelines

Based on Elvik (2006) - the following guidelines for good WZRSI practice can be listed:

1. WZRSI should be applied at all long term road works.
2. The elements included in WZRSIs should stand as risk factors for accidents or injuries.
3. Inspections should be standardised and designed to ensure that all elements included are covered and are assessed in an objective manner.
4. Check lists for WZRSI should include the following core of important elements:
 - a. Traffic signs, their need, their quality and whether they are correctly placed or legible in the dark.
 - b. Road markings, their quality, in particular whether they are consistent with traffic signs or are visible.
 - c. The quality of the road surface, in particular with respect to friction (macro and micro-texture) and evenness.
 - d. The adequacy of sight distances and the absence of permanent or temporary obstacles that prevent timely observation of the road or other road users.
 - e. The presence of roadside traffic hazards.
 - f. Aspects of traffic operation, in particular if vehicle speeds are adequate to local conditions at road work zones.
5. For each element included in an inspection, a standardised assessment should be made by applying the following categories:
 - a. The item represents a traffic hazard that should be treated immediately. A specific treatment should be proposed.
 - b. The item is not in a perfectly good condition or deviates slightly from current standards, but no short-term action is needed. Further observations are recommended.
 - c. The item is in good condition and in accordance with current standards.
6. WZRSI should state the findings and propose safety measures in a standardised report.
7. Inspectors should be formally qualified for their job. They should meet on a regular basis, to exchange experiences and to ensure a uniform application of safety principles in the inspections.
8. There should be a follow-up of WZRSI, to check if the proposed countermeasures have been properly implemented.

WZRSI should be performed in various selected periods of time, so that the most relevant traffic situations are covered: day and night, dawn or dusk in East-West aligned roads; winter and summer. To guarantee that every WZRSI is free of subjective elements, irrespective of the performing inspecting team, standardized report forms should be used. To achieve objectivity, standardised text for most common hazards describing a number of typical frequent situations should be used. A standardized report form has the advantage of being easy to read and allowing to compare different reports. The content of the checklists should reflect the prevailing relevant types of hazards that may be encountered. However, 'Fresh Eyes' are very important in the make-up of the inspection team. (Nadler, et al., 2011)

These guidelines are general and 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. To ensure that there is a diversity of skills within the inspection team, it should have at least two inspectors - in all but the simplest WZRSI.

3.3.2 Checklists

PIARC (2012b) in its publication “Improvements in safe working on roads” presents a checklist and its affiliated instructions to be used to assess the status of a work zone, with an emphasis on critical safety features. Such a checklist can be incorporated into a standard inspection of work zones, immediately after setting up or during operation.

Main headers and topics of the PIARC checklist are:

- Beginning of work zone (information board, signing, warning lights)
- Traffic operation issues (speed limits, temporary traffic signals, flagger)
- Work zone (e.g. barriers, fences, cones, warning devices, temporary road signs and markings, separation of work zone from traffic, crash cushions, detours)
- End of work zone (signing, restoring of speed limits)
- Pedestrian, bicycle and public transport arrangements
- Other (e.g. road worker’s equipment, passive safety requirements of devices, daytime/night-time visibility of signs and barriers, illumination)

Various other checklists can be found and are in use worldwide (see Annex 1). However, it seems reasonable that a simple but effective check list by PIARC (see Annex 2) is used during a work zone inspection.

3.3.3 Electronic tools

Various software tools have been developed to improve the quality and efficiency of the inspections of the road infrastructure. These tools can be employed with advantage for WZRSIs.

EVES (Electronic Safety Recording System)

The EVES software was developed in Austria to assist in carrying out road safety inspections (Nadler, et al., 2011). Depending on the application field the system is run either on a notebook computer (when the inspection is performed by car), or on a mobile device when the inspection is performed on a bike or on foot (e.g. cycle paths, footpaths, etc.). The system is able to:

- register safety relevant events during the inspections
- automatically locate the gathered events using GPS
- provide the user with a clear user interface to give an overview of the registered events
- facilitate post-processing of the registered events by providing editing by means of video synchronization
- facilitate reporting by automatically generating reports according to pre-defined structures.

During the survey the system allows quick interaction of the inspector with the system, so that the inspector can still concentrate on the road. It is also possible to record an audio memo of all registered events. Figure 3 shows the graphical user interface for the survey task. The right side contains the map and position data, as well as the list of already surveyed areas. By clicking on the icon for the event, the coordinates are automatically registered, as well as the video/photo being taken.

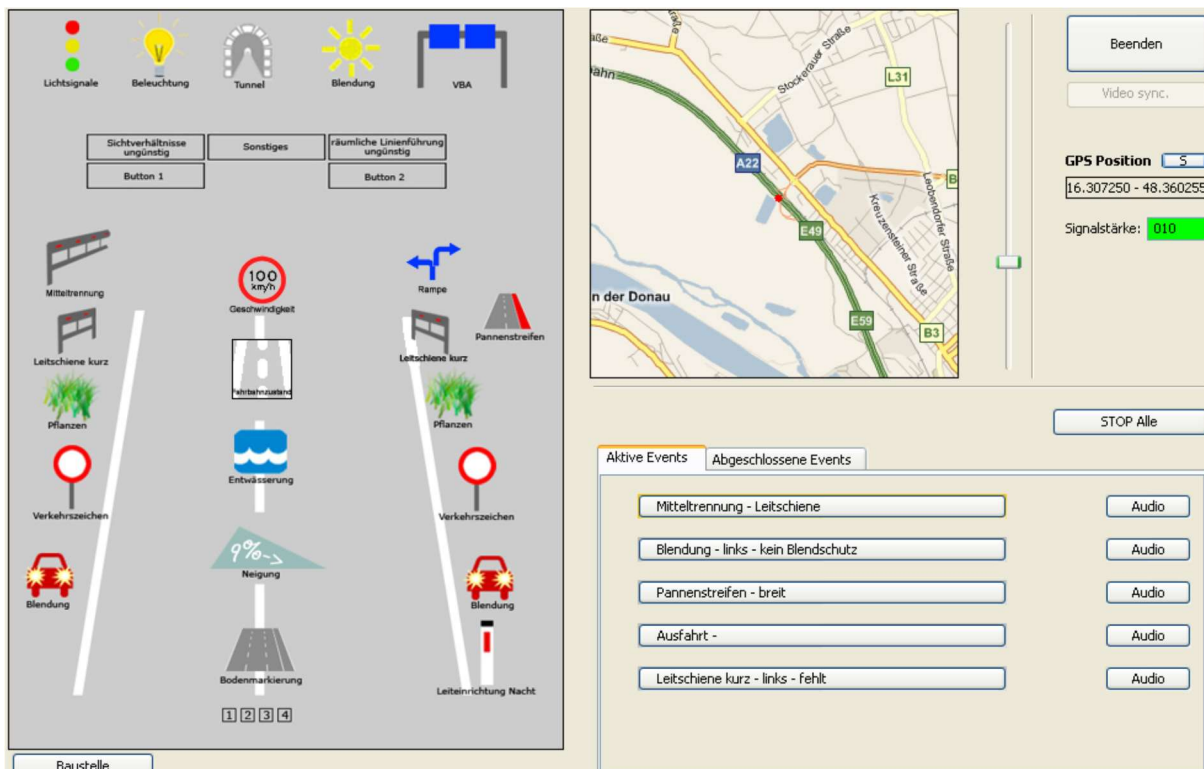


Figure 3. Screenshot of the graphical user interface of EVES during an inspection (Nadler, et al., 2011).

After the on-site inspection itself, post processing is an important part of an inspection. Also here, EVES allows to carry out the task quickly (see Figure 4). EVES provides further features to make the task of controlling and editing the registered information easier. An additional facility allows for easy compilation of final reports.

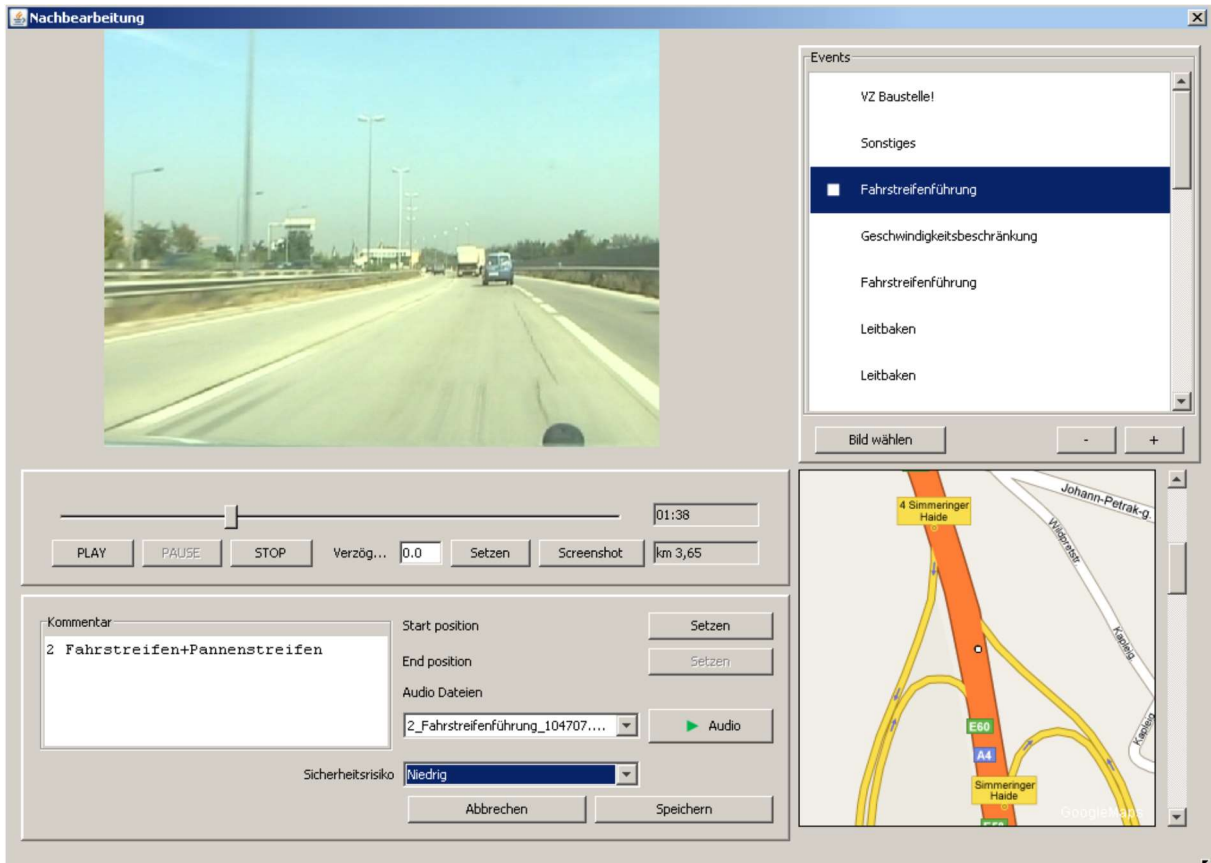


Figure 4. Screenshot of user interface of EVES for post-processing (Nadler, et al., 2011).

UBIPIX

“UBIPIX” is an electronic tool for TTM inspections but also for RSI in Ireland. Video recordings of the driven route are geo-located, which enables the Road agency to locate the problem areas easily and also review the noted issues (<https://nra.ubipix.com/index.php?action=fag>), (see Figure 5). The RSI involves a site survey and video footage of the full route during day-time and night-time. Each ‘item’ that the inspection team tags as important during the drive through survey is later attributed with comments and observations back in the office. The inspection team prepares a report identifying the safety issues based on the site visits and video footage.

Longitudinal safety zone is not being maintained to ensure IPV is not shunted into works area as a result of a rear impact collision by an errant vehicle

Extended TAG details

Extended Tagging Fields

User Inputs

Route Number: N18
 Road Authority: NRA
 Roadworks Start Date: 11/11/2015
 Expected Completion Date: 11/11/2015
 Contractor: Not_Selected
 TSM Designer: DirectRoute
 Roadworks Type: Construction
 PSCS: N/R
 PSDP: N/R
 Roadworks Safety Officer: N/R
 Roadworks Description:
 TSM Type: TSM_MMaRC_Type 2
 TSM Rating: 0
 TSM Comment: Longitudinal safety zone is not being maintained to ensure IPV is not shunted into works area as a result of a rear impact collision by an errant

ID	Title	Event	Location	To Start	To End	Order	Order Time
2880	Tag added on 2015-11-09T12:11:17.61...		OS: 52.682816; -8.715410 TAG: 52.682816; -8.715410	0.3389	0.0038	0.0038	2015-10-19 14:58:55-05
2879	Tag added on 2015-11-09T12:08:08.47...		OS: 52.682816; -8.715410 TAG: 52.682816; -8.715410	0.3389	0.0038	0.0038	2015-10-19 14:58:55-05
2880	Tag added on 2015-11-09T12:08:08.47...		OS: 52.682816; -8.715410 TAG: 52.682816; -8.715410	0.3389	0.0038	0.0038	2015-10-19 14:58:55-05
2882	Tag added on 2015-11-09T12:12:48.38...		OS: 52.682816; -8.715410 TAG: 52.682816; -8.715410	0.3389	0.0038	0.0038	2015-10-19 14:58:55-05
2880	Tag added on 2015-11-09T12:11:17.61...		OS: 52.682816; -8.715410 TAG: 52.682816; -8.715410	0.3389	0.0038	0.0038	2015-10-19 14:58:55-05

Figure 5. UBIPIX used for RSI/WZRSI in Ireland (Courtesy of Desmond O'Connor).

Vidkon

Norwegian experiences with a two-step procedure for carrying out RSI was found to be advantageous since field inspections can be undertaken more quickly with a so-called Vidkon overall inspection, using digital video equipment (Statens Vegvesen, 2005). The road section under inspection is driven through several times, with a digital camera to make two pictures (one on the actual roadway and the other on the roadside area) every 20 metres; alternatively, a video camera may be used to record a continuous stream of the whole section. Based on the video recordings, a preliminary inspection is conducted in the office, to obtain an overview of the road section and to check for overall safety factors such as curvature and visibility, signing and road markings, etc. For an example of a screenshot from Vidkon used for data acquisition in Norway (see Figure 6).

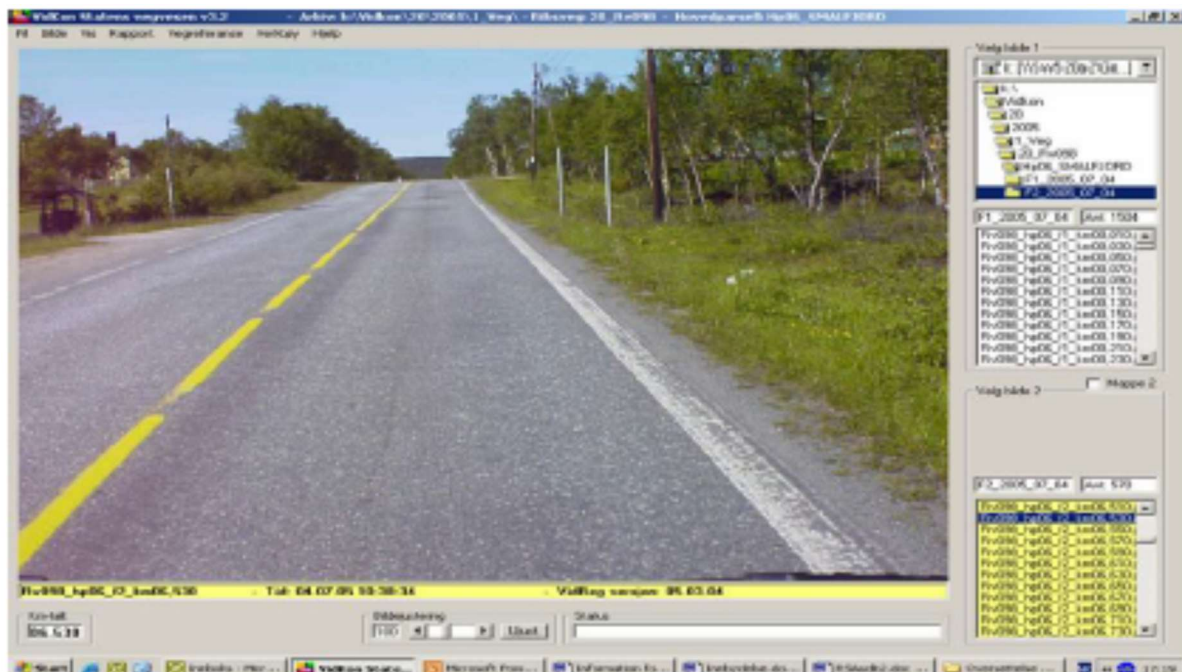


Figure 6. Screenshot from Vidkon used for data acquisition in preliminary RSI in Norway. (Cardoso, et al., 2005).

This type of preliminary road safety inspection offers several advantages:

- A large number of items can be checked by driving slowly along the road.
- Less time spent in traffic means less exposure of the inspectors to running traffic and discussions on safety hazards can be carried out in a safe environment.
- Inspectors can rewind the tape and look as long as needed for critical sites;
- Inspections are possible throughout the year independently of weather or traffic flow.

In Norway, besides the standard report forms in Excel, an additional software named T-ess is used. This program includes listing of all the documentation, as well as using standard text blocks for typical situations. The report form also contains a risk matrix, which can help prioritising possible measures. T-ess also contains a statistics sheet, which provides the total picture for the entire section.

4 Recommendations

Based on the findings from the interviews with practitioners and the literature review, the following recommendations can be made:

- There are good practice guidelines available internationally, however, these guidelines are general, and each country should define its own national regulatory and administrative framework, as well as procedures for work zone RSA and RSI.
- Besides instigating RSA and RSI, formal work zone safety examinations, so called Work Zone Process Reviews, can contribute to achieving long-term improvements in road safety work. A Work Zone Process Review is a periodic evaluation of work zone policies, processes, and impacts that systematically monitors the process of managing the safety and mobility impacts of work zones.
- 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).
- 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”.
- There are various Work Zone Inspection forms and check lists available on a number of internet sites (see Annex I).
- Besides on-site controls according to formal RSIs, the contractor’s documentation of its performance concerning the prescribed daily checks of the work zone should be controlled.
- 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.
- To facilitate on-site inspections, to improve the quality and efficiency of the inspections of the road infrastructure, and to reduce the exposure of the inspectors to traffic hazards, various software tools have been developed and are available on the market.
- If deviations from the road work design are detected, notifications, instructions and 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.
- Since the number of inspectors at national road agencies is far too low today, it is a pressing organisational issue to match the number of trained inspectors with the number of road work sites in the country of question.

5 References

ATSSA (2013a) 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/

ATSSA (2013b) Safe and Effective Work Zone Inspections. American Traffic Safety Services Association, USA.

https://www.workzonesafety.org/training-resources/fhwa_wz_grant/atssa_wz_inspections/

Cardoso, J.L., Stefan, C., Elvik, R., Sørensen, M. (2005) Road Safety Inspections: best practice and implementation plan. Deliverable D5 of the RIPCORD-ISEREST project of the EU sixth framework programme.

https://ec.europa.eu/transport/road_safety/sites/roadsafety/files/pdf/projects_sources/ripcord_d05_road_safety_inspections.pdf

EC (2008) DIRECTIVE 2008/96/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 19 November 2008 on road infrastructure safety management. <https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32008L0096&from=EN>

EC (2019) Proposal for a Directive of the European Parliament and of the Council amending Directive 2008/96/EC on road infrastructure safety management. <https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52018PC0274&from=EN>

Elvik, R. (2006) Road safety inspections: safety effects and best practice guidelines. Report of WP5 of RIPCORD-ISEREST. TØI report 850/2006.

<https://www.toi.no/getfile.php?mmfileid=5959>

Elvik, R., Høye, A., Vaa, T., Sørensen, M. (2009) The Handbook of Road Safety Measures. Second edition. Emerald Group Publishing Limited. Bingley, UK.

Nadler, F., Nadler, B., Elias, D. (2011) Road Safety Inspection Schemes Review. Deliverable D 3.1 of the ERA-NET ROAD Project Nr. 823129.

http://www.cedr.eu/download/other_public_files/research_programme/eranet_road/call_2009_safety/eursi/01_D3-1_20110502.pdf

PIARC (2007) Road Safety Audit Guidelines for Safety Checks of New Road Projects. World Road Association (PIARC).

<https://www.piarc.org/ressources/publications/7/6857,2011R01FR-EN-Securite-Routiere-Road-Safety-World-Road-Association-Mondiale-Route.pdf>

PIARC (2012a) Road Safety Inspection Guidelines for Safety Checks of Existing Roads. 2012R27EN. World Road Association (PIARC).

<https://www.piarc.org/ressources/publications/7/18718,2012R27-EN-Road-Safety-World-Road-Association.pdf>

PIARC (2012b) Improvements in safe working on roads. 2012R29EN. World Road Association (PIARC).

<https://www.piarc.org/en/order-library/18274-en-Improvements%20in%20safe%20working%20on%20roads.htm>

Statens vegvesen (2006) Road Safety Audits and Inspections. Guidelines. Handbook V 720. The Norwegian Public Roads Administration.

<https://www.vegvesen.no/attachment/61483/binary/968121>

TII (2017) Temporary Safety Measures Inspection. TII Publications CC-STY-04002. Transport Infrastructure Ireland.

<http://www.tiipublications.ie/library/CC-STY-04002-03.pdf>

TII (2017a) Temporary Traffic Management Design Guidance. Transport Infrastructure Ireland

<http://trafficsigns.ie/wp-content/uploads/2017/11/Temporary-Traffic-Management-Design-Guidance-Rev-01.pdf>

Annex 1 Links to examples of Work Zone Safety Examinations and Inspection forms

Central Federal Lands Highway Division: work-zone-checklist.pdf

<https://flh.fhwa.dot.gov/resources/design/forms/cfl/>

Dallas Area Road Construction Work Zone Task Force

http://www.workzonesafety.org/files/documents/database_documents/WZ_Checklist.pdf

Missouri DOT: Work Zone Inspection Form

<https://www.modot.org/work-zone-policies-and-tools>

New York State DOT Inspection form

http://www.workzonesafety.org/files/documents/database_documents/nyform.pdf

Maryland State Highway Administration Inspection form

<http://sha.md.gov/OOTS/14AppETTCInspectionFormmastercopyRev2.pdf>

The National Work Zone Safety Information Clearinghouse website

<http://www.workzonesafety.org>

The Federal Highway Administration (FHWA) RSA website:

<http://safety.fhwa.dot.gov/rsa/>

The PIARC report: Improvements in safe working on roads, 2012R29EN, contains checklists and related instructions:

<https://www.piarc.org/en/order-library/18274-en-Improvements%20in%20safe%20working%20on%20roads.htm>

Work Zone Inspections Guidelines - The Federal Highway Administration (FHWA)

https://www.workzonesafety.org/files/documents/training/fhwa_wz_grant/atssa_wz_inspectio ns.pdf

Work zone process review toolbox (The Federal Highway Administration - FHWA):

http://www.ops.fhwa.dot.gov/wz/prtoolbox/pr_toolbox.htm.

Wok Zone Self-Assessment best practices (The Federal Highway Administration - FHWA):

http://www.ops.fhwa.dot.gov/wz/decision_support/self-assess.htm

Annex 2 Work Zone Checklist (PIARC)

WORK ZONE CHECKLIST

Project: _____
 City: _____
 Date/time: _____
 Inspector: _____

Road number: _____
 Road section: _____
 Name of the road: _____

THE WORK ZONE HAS TO BE CHECKED FROM BOTH DRIVING DIRECTIONS

YES	NO	N/A		Please note	When corrected?
1. Work zone begins					
			1.1 Information boards of the construction site are installed		
			1.2 The site is marked with a road construction work sign		
			1.3 Warning lights have been installed		
N/A = not applicable					
2. Reduction of speed limits					
			2.1 Speed limits have been reduced		
			2.2 Temporary traffic signals have been installed		
			2.3 The temporary traffic signals are operating correctly		
			2.4 The flagger is in an appropriate location		
3. Work zone					
			3.1 Barriers, fences, cones and other warning devices are installed		
			3.2 Temporary directional and guidance signs have been installed		
			3.3 Temporary road signs have been installed		
			3.4 Temporary road markings have been installed		
			3.5 The work zone is separated from the traffic with barriers and fences		
			3.6 A crush cushion is installed		
			3.7 The work zone is easy to navigate through		
			3.8 Travel directions are separated		
			3.9 Unnecessary traffic control devices have been removed or covered		
			3.10 Unnecessary road markings have been removed or covered		
			3.11 The quality of the detour is in accordance with requirements		
			3.12 Routes for construction site vehicles are marked		
			3.13 Traffic is warned about construction site vehicles		
4. Work zone ends					
			4.1 The end of the road construction site is marked with a traffic sign		
			4.2 Speed limits are restored		
5. Pedestrian, bicycle and public transport arrangements					
			5.1 Pedestrian and bicycle traffic is separated from vehicle traffic		
			5.2 Directional and warning signs for pedestrian and bicycle ways are installed		
			5.3 Bus stops are accessible		
6. Other					
			6.1 The work zone has been checked from both travel directions		
			6.2 Road worker's equipment and working clothes are in accordance with safety requirements		
			6.3 All traffic control devices and signs are in accordance with passive safety requirements		
			6.4 All traffic signs and barriers have high visibility in day and night conditions		
			6.5 All traffic signs and barriers are undamaged and clean		
			6.6 Construction site vehicles are visible to other traffic		
			6.7 The work site is illuminated when working at night		