CEDR Transnational Road Research Programme

Call: Safety

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

Provision of Guidelines for Roadside Safety (PROGReSS) – Roadside safety elements, state of the art report

WP2 Road Authority Review: Roadside Design and Operations

Deliverable 2.1

July 2019

SWOV Institute for Road Safety Research	
TRL The Future of Transport	
ARUP LNEC Laboratório Nacional de Engenharia Civil h_da Hochschule Darmstadt University of Applied Sciences fbb Fachbereich Bauingenieurwesen	

CEDR Call: Safety

Provision of Guidelines for Roadside Safety (PROGReSS) – Roadside safety elements, state of the art report

WP2 Road Authority Review: Roadside design and operations

Start date of project: 01/09/2017 End date of project: 30/09/2019

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Conférence Européenne des Directeurs des Routes
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Glossary of Terms (WHO, 2015)

Barrier terminals: the ends of safety barriers which often need to be protected by crash cushions.

Breakaway columns: lighting or telegraph poles, designed to break or collapse on impact.

Bridge pier: the support columns of bridges.

Central refuges: areas in the middle of the carriageway, where pedestrians can stop and wait until the road is clear before crossing.

Clear zoning: the systematic removal of all hazardous features near the roadside, to minimise the chances of injury should a vehicle run off the road.

Crash cushions: energy-absorbing applications that can be attached to barrier terminals and other sharp-ended roadside objects to provide crash protection on impact.

Crash-protective roadsides: collapsible or breakaway roadside objects or energy-absorbing “cushions” on barriers and rails that reduce the severity of injury on contact.

Crash-protective vehicles: vehicles designed and equipped to afford interior and exterior protection to occupants inside the vehicle as well as to road users who may be hit in the event of a crash.

Forgiving roadside objects: objects and structures designed and sited in such a way that they reduce the possibility of a collision and severity of injury in case of a crash as well as accommodating errors made by road users. Examples are collapsible columns, guard fences and rails, and pedestrian refuges.

Guard fences and rails: rigid, semi-rigid or flexible barriers which are situated at the edge of a carriageway to deflect or contain vehicles, or in the central reserve to prevent a vehicle crossing over and crashing into oncoming traffic.

Low-cost and high-return remedial measures: low-cost, highly cost-effective engineering measures applied at high-risk sites following systematic crash analysis.

Median barrier: safety barrier positioned in the centre of the road that divides the carriageway, deflects traffic and often has energy-absorbing crash-protective qualities.

Motorised two-wheelers: a two-wheeled vehicle powered by a motor engine, such as a motorcycle or moped.

Offset deformable barrier test: a frontal crash test that aims to reproduce real-world conditions of car-to-car frontal crashes. In this test, the front of the striking vehicle partially overlaps a deformable barrier.

Reflectors: materials that reflect light as an aid to visibility. They may also be fitted to non-motorised transport and roadside objects.

Road infrastructure: road facilities and equipment, including the network, parking spaces, stopping places, draining system, bridges and footpaths.

Roadside furniture: functional objects by the side of the road, such as lamp posts, telegraph poles and road signs.

Road traffic crash: a collision or incident that may or may not lead to injury, occurring on a public road and involving at least one moving vehicle.

Road traffic fatality: a death occurring within 30 days of the road traffic crash

Road traffic injuries: fatal or non-fatal injuries incurred as a result of a road traffic crash.

Road user: a person using any part of the road system as a non-motorised or motorised transport user.

Rumble strips: a longitudinal design feature installed on a roadway shoulder near the travel lane. Rumble strips are made of a series of indented or raised elements that alert inattentive drivers through their vibration or sound. They may also be used for speed reduction.

Safety barriers: barriers that separate traffic. They can prevent vehicles from leaving the road or else contain vehicles striking them, thus reducing serious injury to occupants of vehicles.

Safety performance standards: definitions or specifications for equipment or vehicle performance that provide improved safety. They are produced nationally, regionally, or internationally by a variety of standard-producing organisations.

Self-explanatory road layouts: the use of engineering measures such as road markings and signs that make clear the course of action by different road users.

Skid-resistant surfacing: surface material on a road or pavement designed to prevent vehicles from skidding or pedestrians from slipping.

Transition zones: road marking or features forming a gateway which marks transition from higher speed to lower speed roads, for example, rumble strips, speed humps, visual warnings in the pavement and roundabouts.

Unforgiving roadside objects: objects and structures designed and sited in such a way that they increase the chances of collision and severity of injury in case of a crash. Examples are trees, poles and road signs.

Utility poles: poles at the roadside with a particular function, such as telegraph poles, road traffic sign poles and lighting poles.

1 Introduction

The PROGReSS (Provision of Guidelines for Roadside Safety) project is a study on the relevance, application and use of roadside safety design, operations and maintenance standards and guidelines applicable to European roads with speed limits higher than 70km/h (40mph).

The primary objectives for PROGReSS are:

- To review existing roadside safety design, maintenance and operational requirements for clear (obstacle free) zones and also for road restraint systems (as defined by for e.g. EN 1317).
- To determine to what extent national road authorities in Europe and their contractors are capable of implementing and maintaining compliance with the standards and guidelines throughout the life cycle of roads.
- To develop recommendations for safe roadside design and management ensuring broad acceptance among member National Road Authorities (NRAs) of CEDR.

WP2 made use of the output from WP1, a technical review of current road side standards and guidelines. Its primary aim was to establish current working practices with respect to the design and management of (safe) roadsides in Belgium-Flanders, Ireland, Netherlands, Slovenia, Sweden and the United Kingdom (the countries funding this research). WP2 based this primarily on personal interviews with NRAs in the six funding countries, plus representatives from National and Regional Road Authorities (RRA) in Germany and Portugal. In order to gather information from a broad range of respondents, an internet-based questionnaire survey was issued to road authorities, contractors, consultants, those in academia and involved in research from different countries. Apart from the interviews and surveys, WP2 also informed respondents of the project and specifically drew their attention to the project website. The contact details of respondents, who opted to be contacted following the survey, will provide input to WP6.

1.1 Purpose of this deliverable

The purpose of this report is to describe and assess the findings of the surveys which have collected the experiences of National Road Authorities (NRA), Regional Road Authorities (RRA), Consultants and practitioners in Europe.

The objectives of WP2 were to:

- Arrange personal interviews with NRA representatives from the six funding countries as well as Portugal and Germany
- Establish a mailing list for dissemination
- Identify dilemmas NRAs, RRAs, consultants and practitioners face when making road (side) design and management decisions
- Verify the list of critical roadside elements and their definitions as defined in WP1
- Establish current practice for roadside design

- Establish current practice for safe roadside maintenance
- Establish the role of EU (CEN) standards for vehicle restraint systems on working procedures relating to safe roadside design and management
- Establish the role of Road Safety Audit (RSA) and Road Safety Inspection (RSI), as defined by the Road Infrastructure Safety Management (RISM) Directive (2008/96/EC), on roadside design and operations
- Identify and isolate shortcomings in current (safe) roadside design and operations guidelines and standards.

WP2 included 6 primary tasks, namely:

Task 2.1 focused on the design of a survey questionnaire, which was to be undertaken as a personal questionnaire (with NRA representatives) and an internet-based questionnaire for other road authorities, consultants and practitioners.

Task 2.2 involved collecting the experiences of the NRA's and practitioners involved with roadside management and design in Europe, and specifically in relation to the application and use of design standards and guidelines regulating roadsides and verges alongside rural roads with speed limits higher than 70km/h (40mph) and generally including the higher order rural roads. This information was collected through a mix of personal and online interviews. Maintenance and quality control procedures also formed important parts of the surveys.

Task 2.3 identified any planned roadside and other improvement projects, across the six funding countries plus Germany and Portugal, that may be appropriate for a pilot of the proposals coming out of this research project.

Task 2.4 involved the analysis of the questionnaire results. The results were tabulated and used to provide an overview of current practices with respect to:

- Compliance with current (national/EU) standards/guidelines in new design.
- Shortcomings/problems related to current (national/EU) standards.
- Concessions and dilemmas faced in the design and management of safe roadsides.
- Compatibility of definitions.
- Role of Road Safety Audits (RSA) and Road Safety Inspections (RSI).
- Need for uniformity and standardisation.
- Acceptance of CEDR driven proposals regarding improved procedures for roadside safety.

Task 2.5 included the development of a framework for roadside safety guidelines (design, operation and maintenance, including road worker safety). This task made use of the results of the surveys to draft a user specification for future guidelines. This is based on the experience gathered from participating respondents with current procedures and guidelines regarding roadside safety and specifically aimed at addressing (perceived) problems and shortcomings.

Task 2.6 involved compiling all foregoing tasks within an integrated report describing the results of the surveys, the analysis thereof and the resulting user specification.

The project team anticipated a response rate of between 125 – 222 persons based on approaching multiple road authorities, consultants and practitioners in funding countries plus Germany and Portugal as well as other countries. The survey was provided in English, French and German and it was envisaged that multiple people would be interviewed per country. The project team drafted a list of contacts that were to be approached and invited to take part in the survey. In addition to the survey invitations issued by the project team, invitations and reminder emails were also issued by members of the Programme Executive Board (PEB) and a member of the Conference of European Directors of Roads (CEDR).

Tasks 2.1 – 2.5 were fully met and as a result the nine objectives were achieved. Task 2.6 relates to compiling all foregoing tasks within this report which describes the results of the surveys, the analysis thereof and the resulting user specification.

2 Survey Questionnaire

The survey questionnaire was designed to collect the experiences of NRAs, RRAs and practitioners involved with roadside management and design in Europe, with regard to the application and use of design standards and guidelines regulating roadsides and verges alongside rural roads with speed limits higher than 70km/h (40mph) and generally including the higher order rural roads. Maintenance and quality control procedures also formed important parts of the questionnaire. The survey questionnaire was developed by the project team in consultation with the PEB. The questionnaire is presented in full in Appendix A. Within the following paragraphs, the main findings gained by the responses to the questionnaire are summarised. A more detailed analysis of the responses to the questionnaire, including a selection of supporting information, is presented in Appendix B.

2.1 Background Information

In order to gain a representative result, the target was to collect between 125 and 200 survey responses. A total of 33 responses representing 15 countries, were received. This was much lower than anticipated possibly due to the estimate being too optimistic, responses expected from more countries and more responses expected from road authorities, consultants and practitioners per country. Nevertheless, responses were received from 15 of the 28 member states of the European Union.

The respondents were asked for the information relating to their title, name, country, organisation, position and contact details.

Table 1 contains a list of the countries, organisations and sectors represented by the respondents.

Table 1: List of organisation, sector and country of respondents

Sector Abbreviations:

CNS = Consultant

NRA = National Roads Authority/Administration

RES = Research Institute

ROP = Road Operator

RRA = Regional Road Authority/Administration

UNI = University

	Country	Organisation	Sector
1	Austria	Austrian Institute of Technology (AIT)	UNI
		Austrian Motorway Operator ASFINAG	ROP
2	Belgium	Agency for Roads and Traffic	NRA
		Belgian Road Research Centre	RES
		SPW (Regional Road Authority - Wallonia)	RRA
3	Cyprus	Public Works Department	NRA
4	Germany	BASt (Federal Highway Research Institute)	RES
		DEGES GmbH	ROP
		Hesen Mobil - Road and Traffic Management	RRA
		Land Brandenburg	RRA
		Inver	CNS
5	Hungary	Ministry of Innovation and Technology	NRA
6	Iceland	Icelandic Road and Coastal Administration	NRA
7	Ireland	Kildare National Roads Office	RRA
		Sligo County Council	RRA
		Tobin Consulting Engineers	CNS
		Transport Infrastructure Ireland	NRA
8	Italy	Anas S.p.A.	NRA
9	Luxembourg	National Road Administration	NRA
10	Netherlands	Dept. of Water, Traffic and Living Environment	NRA
		Province of Utrecht	RRA
		Provincie Fryslan	RRA
		Rijkswaterstaat	NRA
11	Poland	General Directorate for National Roads and Motorways	NRA
12	Portugal	Instituto da Mobilidade e dos Transportes	NRA
13	Slovenia	University of Maribor	UNI
14	Sweden	Swedish Transport Authority - Trafikverket	NRA
15	United Kingdom	Highways England	NRA

2.2 Knowledge and Relevance of Research Programmes

The questionnaire requested respondents to indicate their awareness of road safety research programmes, and their impact, if any, upon national rules and regulations. Based on the responses, almost 60% (19/34) were aware of previous road safety research programmes financed by CEDR. 95% (18/19) of those respondents are of the opinion that the output of these programmes is useful however, only three quarters (14/19) made use out of the findings.

Following a review of narratives added by respondents, it appears that the results of previous CEDR projects were useful on different levels which ranged from the exchange of experiences up to assistance in writing country guidelines. Furthermore, the value of collaboration and of common development of guidelines was mentioned. Those who did not find the outputs of previous CEDR programmes useful suggested that difficulties exist when attempting to update or revise national guidelines based on the results of an international project. Another aspect is that the findings of the project reports are not suitable for direct integration into guidelines. In addition, it was mentioned that there is not always value to be gained from the results when compared to existing knowledge at the national level.

The responses make it clear that there is significant variance concerning awareness of previous road safety programmes. Of 19 previous road safety programmes mentioned by respondents, awareness of said programmes ranged from 1 to 14.

2.3 Country Guidelines and Standards Applied in Roadside Design, Road Cross Section Design, Road Maintenance and Road Works

With a view to establishing current practice relating to roadside design and safe roadside maintenance, the questionnaire requested respondents to provide information and links to their guidelines/design standards, if available. In addition to establishing whether countries have guidelines/design standards, the suitability of said guidelines/design standards to provide a high level of roadside safety was also requested. With regard to roadside design, 88% (29/33) indicated that a design standard is available within their country. 76% (22/29) consider their roadside design standards to be sufficient for a high level of roadside safety. With regard to roadside maintenance, 64% (21/33) indicated that a design standard is available within their country, however only 52% (11/21) consider their roadside maintenance standards to be sufficient for a high level of roadside safety. This response, which equates to 33% (11/33) of all respondents, is of concern and suggests that perceived issues exist in this area.

With regard to guidelines/design standards for road works, 85% (28/33) indicated that a design standard is available within their country. 71% (20/28) consider their road works design standard to be sufficient for a high level of roadside safety. Narrative included with some responses suggests that standards are not always used or followed however, several responses indicated that road works standards are currently being reviewed or updated.

2.4 Role of RSA and RSI and Compliance with Directive 2008/96/EC

In order to ascertain the role of RSA and RSI on roadside design and operations the questionnaire requested respondents to provide information relating to the role that RSA and RSI play and the implementation of the RISM Directive which required the establishment and implementation of procedures in all Member States relating to:

- Road Safety Impact Assessments (RSIA)
- Road Safety Audit (RSA) & Training Requirements
- Safety Ranking & Management of the road network in operation (NSM)
- Road Safety Inspection (RSI)

15% (5/33) of respondents indicated that the RISM Directive has not been implemented in their jurisdiction, however upon further examination, these responses were received from those working in Regional or Local Road Authorities which have no responsibility for TEN-T roads, where the RISM Directive does not apply.

The implementation of the RISM Directive across the countries represented appears to be high with RSAs being undertaken on TEN-T roads in all countries. RSIA shows an implementation rate of 89% (25/28), RSI shows an implementation rate of 93% (26/28) and NSM shows an implementation rate of 82% (23/28).

2.5 Role of Roadside Safety Performance Monitoring through the use of Crash Statistics

So as to gain an understanding of the use of crash statistics in each jurisdiction, respondents were asked to provide information relating to the role of roadside safety performance. 66% (22/33) indicated that their organisation has established processes for monitoring roadside safety. While this figure may appear to be low, it is noted that some respondents are employed in areas other than national or regional road authorities and therefore would not be in a position to collect such data. Of those that indicated that their organisation makes use of crash statistics there was a large variation in the frequency of data review, the amount of data collected/available and the quality of incident data available. A selection of both positive and negative narratives relating to the above is included in Appendix B.

2.6 Definition of Roadside Hazards / Obstacles

In an effort to understand whether ‘hazard’ or ‘obstacle’ was a defined term within the guidelines/standards in each jurisdiction, the project team requested definitions, if available, from the respondents as this would have a bearing on potential proposals for safe roadsides. 82% (27/33) indicated that ‘hazard’/’obstacle’ was a defined term. The respondents were also asked whether roadside features/RRS could become hazards after the design phase. Discounting five respondents that answered “Not Applicable” the remaining respondents answered 50% Yes and 50% No (14/28). Definitions which were received from nine of fifteen countries are included in Appendix B.

2.7 Evaluation and Selection of Design Options

With the aim of determining whether there are existing common processes relating to the evaluation of hazards/obstacles and the resultant selection of design options that could be applied across all Member States, the project team requested information from the respondents. 76% (25/33) indicated that there is a process for dealing with hazards either by way of a dedicated standard/guideline or alternative. Respondents from Italy, Poland and Portugal indicated that no such process is in place in their jurisdictions.

2.8 Typical Problems Associated with Roadside Safety

It was decided to gather information relating to typical problems associated with roadside safety in each jurisdiction. It was also intended to gather information relating to data collection for single vehicle and run off road crashes as well as crashes with objects/hazards in the roadside. The responses received are presented in Appendix B. 61% (20/33) indicated that data on run off road crashes, single vehicle crashes and crashes with objects/hazards in the roadside is collected in their jurisdiction.

2.9 Typical Problems (Dilemmas) Associated with Applying the Guidelines and/or Standards (in all Design Stages)

The project team wanted to gather information relating to typical problems associated with applying guidelines and/or standards in order to determine whether common problems exist amongst those surveyed. It was also intended to gather information relating to maintenance of roads following construction and problems identified during RSI, which are undertaken on existing roads.

2.10 Opinions Related to Clear Zones versus Application of Guardrails/RRS

A philosophy of forgiving roadsides, the basis of which is verges free of hazards or with crash friendly infrastructure, was developed by the IRDES ERA-NET project [1] in collaboration with the CEDR Technical Group Road Safety and was published in 2013. The project team wanted to gather information relating to design approach with regard to the philosophy of forgiving roadsides versus the application of RRS. 88% (29/33) indicated that the philosophy is promoted within their jurisdiction. 70% (23/33) suggested that a policy to provide a clear or obstacle free zone before a guardrail/RRS is installed exists within their design standards. However, it is noted that the satisfaction rates for the area of land available either side of the road typically being sufficient to provide the required forgiving roadside was 42% (14/33) and those that encountered difficulties when attempting to install RRS due to poor ground conditions, existing utility ducting etc. amounted to 51% (17/33).

2.11 Funding Constraints and Costs

In determining whether funding constraints and costs can have an impact upon the provision of safe roadsides at design level, it was discovered that 55% (18/33) indicated that funding constraints and/or construction costs are a factor when assessing whether to provide forgiving roadsides via the introduction of clear zones/obstacle free zones. Concerning the alternative of providing a forgiving roadside versus the introduction of a VRS, 52% (17/33) indicated that funding constraints and/or construction costs are a factor.

2.12 Role of Contractors and Consultants

A question was posed to those employed by road authorities requesting information relating to the role that contractors and consultants play, if any, in the development and revision of standards and/or guidelines. The specific question resulted in 23 responses (those employed by road authorities). 78% (18/23) indicated that consultants and contractors are engaged with during updates to design standards. Contractors were asked whether there is a mechanism for providing feedback to the roads authority or author of design standards and/or guidelines. Of the four contractors that responded to the questionnaire, 50% indicated Yes and 50% indicated No.

2.13 Successful and Innovative Roadside Safety Risk Mitigation Measures (Individual Site Level)

In addition to the development of new and innovative approaches, the exchange of experiences is another aspect of multinational projects. In order to develop recommendations that could improve roadside safety, the project team requested information relating to successful and innovative risk mitigation measures, at an individual site level. A selection of the responses received is included below and a full list is included in Appendix B:

- A road authority decided years ago that passively safe lighting columns would be the standard choice for lighting supports.
- RRS with underrun protection installed across a regional road authority jurisdiction.
- Make the road more visible in darkness (reflectors, vertical beacons in curves, lighting at intersections and in dangerous places).
- There are shoulder rumble strips applied along almost the entire length of the network.

2.14 Successful and Innovative Roadside Safety Management Processes (Network Level)

Similar to the question posed above, the project team requested information relating to successful and innovative risk mitigation measures, on a network wide level. A selection of the responses received is included below and a full list is included in Appendix B:

- Main process includes the promotion and implementation of Road Infrastructure Safety Management procedures such as Road Safety Audits and Road Safety Inspections.
- Plan-based approach to roads: improvement measures in accordance with sustainable safe guidelines.
- In the formation and further updating of the Framework Design process, the designing party must also submit the designs of the safe verge to the client first.
- We have an independent assessment scheme for non-harmonised products. Products have to go through independent third-party checks to ensure manufacturers or test houses didn't cheat on impact tests.

2.15 Pilot Projects

One part of PROGReSS is to test the possible implications of the recommendations and outcomes of the project, their consequences as well as the acceptance of recommendations developed within the framework of this project. Therefore, the project team requested respondents to nominate potential pilot projects that may be suitable to trial the roadside safety evaluation tool which is being developed as part of this research package and is discussed in further detail in Chapter 3 of this report. Highways projects at all design stages were welcome and a selection of the responses received are included below:

Pilot Project	Design Stage	Country
Antwerp ring road	Detailed Design	Belgium
Minor improvement works	Preliminary Design	Ireland
Existing upgrade works	Preliminary Design	Sweden

3 A Framework for Roadside Safety Guidelines

3.1 Motivation and Approach

One of the primary aims of this work package was to draft a user specification for future roadside safety guidelines by making use of the findings of the survey. To achieve this aim, the survey responses were analysed in detail to identify and understand the various issues, problems and shortcomings experienced by road authorities.

The first step of the analysis was a detailed review of the survey responses received. As the responses were reviewed, each problem and shortcoming identified was added to a list. Every item added to this list was effectively a factor that may contribute to the ultimate undesired outcome of injury resulting from a Run-off-Road (RoR) crash. As the list grew in size, it became clear that the identified contributory factors may be introduced at different stages of the lifecycle of a roadside, such as the design, implementation and maintenance phases.

The analysis resulted in the identification of a variety of contributory factors. It was then decided to create a mind map to visually organise the identified factors and generate a model which presented them in a logical flow, see **Figure 1 –** An early iteration of the mind map from an internal workshop**Fout! Verwijzingsbron niet gevonden.**. This mind map was created through a series of internal workshops in TRL.

It should be noted that some similar factors were grouped into a single overarching factor and represented by a single sticky note.

As the mind map matured, it became apparent that the team was effectively developing a type of fault tree analysis through the way the contributory factors were organised. Therefore, it was decided to call this model the "Roadside Safety Organisational Robustness Fault Tree". This model is presented in **Fout! Verwijzingsbron niet gevonden.**.

> *"A Fault Tree Analysis (FTA) is a tool for analysing, visually displaying and evaluating failure paths in a system, thereby providing a mechanism for effective system level risk evaluations"* [2]

Originally developed in 1962 by H.A. Watson in relation to a U.S. Air Force Missile System contract, the FTA is widely used today in safety engineering and reliability engineering fields to understand the different ways through which a system can fail and the corresponding mitigation measures that can be introduced to reduce the associated risk. FTA is utilised by a wide variety of industries, including not only road safety and collision analysis but also the likes of aerospace [3], nuclear [2], chemical [4] and pharmaceutical [5] industries.

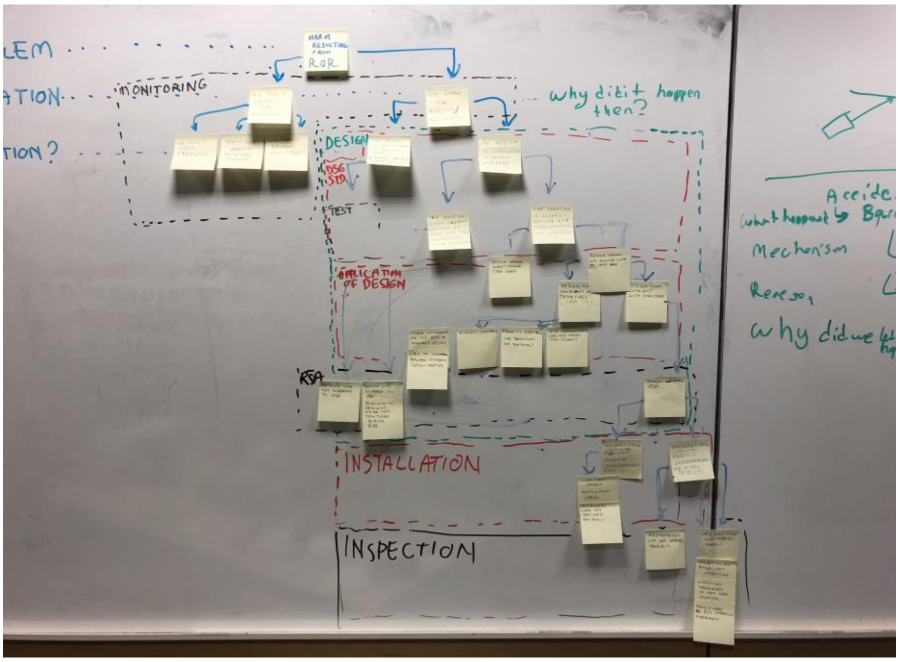

Figure 1 – An early iteration of the mind map from an internal workshop

3.2 Structure of the Tool

A FTA begins with the definition of an undesirable outcome of the system. All of the possible ways that can lead to the undesirable outcome and the underlying contributory factors are then identified. These factors are then visually organised in a fault tree diagram so that the logical connections between the contributory factors that can lead to the undesirable outcome can be sequentially displayed and analysed.

At the beginning, the Roadside Safety Organisational Robustness Fault Tree was only based on the findings of the survey. This stage only represented a partial FTA as the team has already identified a number of other ways, during the workshops, which could contribute to the analysed undesired outcome. Therefore, it was decided to include all of these other identified contributory factors to represent a more complete FTA, which could also form the basis for the WP3 risk assessment tool.

The logic behind the Organisational Robustness Fault Tree relates back to the original aims of the CEDR call which led to this project. As described within the call, despite the existing roadside design standards, guidelines, safety products and established processes, road users continue to get injured as a result of run-off-road crashes. While some solutions look good on paper, they may not always result in a safe, real-world application. There are many factors that may contribute to the ultimate undesired outcome of injury resulting from a Run-off-Road (RoR) crash and these contributory factors may be introduced at different stages of the lifecycle of a roadside, such as the design, implementation and maintenance phases. For example, a roadside design which is compliant with existing guidelines may end up contributing to negative consequences in the event of a RoR crash if it is not implemented properly; a compliant VRS installation may end up contributing to negative consequences in a RoR crash if it is not maintained properly; or a roadside design guide may fail to prevent harm in the event of a RoR crash if the local problems are not understood properly due to lack of network monitoring.

National Road Authorities (NRAs) must be aware of, and take into account, these potential failure mechanisms so that necessary countermeasures can be introduced in the form of more comprehensive standards, guidelines and processes. The more the potential failure mechanisms are countered, the greater the organisational robustness will be. The Roadside Safety Organisational Robustness Fault Tree is an attempt at classifying all of these potential roadside safety risk contributors, which relate to the organisational processes which are within the realm of influence of NRAs. Therefore, it constitutes a framework for future guidelines as the NRAs can use the fault tree to assess their own organisational robustness and identify the necessary countermeasures for the identified areas of shortcomings (this will be supported by the WP3 tool).

As can be seen in **Fout! Verwijzingsbron niet gevonden.**, the fault tree begins with the undesired final outcome of “injury resulting from a RoR crash” and then outlines the potential factors that may contribute to the undesired outcome and the associated stages of the roadside timeline, namely the network monitoring, design (standard writing and policy, use of the standard, departures from standard, RSA), implementation/installation, operational life and RSI.

The general logic of the chart is that:

- Green boxes represent ideal situations;
- Blue boxes represent factors which may have contributed to the undesired result of injury as a result of a RoR crash (most of these are based on the survey responses);
- Grey arrows represent the logical flow of how these contributory factors are related.

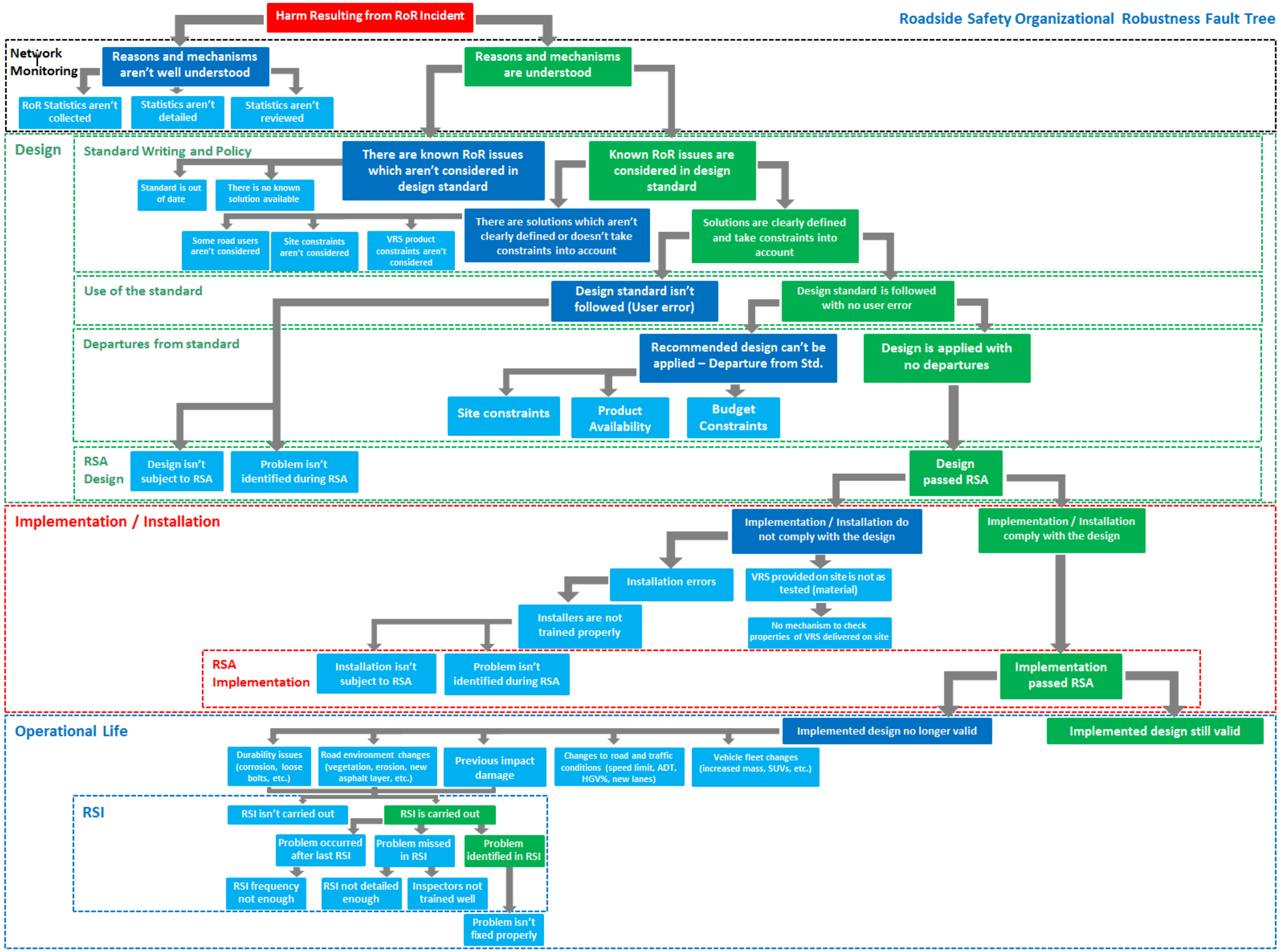

Figure 2 – Roadside Safety Organisational Robustness Fault Tree

3.3 Network Safety Performance Monitoring

The first section of the Organisational Robustness Fault Tree relates to the network safety performance monitoring phase (see **Fout! Verwijzingsbron niet gevonden.**). Ideally, NRAs should monitor the roadside safety issues on their network, including regular reviews of incident statistics so that they can have an in-depth understanding of the problems they are facing, as well as the factors that lead to them. If the reasons and mechanisms of the RoR casualties are not understood, the NRA will have limited ability to consider these problems within their roadside design guidelines and regulations and therefore apply the necessary countermeasures and/or undertake research to further understand the phenomenon. Ultimately, preventable issues would persist and continue to contribute to RoR casualties.

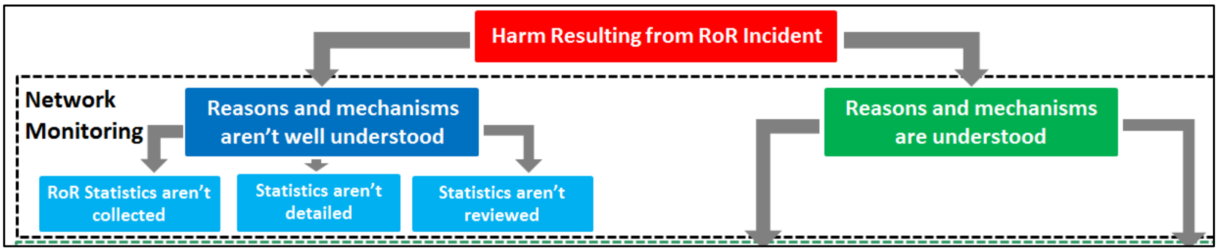

Figure 3 – Network Monitoring Phase of Roadside Safety Organisational Robustness Fault Tree

The survey results have shown that 33% of the respondents do not have established processes for the monitoring of roadside safety through incident statistics, while a number of respondents included issues such as lack of detail in the collected data or lack of periodic reviews (see Section 2.5).

For example, in the UK road traffic incident statistics are periodically reviewed at a national level, however the level of detail in the collected data (within STATS19 database) with regard to the roadside is very limited. Due to this lack of detail, the issue of the danger posed by wooden boundary fencing was undetected until recently, when an in-depth research project identified a number of high severity RoR crashes involving wooden fencing [6]. Within this project a search was undertaken on Road Accident In-Depth Studies (RAIDS), On the Spot (OTS) and Highways England Fatal databases to identify any incident involving a post and rail wooden boundary fence. To help understand the level of underreporting, each case was matched with its corresponding STATS19 record. The analysis has shown that due to shortcomings in the design of STATS19 data collection form (only the first object hit off carriageway is recorded, and a wooden fence category was not added until 2011) it wasn't possible for the police officers to record the involvement of a wooden fence in the majority of incidents. By relying on the STATS19 records alone, it would not be possible to identify 94% of the cases as a wooden boundary fence incident.

It is now understood that, in the event of a collision, the risks associated with wooden boundary fencing is significantly higher than it was previously considered.

It is recommended that NRAs should put in place processes for efficient network safety performance monitoring, so that the local roadside safety issues can be better understood. Guidelines should include requirements for regular reviews of the RoR crash statistics. Incident data collection forms should take RoR issues into consideration.

3.4 Design Phase

The second section of the Organisational Robustness Fault Tree, relates to the design phase and is divided into four sub-phases of standard writing and policy, use of the standard, departures from standard and RSA (see **Fout! Verwijzingsbron niet gevonden.**). A specific roadside safety issue may be known to the NRA, however problems may be introduced in one of the design phases.

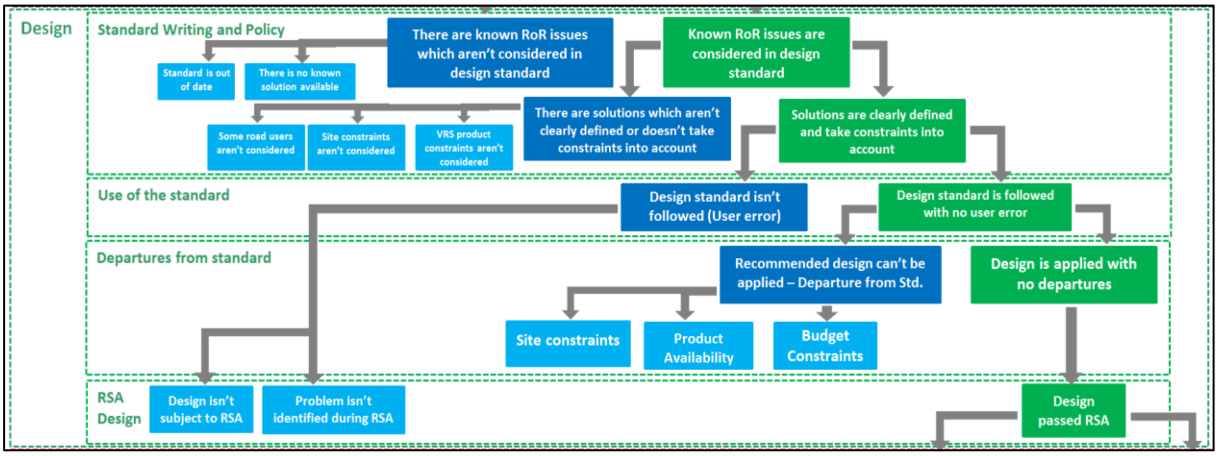

Figure 4 – Design Phase of Roadside Safety Organisational Robustness Fault Tree

The first potential issue with standard writing and policy is if a problem is not considered in the design standard. If a problem is not considered, then the standard cannot provide the necessary solutions and therefore the designer cannot apply any. This situation could occur if the roadside design standard is out of date. For example, one of the respondents from Netherlands pointed out that the local roadside design guidelines have not yet taken the recently introduced speed limit increase from 120km/h to 130km/h (75 to 80 mph) into consideration. This means that a designer may not be able to account for roads with 130km/h speed limits. In the case of a RoR crash in such a location, the design standard itself could be seen as a contributory factor for an undesired outcome.

Another reason why a roadside safety problem may not be considered within a design standard could be due to lack of known solutions to address it. For example, a recent study [7] in the UK has shown a growing issue with the incompatibility of existing VRS with Sports Utility Vehicles (SUVs). Of the 349-recorded single vehicle SUV-to-VRS incidents, 182 (52.1%) resulted in a rollover.

Unfortunately, there is no SUV class in EN1317 (the European testing standard for VRS) and therefore it is not currently possible to find off-the-shelf VRS which are proven to work with SUVs. A further case point is the growing popularity of electric vehicles (EV) in the European fleet. Total EV sales exceeded 100,000 in quarter one of 2019 with plug in electric vehicle sales up 31% and pure electric vehicle sales up 85% [8]. The weight of batteries usually makes an EV heavier than a comparable gasoline vehicle [9]. As a result, the roadside design standard is currently unable to provide a solution for these specific problems. It could be argued that the lack of consideration of this issue within the existing European testing standard is a contributory factor for injury resulting from SUV and EV to VRS crashes.

It is recommended that NRAs should regularly update their roadside design standards/guidelines to ensure consistency with their other design regulations.

It is recommended that the existing roadside design guidelines are reviewed regularly to ensure that the issues identified through the regular network safety performance monitoring are taken into consideration.

Sometimes a problem is considered within the roadside design standard, however the solution / countermeasure may not be clearly defined, or it may not take some constraints into account. This lack of detail within the standard, may lead to undesirable designs, despite being “compliant” on paper.

For example, a design standard may state that motorcyclist protection systems should be considered at sites with a high risk for motorcycle accidents. However, the term “high risk site” would be open for interpretation if a precise definition of what constitutes a “high risk site” is not provided. While one designer may see a site as low risk for motorcyclists, another may see it as high risk. This lack of clarity could be a contributory factor for injury resulting in a motorcycle-to-VRS impact, where no countermeasure was applied, despite having a compliant design.

The underlying reasons for such lack of detail in the design standards could be:

- a lack of consideration of different road users,
- a lack of consideration of site constraints,
- and a lack of consideration of VRS product constraints.

In addition to the previous example about motorcyclists, 6 out of 27 survey respondents said that provision for motorcyclists, cyclists, equestrians and pedestrians were not taken into consideration within their design standards/guidelines.

Another common theme within the survey responses was issues relating to a lack of consideration of site constraints within the design standards/ guidelines. Examples of these issues included guidelines not aligning with typical road layouts and existing utilities not taken into consideration during VRS design.

Similarly, a lack of consideration given to VRS product constraints within the design standards was noted by the survey respondents.

A typical example of this is the lack of detail in ground condition requirements for VRS. A VRS which was installed, and crash tested on a concrete surface may not necessarily perform in the same way if it is installed on an actual roadside with loose soil. NRAs and designers have limited control over such unproven installations, if substantiated design advice related to VRS ground conditions are not included within the installation manual. The roadside design manual could include a series of checks to ensure the proposed VRS system is proven to work with the existing ground conditions.

A common theme within the survey responses related to deflection distances and lack of roadside space available for VRS installation to accommodate deflection. Cable VRS are known to deflect less when crash tested in short lengths, as deflections are limited by the fixed anchors at the terminals. Longer installations of such VRS in the real world can result in higher deflections. In such cases the tested length is considered a constraint for the VRS in question. Lack of consideration of such product limitations within a design manual can lead to longer-than-tested lengths of cable VRS designs, which could result in unknown deflection properties that can cause injury in a RoR crash.

It is recommended the solutions/countermeasures within roadside design standards/guides are clearly defined to minimise personal interpretation. The solutions/countermeasures should also include sufficient technical detail so that the constraint of the site, the VRS products and the needs of different road users can be taken into consideration during the design phase.

The design standard/guideline may be comprehensive with an adequate level of detail to address the roadside safety issues inherent within the country. However, there is still the possibility of safety issues which may be introduced by the designer, due to misuse or misinterpretation of the design standard. Design stage road safety audits are often utilised to ensure that unsafe (which can include non-compliant) designs are not carried over to final implementation. However, it is still possible for a non-compliant design to reach the implementation stage, if it wasn't subject to a RSA, or if the auditors could not identify the issues during the audit. It is also possible that the RSA recommendations may not have been taken into consideration or adopted by the design team. This could also contribute to an unsafe design reaching the implementation stage.

It is recommended that NRAs should implement processes for road safety audits during the design phase for all roads.

It is recommended that guidelines for the RSAs take common issues relating to the latest roadside safety requirements specific to their country into consideration.

In some cases, despite the design standard being understood and applied, a compliant design may not be achieved due to reasons such as site constraints, cost constraints and product availability. In such cases, the overseeing organisation may consider issuing a departure (variation) from the standard. A departure from standard should only be applied for following a comprehensive evaluation, which often includes risk assessment and cost/benefit analysis. Such departures may introduce increased (even though accepted) risks which may contribute to injury as a result of RoR crashes.

As part of the Work Package 1 activities, a database of roadside design relate departures was provided by Highways England. Some of the more common types of departures featured within this list were VRS length of need issues caused by site restrictions, VRS transition issues cause by lack of product availability and provision of a lower containment level for central reservation VRS caused by cost issues.

While it is a challenge to come up with an overarching solution for all of the individual departures, one thing the NRAs can do is to have a process for regular review and analysis of the departures they have issued. Through these analyses, it may be possible to identify the underlying reasons for the most common departures. Through better understanding of these reasons, the NRA could develop a targeted strategy to minimise the need for the departures. These may include strategies such as improvement of the design standard, improvement of collaboration mechanisms with the other design parties, evaluation of the reasons and effects of budget constraints with wider NRA management, etc.

For example, one of the survey responses pointed out that "*Detailed planning of VRS starts after the road design has already been finalised - often too late to make necessary changes*". Such a systematic issue could easily lead to common VRS related departures. In such a case, perhaps the solution lies within an improvement of the design approach to ensure roadside design and roadside safety is incorporated within the road design process at an early stage.

It is recommended that NRAs should implement a process for regular review and analysis of the roadside safety related departures from standard. This way the underlying reasons for the most common types of departures could be understood and the necessary strategies to minimise the need for these departures can be put in place.

3.5 Implementation Phase

The third section of the Organisational Robustness Fault Tree, relates to the installation / implementation phase (see **Fout! Verwijzingsbron niet gevonden.**). A compliant design may result in an unsafe roadside if it is not implemented properly.

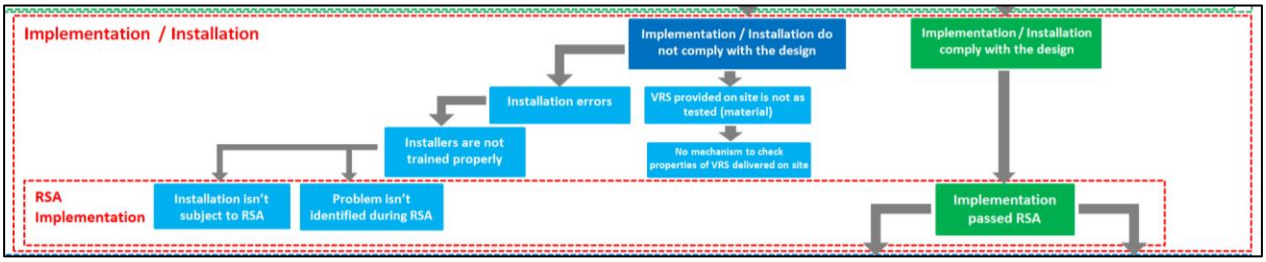

Figure 5 – Implementation Phase of Roadside Safety Organisational Robustness Fault Tree

VRS installation error was a common issue pointed out by a number of respondents within the survey. As a basic example, a w-beam VRS which is lapped in the wrong direction can impale an impacting vehicle; effectively transforming the VRS from a risk mitigation measure into a hazard. Similarly, other installation errors could convert VRS into a higher risk hazard, which may then contribute to injury as a result of a RoR crash.

Installation errors can be caused by lack of adequate training of the installers. To mitigate this risk, a number of NRAs have started to put in place obligatory training for VRS installers.

The installation errors should ideally be identified during the construction level RSA. However, it is possible that these errors are missed if the RSA is not carried out or if the issues were not identified by auditors during the RSA; effectively resulting in an unsafe roadside. Therefore, it is important to ensure the RSAs are carried out and the auditors are informed about the technical requirements of the project under audit.

Another potential issue that may be introduced during the construction phase is if the material properties of the VRS provided on site is not as tested. CE marking procedures have introduced mandatory factory production control, however these controls are carried out six monthly and it may still be possible that sub-standard materials are provided on site, which could result in a VRS that is not capable of performing as intended. Furthermore, non-harmonised VRS products cannot yet be CE marked and therefore these products are not subject to mandatory factory production control inspections. NRAs could consider introducing additional processes to ensure the quality of the installation.

It is recommended that NRAs should put in place the processes to ensure VRS installers and inspectors are adequately trained, so that the risk of installation errors can be minimised.

It is recommended that NRAs should put in place processes for road safety audits following the construction phase for all roads. It is also recommended that NRAs consider processes to ensure the quality of VRS delivered and installed on site.

3.6 Operational Phase

The final section of the Organisational Robustness Fault Tree, relates to the operational life phase (see **Fout! Verwijzingsbron niet gevonden.**). A roadside may have been designed and constructed in accordance with the standards. However, even a compliant roadside may become unsafe within its life span if it is not maintained adequately.

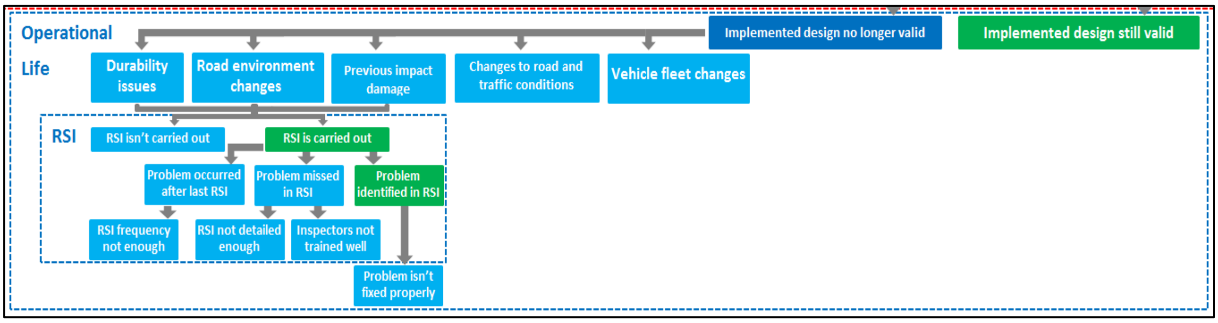

Figure 6 – Operational Life Phase of Roadside Safety Organisational Robustness Fault Tree

Examples of issues that can occur throughout the operational life include, durability issues such as corrosion, loss of tension, loosening of bolts, which can transform a compliant VRS into a roadside hazard. Similarly, if an impacted VRS is not repaired in time, it may fail to perform as expected in a succeeding impact. Sometimes changes in the road environment may have an effect on the existing VRS installation. For example, where pavement overlays are constructed without any adjustments to the height of a roadside VRS, the VRS may be too low relative to the road surface to perform as intended. Similarly changes to the roadside environment such as erosion around the VRS foundations or overgrown vegetation can turn a safe design into an unsafe one over time. All of these factors could become a contributor of injury as a result of a RoR crash.

NRAs often utilise road safety inspections (RSIs) to detect and rectify these issues over time. If RSIs are not carried out, these issues may not be detected. However, even when regular RSIs are carried out, some of these issues may be missed. For example, the issue may have occurred after the RSI was undertaken. If such cases are common, it may be a good idea to increase the frequency of RSIs. Another possibility is that the RSI is undertaken, but the problem is not detected. This could occur if the RSI methodology is not detailed enough to cover the specific roadside safety related issues or it may be that the inspectors may not have the necessary level of training or experience with the unique problems of roadside safety design. In such cases, the overseeing organisation may consider improving their RSI processes or improve the training requirements for road safety inspectors.

Issues may have been detected within the RSI; however, solutions for the identified problems may not have been applied adequately or in a timely manner. If such cases are a known issue, the NRA should consider reviewing the shortcomings of their processes which are causing these issues.

It is recommended that NRAs should put in place processes for regular RSIs, preventative maintenance and inspections.

It is recommended that guidelines for the RSIs take common issues relating to roadside safety requirements specific to that country into consideration.

Finally, there could be other changes through the lifecycle of a roadside, which may have an effect on the overall safety but may not be easily detectable through RSIs. For example, if there are significant changes to the traffic characteristics of the road over the years, such as a considerable increase in the percentage of heavy goods vehicles (HGVs), the original assumptions for the selection of the existing barrier may no longer be true. Therefore, the risk of a heavy vehicle impacting the VRS would be significantly higher than it was assumed at the design phase.

Another example is the changes in the vehicle fleet composition and vehicle characteristics over time. For example, a recent study has demonstrated the significance of the trend of increasing vehicle mass over time [7]. In 2016 40% of the UK car fleet weighed over 1,500kg with two occupants on board. 1,500kg is the mass of the test vehicle used for the most commonly used VRS containment class of N2 in the UK. With all of these on-going changes, the level of safety provided by existing installations is decreasing over time. This is because the number of vehicles that fall outside of the original design assumptions of the roadside is increasing.

As these types of changes are unlikely to get picked up at RSI, they should be monitored at an NRA level through asset management, network monitoring and research activities.

It is recommended that NRAs should put in place processes to monitor and assess the long-term effects of changes to road traffic and vehicle fleet on the safety of existing roadsides.

As previously mentioned, the Roadside Safety Organisational Robustness Fault Tree is an attempt at classifying the potential organisational shortcomings which may contribute to injury as a result of RoR crashes. A NRA can utilise this fault tree to help assess their roadside safety organisational robustness. This can be done by identifying the existing issues, the stages at which they are introduced and then assessing if there are countermeasures in place to mitigate the identified shortcomings. WP3 will utilise this fault tree and the findings to help create a roadside safety risk self-assessment tool.

4 Summary

4.1 Conclusion

The responses to the survey questionnaire provide a valuable insight into the thoughts and experiences of road authorities and practitioners regarding the area of roadside safety. Responses were received from 15 of the 28 Member States and it can be seen that there are similarities as well as differences in design approaches with regard to roadside design and roadside safety.

Compliance with Directive 208/96/EC appears to be high across the represented Member States, however it is noted that, aside from RSA, not all States are fully compliant. In order to gain the road safety benefits of the Directive, Member States should be implementing its requirements in full. In light of the impending amendment to the Directive, as discussed later, Member States should aim for full compliance as early as possible.

An analysis of the results of the survey in combination with the output of Work Package 1 have formed the basis of the tool which is under development, as indicated in Chapter 3 of this report, and which will be completed in Work Package 3.

4.2 Recommendations

Based on the responses received and supporting text provided it is proposed that CEDR consider the following:

- Of particular interest to this project, and for CEDR in general, is that 18 of 19 respondents who were aware of previous CEDR road safety research programmes found the outputs useful. Nevertheless, the awareness of specific projects ranged from a single person to multiple people. Concerning the implementation of the findings of CEDR projects it is recommended that analysis of why some projects and their findings are well known and considered useful while others are not being undertaken.

- Regarding the ability to implement the outputs of CEDR road safety research programmes and on the basis that:
    - *"only ~75% (14/19) made use out of the findings"*
    - *"it was mentioned that there is not always value to be gained from the results when compared to existing knowledge at the national level"*
    - *"only 52% (11/21) consider their roadside maintenance standard to be sufficient for a high level of roadside safety",*

  it is recommended that collaboration between road authorities is increased with a view to sharing experiences, best practices, trial project results etc. This will hopefully enable road authorities to develop or revise standards to include an agreed common approach rather than each nation identifying similar problems and developing varying solutions.

- A standard definition for roadside hazard/obstacle is recommended as the responses received from nine countries, while broadly similar, varied. The project team proposes the following as a definition:
  "A hazard is any physical obstruction which may, in the event of an errant vehicle leaving the carriageway, result in serious injury to the occupants of the vehicle."

- Similarly, a standard definition for a forgiving roadside is recommended as the responses received from seven countries varied. It is also noted that the CEDR Forgiving Roadsides Design Guide, published in November 2012, does not include a definition. The project team proposes the following as a definition:
  "A forgiving roadside is a roadside that minimises the risk and consequences of driving errors".

- It is recommended that NRAs should put in place processes for efficient network safety performance monitoring, so that the local roadside safety issues can be better understood. Guidelines should include requirements for regular reviews of the RoR crash statistics. Incident data collection forms should take RoR issues into consideration.

- It is recommended that NRAs should regularly update their roadside design standards/guidelines to ensure consistency with their other design regulations.

- It is recommended that the existing roadside design guidelines are reviewed regularly to ensure that the issues identified through the regular network safety performance monitoring are taken into consideration.

- It is recommended the solutions/countermeasures within roadside design standards/guides are clearly defined to minimise personal interpretation. The solutions/countermeasures should also include sufficient technical detail so that the constraint of the site, the VRS products and the needs of different road users can be taken into consideration during the design phase.

- It is recommended that NRAs should implement processes for road safety audits during the design phase for all roads.

- It is recommended that guidelines for the RSAs take common issues relating to the latest roadside safety requirements specific to their country into consideration.

- It is recommended that NRAs should implement a process for regular review and analysis of the roadside safety related departures from standard. This way the underlying reasons for the most common types of departures could be understood and the necessary strategies to minimise the need for these departures can be put in place.

- It is recommended that NRAs should put in place the processes to ensure VRS installers and inspectors are adequately trained, so that the risk of installation errors can be minimised.
- It is recommended that NRAs should put in place processes for road safety audits following the construction phase for all roads. It is also recommended that NRAs consider processes to ensure the quality of VRS delivered and installed on site.
- It is recommended that NRAs should put in place processes for regular RSIs, preventative maintenance and inspections.
- It is recommended that guidelines for the RSIs take common issues relating to roadside safety requirements specific to that country into consideration.
- It is recommended that NRAs should put in place processes to monitor and assess the long-term effects of changes to road traffic and vehicle fleet on the safety of existing roadsides.

4.3 Proposed Amendment to Directive 2008/96/EC

It is noted that a proposal for a Directive of the European Parliament and of the Council amending Directive 2008/96/EC on road infrastructure safety management was provisionally agreed on February 21, 2019. The revision will extend the scope of the current rules to motorways and other primary roads beyond the trans-European network for transport (TEN-T), including roads outside urban areas that are built using EU funding. It will become mandatory to take systematic account of pedestrians, cyclists and other vulnerable road users in road safety management procedures. At the time of issuing this report the provisional agreement remains to be endorsed by the Council and the relevant European Parliament committee, before being formally adopted.

The proposed amendment was provisionally agreed following the completion of the survey questionnaire. As a result, it was not possible to include questions relating to the proposed amendment.

5 References

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[8] B. Gaton, “The Driven,” 30 April 2019. [Online]. Available: https://thedriven.io/2019/04/30/european-q1-new-car-market-results-out-ice-down-ev-way-up/. [Accessed 08 July 2019].

[9] M. Ehsani, Y. Gao, S. E. Gay and A. Emadi, “Modern Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design,” Taylor and Francis, 2004, p. 22.

[10] D. Adminaite, G. Jost, H. Stipdonk and H. Ward, “Reducing Deaths in Single Vehiclle Collisions,” European Transport Safety Council, Brussels, 2017.

Appendix A Survey Questionnaire

This questionnaire was distributed through email. An invitation was sent to a select group of professionals and experts within highway design, roadside safety and forgiving roadsides. Initial take up was slow although with follow up emails and telephone conversations it was possible to gather further results. Questionnaire responses are a combination of online survey responses and personal interview responses. Lessons learned from this form of data collation include the need to personalise email invitations to allow the receiver to understand the value of their response. Personal interviews provided the recipient the opportunity to have the interviewer time to explain a question thus allowing for a more applicable response to the question.

The questionnaire responses are of the ***individual only*** and not a representation of the views of the respondent's country or employer.

1. Background information

- Title
- Name
- Country
- Organisation
- Position
- Email Address
- Telephone
- Date

2. Knowledge and relevance of research programmes

- Are you or members of your organisation aware of previous Conference of European Directors of Roads (CEDR) road safety research programs? YES/NO
- If you answered "YES" please provide a list of the programs.
- Have you or members of your organisation made use of results from previous CEDR road safety research programs? YES/NO
- We have never used CEDR results ☐
- We have used CEDR results as follows: ☐
    - Project 1:
    - Project 2:
    - Project 3:

- Have you found the output of previous research programs useful? YES/NO/Not Applicable
- If you answered ”YES” please provide examples.
  - Project 1:
  - Project 2:
  - Project 3:
- If you answered ”NO” please give reasons
  - ___________________
- Does your organisation have the ability to implement outputs of CEDR road safety research programs? YES/NO
- If you answered ”YES” please provide examples and indicate whether all or aspects of research programs were used.
  - Project 1:
  - Project 2:
  - Project 3:
- If you answered ”NO” please list the restrictions.
  - Project 1:
  - Project 2:
  - Project 3:

3. Country guidelines and standards applied in roadside design, road cross section design, maintenance and road works

- Does your country have a national guideline and/or standard for roadside design? YES/NO
  - If you answered ”YES” please provide a copy of the guidelines, hyperlinks, if available, or contact details for the relevant body that published these documents?
  - If you answered “YES” are you of the opinion that these guidelines/standards are up to date and sufficient for a high level of roadside safety?
  - If you answered “NO” are there typical situations which are not covered within the guidelines/standards? Please list examples
  - Within the roadside design guideline/standard is provision made for specific road users i.e. motorcyclists, cyclists, equestrians, pedestrians? YES/NO

- Does your country have a national guideline and/or standard for typical road cross section design?
  - If you answered "YES" please provide a copy of the guidelines, hyperlinks, if available, or contact details for the relevant body that published these documents?
  - Are soft shoulders common YES/NO
  - If you answered "YES" typically what shoulder width is provided?
  - Is it standard practice to provide unpaved (load bearing) shoulders? YES/NO
  - If you answered "YES" typically what shoulder width is provided?
- Does your country have a national guideline and/or standard for road maintenance? YES/NO
  - If you answered "YES" please provide a copy of the guidelines, hyperlinks, if available, or contact details for the relevant body that published these documents?
  - If you answered "YES" are you of the opinion that these guidelines/standards are up to date and sufficient for a high level of roadside safety?
  - If you answered "NO" are there typical situations which are not covered within the guidelines/standards? Please list examples
- Does your country have a national guideline and/or standard for road works? YES/NO
  - If you answered "YES" please provide a copy of the guidelines, hyperlinks, if available, or contact details for the relevant body that published these documents?
  - If you answered "YES" are you of the opinion that these guidelines/standards are up to date and sufficient for a high level of roadside safety?
  - If you answered "NO" are there typical situations which are not covered within the guidelines/standards? Please list examples

4. Role of Road Safety Audit and Road Safety Inspection in the design and management of (safe) roadsides and compliance with Directive 2008/96/EC Road Infrastructure Safety Management (RISM) (quality control in design and management/operations)

- Has the RISM Directive been implemented in your jurisdiction? YES/NO
- Are all parts of the RISM directive applied to all Trans European Network for Transport (TEN-T) roads?

Road Safety Impact Assessment (RSIA) ☐ YES/NO

Road Safety Audit (RSA) ☐ YES/NO

Road Safety Inspection (RSI) ☐ YES/NO

Network Safety Management (NSM) ☐ YES/NO

- As above but applied to projects falling on a Regional/Municipal Road Network

RSIA ☐ YES/NO

RSA ☐ YES/NO

RSI ☐ YES/NO

NSM ☐ YES/NO

5. Role of roadside safety performance monitoring through the use of crash statistics

- Does your organisation have established processes for the monitoring of roadside safety, through periodic review of roadside incident statistics? YES/NO
- If you answered “YES” please provide some details about:
  - How often the data is reviewed,
  - The amount of data available for each incident,
  - The quality of incident data available,
- If you answered “YES” are you of the opinion that the quality of incident data available is sufficient to be able to effectively identify the most important roadside safety issues on your network?
- If you answered “NO” what do you think are the reasons why roadside safety is not monitored through periodic review of incident statistics?

6. Definition of roadside hazards / obstacles

- Is “hazard” or “obstacle” in relation to roadsides a defined term within national guidelines and/or standards within your jurisdiction? YES/NO
- If you answered “YES” please provide the definition.

- If you answered “YES” which sections of the design and/or maintenance guidelines in Section 3 deal specifically with roadside hazards/obstacles and assessment of these?
- If you answered “NO” please indicate how an assessment of roadside hazards or obstacles is undertaken?
- Do the roadside safety standards / guidelines within your jurisdiction provide any guidance, with regards to roadside features and/or Road Restraint Systems (RRS) becoming hazards after the design phase, due to reasons such as: incorrect RRS installation, growth of vegetation, weather effects, RRS durability, RRS not performing with modern vehicles, etc.?
  - If you answered “YES” can you please provide some examples?
  - If you answered “NO”, are there other processes in place to ensure these hazards are detected at stages following the design?

7. Evaluation and selection of options

- Where a hazard or obstacle is present is there a guideline and/or standard which sets out a process to determine if the hazard or obstacle should be removed, relocated, redesigned, requires a road restraint system or other? YES/NO (If “other” please include details)
- If you answered “YES” is an order given in the guidelines which prioritises the measures i.e. Empirical relationship with crashes (described in guidelines), International Best Practice, Cost Benefit Analysis, Other (name)?

8. Typical problems associated with roadside safety

- Please list (typical) problems associated with roadside safety within your jurisdiction and give reasons (i.e. hazards within the verge or median, sealed/unsealed shoulders, shoulder drop-offs; lack of maintenance, etc)
- Does your organisation collect data on run off road crashes, single vehicle crashes and crashes with objects/hazards in the roadside? If so, please provide this information.
- Please provide an estimate (%) of the severity levels associated with run off road incidents.

Fatal ☐

Serious ☐

Minor Injury ☐

Material Damage Only ☐

- Please provide examples that are relevant to roadside safety, but for which there is insufficient regulation within the existing guidelines.

9. Typical problems (dilemmas) associated with applying the guidelines and/or standards (in all design stages)

- From the following list, please select the three most important difficulties that you have encountered when attempting to apply guidelines and/or standards relating to road side safety within your jurisdiction.
    - Cost implications (i.e. poor rate of return, lack of initial funding etc).
    - Guidelines do not align with the typical road layouts.
    - Insufficient space available to install a RRS.
    - Lack of information in the guideline.
    - Proposed scheme is fixed.
    - Other.
- Please list typical roadside design problems that have been identified by Road Safety Audits and whether these problems have been addressed.
- From the following list, please select the three most important difficulties that you have encountered when attempting to apply guidelines and/or standards relating to road maintenance within your jurisdiction.
    - Insufficient consideration of maintainability
    - Insufficient planning and design activities
    - Insufficient funding available
    - Traffic overloading (compared to projected traffic loading)
    - Untimely maintenance
    - Lack of inventory gathering
    - Other
- Please list typical roadside design problems that have been identified by Road Safety Inspections and whether these problems have been addressed.

10. Opinions related to clear zones versus application of guardrails/vehicle restraint systems (RRS) (i.e. optimising forgiving roadsides by using clear zones or road restraint systems)

- Within your jurisdiction is a forgiving roadsides philosophy promoted? YES/NO
- If you answered “YES” please provide the definition for a forgiving roadside.
- Within your jurisdiction is it policy to provide an obstacle free zone before a guardrail/RRS is installed? YES/NO
- When are guardrails placed as standard:
  - When a clear zone cannot be provided
  - When there are roadside hazards/obstacles that require protection
  - On road bends
  - Where shoulders and verges are soft
  - Other (name)
- Is there a policy within your jurisdiction that promotes RRS over clear zones or vice versa? YES/NO
- If you answered ”YES” please provide a copy of the guidelines, hyperlinks, if available, or contact details for the relevant body that published these documents?
- On new road schemes is the area of land available either side of the road typically sufficient to provide the required forgiving roadside by a clear zone/obstacle free zone? YES/NO
- On new road schemes is the area of land available either side of the road typically sufficient to provide the required forgiving roadside by a RRS most commonly used? YES/NO
- Have you experienced difficulties when attempting to install RRS due to poor ground conditions, existing utility ducting etc? YES/NO
- If you answered “YES” is there a process whereby a designer can develop a proposal for installing a bespoke system which is subject to the approval of the overseeing authority? YES/NO
- If you answered “YES” please provide an example of how this process operates.
- What RRS is predominantly used and to which standard is this applied?

11. Funding constraints and costs

- Are funding constraints and/or construction costs a factor when assessing whether to provide forgiving roadsides via the introduction of clear zones/obstacle free zones? YES/NO
- Are funding constraints and/or construction costs a factor when assessing whether to provide forgiving roadsides via the introduction of RRS? YES/NO

- Are funding constraints and/or construction costs a factor when assessing whether to remove an obstacle / a hazard versus implementing RRS? YES/NO

12. Role of contractors and consultants

- If you are part of a roads authority do you engage with consultants or contractors who regularly work with the standards to take part in updates to standards and/or guidelines? YES/NO
- If you are a consultant or contractor is there a mechanism for providing feedback to the roads authority or author of design standards and/or guidelines? YES/NO

13. Successful & innovative roadside safety risk mitigation measures (individual site level)

- With reference to any supporting material such as research papers, journals or articles etc. can you please provide examples of roadside safety risk mitigation measures adopted in your jurisdiction, which are shown to be successful in decreasing the number and severity of roadside safety incidents? These can be:
    - Measures adopted to stop vehicles from leaving the carriageway (such as rumble strip installation, public awareness campaigns targeting in-vehicle distractions, mandating lane keep assist system for all new cars, etc.),
    - Measures adopted to decrease likelihood of errant vehicles reaching hazards (such as hazard elimination, provision of wider clear zones, etc),
    - Measures adopted to decrease consequences of reaching roadside hazards (such as use of energy absorbing terminals, passively safe support structures, etc.)
- Can you please provide examples of new and innovative roadside safety risk mitigation measures, which are being trialled in your jurisdiction?

14. Successful & innovative roadside safety management processes (network level)

- With reference to any supporting material such as research papers, journals or articles etc. can you please provide examples of new and innovative processes adopted by your organisation, which are shown to be successful in improving the roadside safety in your jurisdiction? These can be:
    - Processes adopted to improve roadside safety at design stage (such as mandatory economic analysis, national roadside risk assessment software, adoption of new crash test requirements to cater for all road users, etc.),
    - Processes adopted to improve roadside safety at installation / construction stage (such as, mandatory training for RRS installers, national requirements for RRS foundations, RRS material property checks, etc.),

  - Measures adopted to maintain roadside safety over lifetime, i.e. at monitoring stage (such as, periodic in-depth roadside accident data analyses, monitoring crash performance of historic RRS when impacted with modern vehicles, etc.)

- Can you please provide examples of new and innovative roadside safety management processes, which are being trialled in your jurisdiction?

15. Pilot Projects

- Does your organisation have proposed or upcoming highways projects that may be suitable for assessing and optimising roadside safety using the tool which will be developed in a later work package (highways projects at all design stages are welcome)? YES/NO
  - If you answered “YES” please provide details of the project/s.
  - Project 1:
  - Project 2:
  - Project 3:

Appendix B Questionnaire Responses and Commentary

Knowledge and Relevance of Research Programmes

This section of the questionnaire requested the respondent's awareness, if any, of previous CEDR Safety Call programmes in order to gain an understanding of the potential impact of results from previous Safety Calls.

Awareness of Previous Research Programmes

The respondents were asked: *Are you or members of your organisation aware of previous Conference of European Directors of Roads (CEDR) road safety research programmes?* Figure 1 shows the responses received (33)

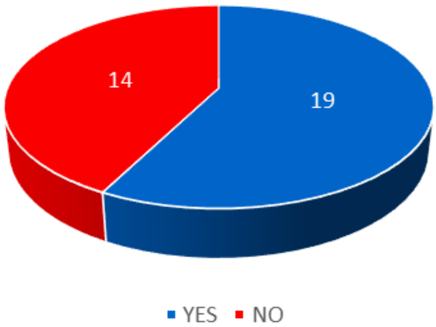


Figure 7 – Awareness of Previous CEDR Road Safety Research Programmes

Those that were aware (19) were asked: *Please provide a list of previous CEDR road safety research programmes*. A summary of the responses received is presented in Table 1:

Table 2: Knowledge of previous CEDR Safety research programmes

Programme Title	Programme Year	Number of Mentions	Programme Title	Number of Mentions
ADVERTS	Call Safety 2016	3	PRACT	4
ASAP	Call Safety 2012	7	PREMIUM	2
BROWSER	Call Safety 2012	9	RISER	1
ERANET	-	3	RISMET	4
ERASER	Call Safety 2009	2	SAFEROAD	2
ESReT	Call Safety 2013	4	SANA-4-U	2
EuRSI	Call Safety 2009	3	SAVeRS	14
EuSIGHT	Call Safety 2013	4	SPACE	2
IRDES	Call Safety 2009	4	STARS	2
IRIS	Call Safety 2016	2		

Results of Previous Research Programmes

Those that were aware (19) were asked: *Have you or members of their organisation made use of results from previous CEDR road safety research programmes?* Figure 2 shows the responses received (19)

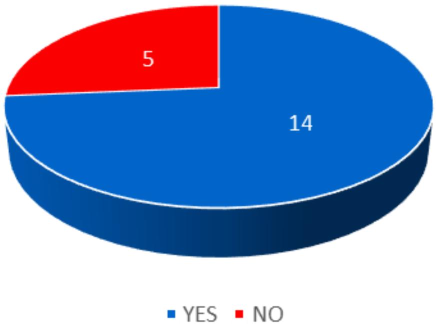


Figure 8 – Use of the Results of Previous CEDR Programmes

Usefulness of Output of Previous Research Programmes

The 19 respondents that were aware of previous CEDR Programmes were asked: *Have you found the output of previous research programmes useful?* Figure 3 shows the responses received (19).

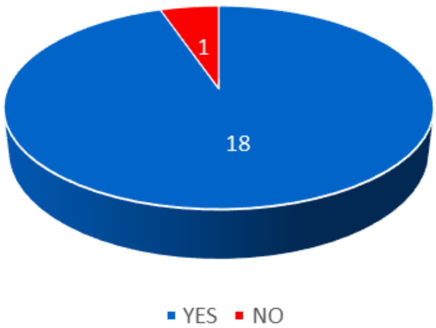


Figure 9 – Previous Program Outputs Useful?

Figure 3 shows that 18 respondents found the outputs of previous CEDR programmes useful. These respondents were asked to provide examples, which included the following:

- Writing country guidelines
- General information
- Forgiving roadside manual information
- Utilisation of the SAVeRS programme to assist in crash probability

- Exchange of lessons learnt

The 14 respondents that did not find the outputs of previous CEDR Programmes useful were asked to provide an explanation as to why not. The answers provided included the following:

- CEDR findings not able to supersede the national guidelines.
- CEDR outputs would require updating or revision of the standards to be implemented.
- The SAVeRS tool that was extracted from the program was the same as an existing tool (RRRAP) making the output tool of CEDR redundant.
- Regarding SAVeRS, there was no additional value in relation to our knowledge.

Ability to Implement Outputs of Previous Research Programmes

The respondents were asked: Does your organisation have the ability to implement outputs of CEDR road safety research programs? Figure 4 shows the responses received (33).

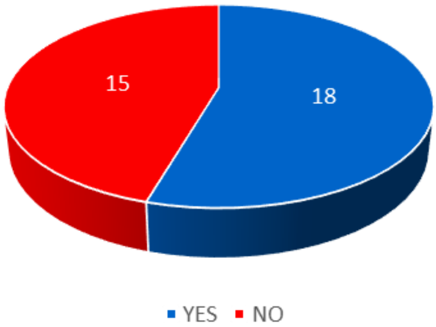


Figure 10 – Ability to Implement Outputs of CEDR Road Safety Research Programmes

Those that responded positively (18) were asked to provide examples and indicate whether all or aspects of research programmes were used. A selection of the responses received is included below:

- Outputs of CEDR road safety research programs often require changes in the “law”. The road authority is not able to make any changes to the applicable traffic safety regulations.
- SAVeRS and BROWSER were both mentioned as implemented programmes.
- Aspects of EuRSI included within RSI standard.
- Most issues are interesting and probably useful. It's better that there is one European organisation to give guidelines, instead of every nation working on the same problems and comes with different solutions.
- As part of RSA and RSI.
- Collaboration in the development of national guidelines.

Those that responded negatively (15) were asked to provide examples of restrictions. A selection of those responses is included below:

- Financial issues.
- We are in a position to implement if we want to but we didn't feel the need to implement. Also, in the past CEDR project results were in the form of research reports, which were difficult to implement, because of the nature of the deliverable. E.g. unclear implementation strategy
- The road authority may accept a calculated risk meaning the findings / recommendations may be ignored if for instance the benefit / cost ratio is too low;
- Too much distance between the results of the research and the needs of our organisation. "We want to improve the dissemination and the implementation of the results".
- The respondent that mentioned that the information is "very good" also stated that CEDR reports are too large and contain too much information.

Country Guidelines and Standards Applied in Roadside Design, Road Cross Section Design, Road Maintenance and Road Works

This section of the questionnaire requested the respondents to indicate whether their jurisdiction have design standards relating to roadside design, road cross section design, road maintenance and road works.

Roadside Design Standards

The respondents were asked: *Does your country have a national guideline and/or standard for roadside design?* Figure 5 shows the responses received (33).

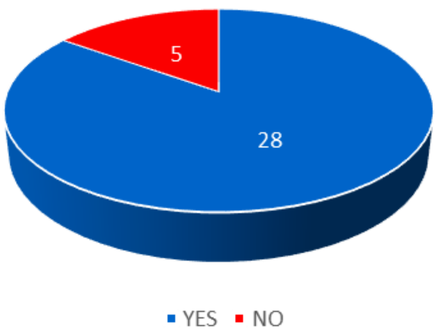


Figure 11 – Roadside Design Standards

Upon further investigation, the 5 "No" responses included 2 from Germany where roadside design is covered in several design standards, 2 from Austria where roadside design is also covered in several design standards and 1 from Luxembourg which utilise the standards and guidelines of France, Germany and Switzerland.

Guideline/Standard Suitability

Those that responded positively (28) were asked: *If you answered "Yes" are you of the opinion that these guidelines/standards are up to date and sufficient for a high level of roadside safety?* Figure 6 shows the responses received (28).

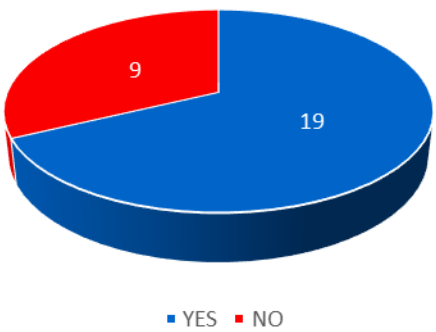


Figure 12 – Roadside Design Standard Sufficient for a High Level of Roadside Safety

Negative Responses – Examples of Shortcomings

Those that indicated that the standards/guidelines were not suitable (9) were asked to provide examples of typical situations which are not covered within the guidelines/standards. A selection of those responses is included below:

- Forgiving roadsides solutions are not covered.
- There are no relevant standards for roadside design to determine clear zones for errant vehicles, without road restraint systems (RRS).
- The last update was done in 2005 and standards need updating.
- It doesn't cover roads under 50mph (80km/h) and low capacity roads with less than 5,000 vehicles per day.
- There has not been a review of the design speeds in the standards though with speed limit regime change from 120 to 130 km/h (75 to 80 mph).
- The application of these guidelines could use improvement (e.g. meaning and requirement of Vehicle Intrusion for vehicle restraint systems (VRS)).
- National guidelines sometimes are developed by the scientific community without the involvement of road authority.

Provision for Specific Road Users

Those that indicated that their country has a national guideline and/or standard for roadside design were asked: *Within the roadside design guideline/standard is provision made for specific road users i.e. motorcyclists, cyclists, equestrians, pedestrians?* Figure 7 shows the responses received (28).

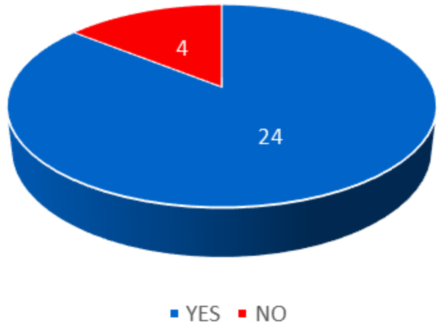


Figure 13 – Specific Road Users Accounted for within the Standard

The respondents that answered “No” were from Belgium (x 2), Italy and Portugal. In the case of Belgium, it should be noted that 2 other respondents answered “Yes” so the result is inconclusive. In the cases of Italy and Portugal, it is concerning that the respondents have indicated that there are no specific provisions for motorcyclists or non-motorised users.

Road Cross Section Design

The respondents were asked: *Does your country have a national guideline and/or standard for typical road cross section design?* Figure 8 shows the responses received (33).

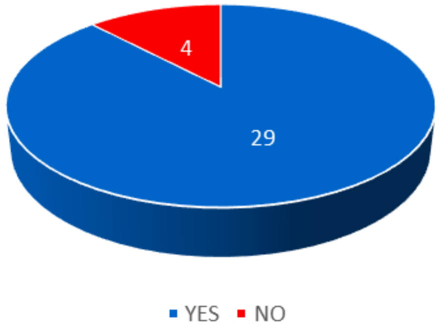


Figure 14 – Typical Cross Section Design Standard

Soft Shoulders

A soft shoulder is the edge of a road which is constructed from soil rather than hard material.

The respondents were asked: *Are soft shoulders common?* Figure 9 shows the responses received (33).

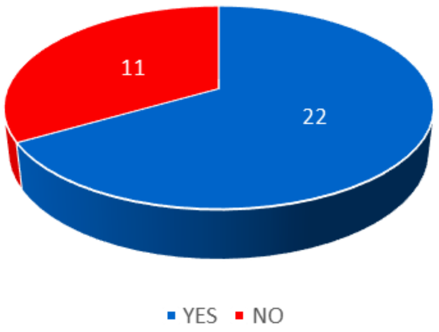


Figure 15 – Are Soft Shoulders Common?

The majority of respondents (22) indicated that soft shoulders are common within their jurisdiction. The same respondents indicated that the width of soft shoulders ranges from 0.25m to 2.50m and is dependent on the road type and design class.

Unpaved (Load Bearing) Shoulders

The respondents were asked: *Is it standard practice to provide unpaved (load bearing) shoulders?* Figure 10 shows the responses received (33).

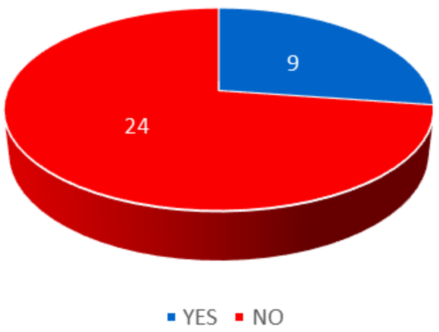


Figure 16 – Standard Practice for Unpaved Shoulders

Road Maintenance Guideline and/or Standard

The respondents were asked: *Does your country have a national guideline and/or standard for road maintenance?* Figure 11 shows the responses received (33).

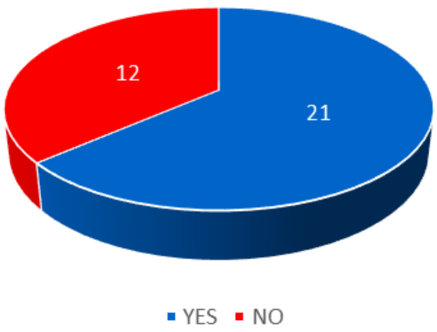


Figure 17 – Road Maintenance Guideline/Standard

A number of respondents that answered “No” included text to state that road maintenance practices are covered in their standards but that a specific standard/guideline does not exist.

Guideline/Standard Suitability

The respondents were asked: *If you answered "Yes" are you of the opinion that these guidelines/standards are up to date and sufficient for a high level of roadside safety?* Figure 12 shows the responses received (21).

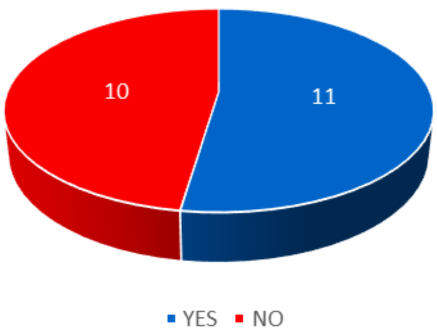


Figure 18 – Road Maintenance Standard Sufficient for a High Level of Roadside Safety

Negative Responses – Examples of Shortcomings

The respondents were asked: *If you answered "No" are there typical situations which are not covered within the guidelines/standards?* A selection of the responses is included below:

- Surplus of information for new builds. Maintenance guidelines minimal.
- Motorways are addressed but other carriageway types are not addressed.
- Document requires significant revision and was never formally published.
- Within the past few years, it becomes obvious in Germany and other European countries that the description of the durability, regulated by the product standard EN 1317-5 and the monitoring based on that standard have to be improved.
- Road maintenance standards currently being reviewed and updated.

Road Works Guideline and/or Standard

The respondents were asked: *Does your country have a national guideline and/or standard for road works?* Figure 13 shows the responses received (33).

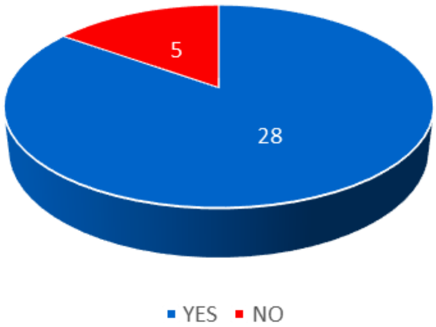


Figure 19 – Road Works Guideline/Standard

Two respondents that answered "No" to the above question included explanatory text as follows:

- "Luxembourg utilise the standards and guidelines of mainly Germany, France and Switzerland".
- "We have a series of guideline drawings for various types of roadworks (temporary, long term)" (Cyprus)

Guideline/Standard Suitability

Those that responded positively were asked: *If you answered "Yes" are you of the opinion that these guidelines/standards are up to date and sufficient for a high level of roadside safety?* Figure 14 shows the responses received (28).

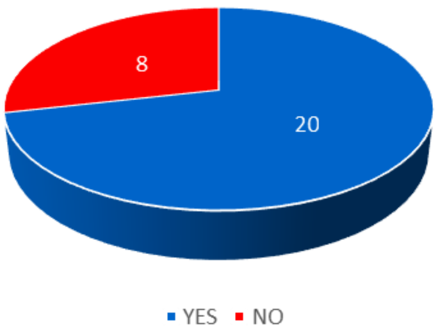


Figure 20 – Road Works Standard Sufficient for a High Level of Roadside Safety

Negative Responses – Examples of Shortcomings

Those that responded negatively were asked to provide typical situations which are not covered within the guidelines/standards. A selection of those responses is included below:

- Updating in process; revisions to current design guidelines and to road worker safety aspects.
- Roadside issues are not part of the respective guideline.
- These standards are not always followed.
- Very difficult to update the law, through government. Not done often. Too many sub laws implemented by ministry. Motorway agency has guidelines but cannot address everything on their own.
- There is only a manual for signage at road works and temporary situations.
- The standards are not always followed or used.
- Several responses stated that road works standards are currently being reviewed or updated.

Role of RSA and RSI and Compliance with Directive 2008/96/EC

This section of the questionnaire was designed to gather information relating to the role that RSA and RSI play and the implementation of the RISM Directive in each jurisdiction. The questionnaire was undertaken prior to the agreement between the European Parliament and the European Council on the updating of the RISM Directive. The main improvements rely on the extension beyond the current TEN-T network and covering all “primary roads” as well as all non-urban roads built using EU funding along with other changes including road markings and signs.

The RISM Directive details specific procedures relating to road safety covering the Trans-European Network for Transport (TEN-T). The purpose of the legislation was to ensure that road safety is taken into account in all phases of the planning, design and operation of road infrastructure; to promote a high and consistent level of road infrastructure safety across Member States and to target limited available funds on more efficient road construction and maintenance. The Directive required the establishment and implementation of procedures in all Member States relating to:

- Road Safety Impact Assessments (RSIA)
- Road Safety Audit (RSA) & Training Requirements
- Safety Ranking & Management of the road network in operation (NSM)
- Road Safety Inspection (RSI)

RISM Directive Implementation

The respondents were asked: *Has the RISM Directive been implemented in their jurisdiction?* Figure 15 shows the responses received (33).

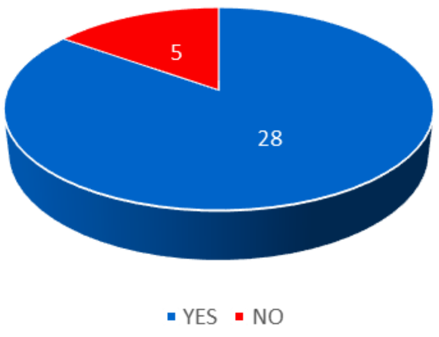


Figure 21 – RISM Directive Implementation

Following an analysis of the "No" responses it became apparent that these were received from those working in Regional or Local Road Authorities which have no responsibility for TEN-T roads within their jurisdiction. As a result, the graphical information presented in 2.4.2 and 2.4.3 only relates to the "Yes" responses (28).

RISM Directive Applied to all TEN-T Roads

The respondents were asked: *Are all parts of the RISM directive applied to all Trans European Network for Transport (TEN-T) roads?* Figure 16 shows the responses received (28) and represents 15 countries.

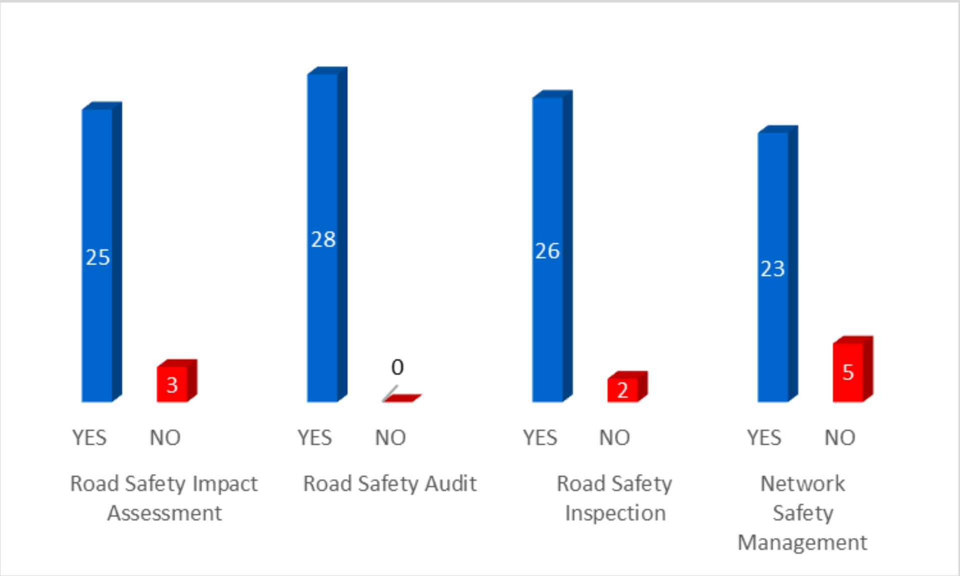


Figure 22 – RISM Directive Application to all TEN-T Roads

RISM Directive Applied to Non-TEN-T Roads

The respondents were asked: *Are all parts of the RISM Directive applied to projects falling on a Regional/Municipal Road Network?* Figure 17 shows the responses received (28) and represents 15 countries.

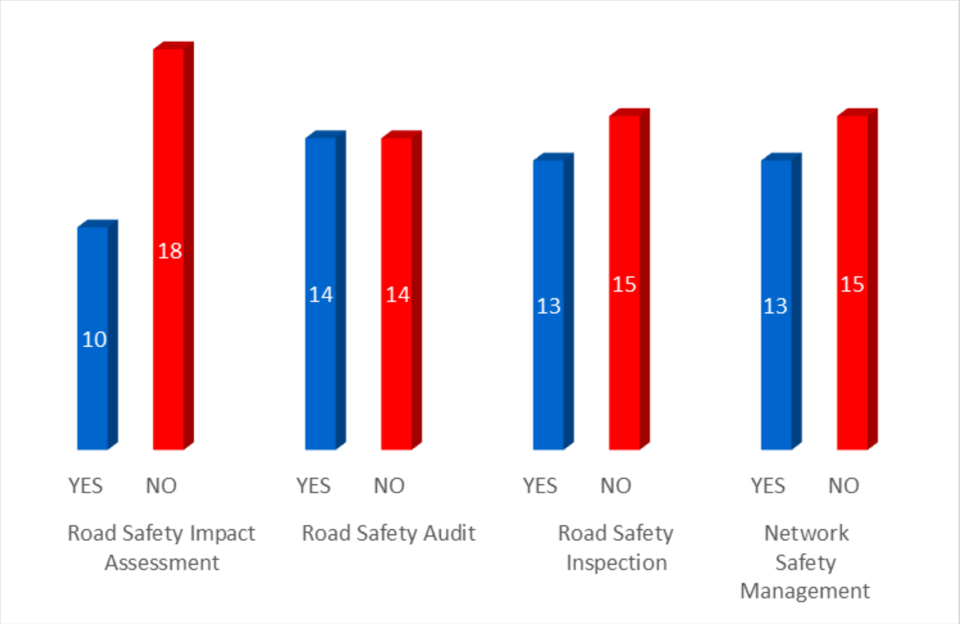


Figure 23 – RISM Directive Application to all Non-TEN-T Roads

Role of Roadside Safety Performance Monitoring through the use of Crash Statistics

This section of the questionnaire was designed to gather information relating to the role of roadside safety performance through the use of crash statistics in each jurisdiction.

Roadside Safety Monitoring

The respondents were asked: *Does your organisation have established processes for monitoring of roadside safety, through periodic review of roadside incident statistics?* Figure 18 shows the responses received (33).

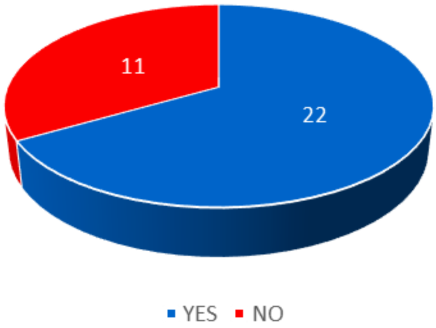


Figure 24 – Processes for Monitoring Roadside Incidents

Positive Responses – Further Information

Those that responded positively were asked to provide details about:

1. How often the data is reviewed.

The responses relating to the frequency of data review ranged from daily – monthly – biannually – annually. In Sweden, fatal accidents are analysed 8-10 per year. In Ireland, an annual review of the previous three years is undertaken. In the UK, detailed road safety data about the circumstances of personal injury road accidents (STATS 19) is reviewed every six months

2. The amount of data available for each incident

The amount of data available varies across the countries for which responses were received. In Italy, approximately 50 information points are available for use. In Poland location of the accident, date and hour of accident, information on the road such as area type, road type, junction type incl. signalling, number of lanes, markings, road surface, lighting and weather conditions, speed limit, roadside obstacles, accident severity, including number of fatalities and injured persons, data on the vehicles involved, accident data such as accident type, collision type, vehicle and driver manoeuvre are recorded. In the UK, the level of detail available in STATS-19 is insufficient, because it doesn’t record events occurring outside of the carriageway very well. For example, it only records first object hit off carriageway but doesn't record any other objects hit afterwards, including the ones which may be the primary cause for fatal injury. So, it is not good enough to make detailed analysis on roadside incidents.

3. The quality of incident data available.

The quality of data recording at collision sites can vary as it is generally the attending police that collect the data, and this is not their priority once they arrive at a collision site. A number of respondents also stated that there can be issues when accurately recording the location of collisions which can potentially lead to cluster sites not being identified properly.

Those that responded “Yes” were also asked if these processes are sufficient to be able to effectively identify safety issues on their network. A selection of those responses is included below:

- Yes - Fully Integrated with Police and Hospitals. Very good.
- Depends greatly on the severity of the incident. Lesser severity incidents have lower registration rates and details on the incident.
- Yes and no. For example, it always identifies trees which is known to be a problem. But it also identifies other objects (coded as "other object") which we don’t know what they are. It is useful for trends of objects which are listed in the accident record form, however there is a whole level of unknown trends about objects which are not listed on the form.
- 148 possible characteristics.
- Yes, updated Road Safety Authority website very helpful - map and data sufficient.
- Yes. Very good data for the road sections on which RSI has been performed but also, we can look at the place for all major roads in Google maps or similar.

Negative Responses – Further Information

Several respondents claimed their incident monitoring is not effective. A selection of those responses is included below:

- There is still a fairly significant problem with the location of accidents. The percentage of incorrectly located accidents is over 20%.
- Depends greatly on the severity of the incident. Lesser severity incidents have lower registration rates and details on the incident.
- Accident data is not sufficient.
- Lack of data concerning hazardous roadside objects and lack of resources.
- Legislative guidelines (RPS) on how to deal with danger spots and which passive safety barrier has to be installed.
- An unspecific monitoring takes place. Problematic cases are discussed in a Group of representatives of the state governments and the national government. Furthermore, regarding noticeable problems/special cases.
- Because the crashes are spread out over the road network, there is too less information to determine a statistic reliable measure. In our opinion it works better if you have a strategy on risk assessment.
- Adequate / detailed incident statistics are not available.

Definition of Roadside Hazards / Obstacles

This section of the questionnaire was designed to gather information relating to the definition of roadside hazards / obstacles, if a definition exists, in each jurisdiction.

Hazard/Obstacle Definition within Guideline and/or Standard

The respondents were asked: *Is hazard or obstacle in relation to roadsides a defined term within national guidelines and/or standards within your jurisdiction?* Figure 19 shows the responses received (33)

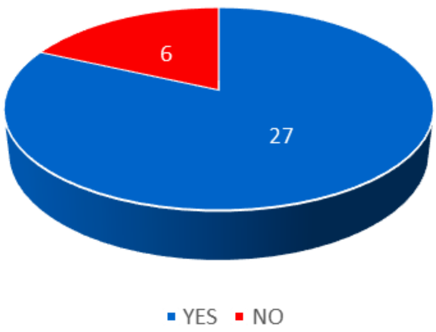


Figure 25 – Hazard/obstacle defined within guideline and/or standard

Those that responded positively were asked to provide the definition and reference within the guidelines and/or standards which is included in Table 3 below.

Table 3: Hazard/ Obstacle Definition and Reference within the Guideline and/or Standard

Country	Definition	Reference
Austria	Elements of the near roadside in connection with the artificial or natural subsurface	A new and specific guideline will be published soon.
	Not a static definition, a risk-based methodology will be used.	
Belgium	Fixed object that, in the event of a collision, causes delays in vehicle, causes serious damage to the vehicle and / or increases the risk of serious (fatal) injury to the occupants or third parties.	Handboek Vergevingsgezinde Wegen (Handbook of Forgiving Roads) Chapter 4
Germany	An area or a section next to the roadway, in which hazards exist for uninvolved third parties, areas or occupants of vehicles requiring protection if vehicles depart the roadway.	
	Obstacle or hazard is defined depending on the distance to the road and slope of the embankment next to the verge	

Country	Definition	Reference
	The hazard potential is differentiated according to four hazard levels: **Hazard level 1**: areas with a special risk to third parties requiring protection (such as chemical plants at risk for explosions, intensively used locations, adjacent rapid transit lines with approved speeds of > 160 km/h (100mph), structures at risk of collapse). **Hazard level 2**: areas with a special risk to third parties requiring protection (such as adjacent heavily frequented walkways and bicycle paths, adjacent rail lines with more than 30 trains/24 h, adjacent roads with ADT > 500 vehicles/24 h). **Hazard level 3**: obstructions with a special risk to vehicle occupants (such as non-deformable extensive obstacles vertical to the direction of travel, non-deformable select individual obstacles, noise barriers). **Hazard level 4**: obstructions with a special risk to vehicle occupants (such as still deformable, circumnavigable / shearable selective individual obstacles, crossing ditches, rising slopes (1: 3 inclination), dropping slopes (Height > 3 m and inclination of > 1: 3), water with a depth of > 1 m, wild water).	Richtlinien passiven Schutz an Straßen durch Fahrzeug Rackhaltesysteme (Guidelines for passive protection on roads by vehicle restraint systems) - RPS 2009
Ireland	A hazard is any physical obstruction which may, in the event of an errant vehicle leaving the carriageway, result in significant injury to the occupants of the vehicle	TII Publication DN-REQ-03034 Safety Barriers

Country	Definition	Reference
Italy	Fixed obstacles (front or side) that could constitute a danger for road users in the event of a collision, such as bridges abutments, outcropping rocks, drainage works that cannot be crossed, trees, lighting poles and supports for non-compliant signs, waterways, etc., and the artefacts, such as public or private buildings, schools, hospitals, etc., which in case of spillage or impact of vehicles they could be damaged, thus causing danger even for non-road users	The Minister of Infrastructure and Transport Ministerial Decree number 2367 21-06-2004
Netherlands	An obstacle/hazard within 4,5m which will cause severe injuries to driver and passengers in case of run off road accidents.	Paragraf 2.2 of Richtlijn ontwerp autosnelweg (ROA): Veilige Inrichting van Bermen (Highway design directive: Safe Installation of Roadside)
Portugal	Lists of obstacles (there is no definition): Trees over 0,20 m in diameter, sign poles over 0,10 m in diameter, lighting, electricity and telephone poles over 0,20 m in diameter, S.O.S telephone booths, safety barriers, curbs, fences, deep ditches and other dangerous drainage devices, pillars of bridges and viaducts, retaining walls, high / steeped slopes, adjacent roads and railways, adjacent water surfaces.	Institute of Infrastructure publication: Manual Sobre Aspectos de Segurança - Área Adjacente à Faixa de Rodagem (Manual About Safety Aspects - Area Adjacent to the Strip)
Sweden	Hazards are referred to as larger solid objects, for example: Trees diameter >100 mm, Bridge pillars, Concrete foundation or earthbound stones higher than 0,1 m, Electricity connection cabinets, Rock cut, Houses, walls etc, Posts that are not yielding according to EN12767.	Vägar och gator utformning, VGU (Roads and streets design)

Country	Definition	Reference
United Kingdom	A hazard is a feature (e.g. embankment) or object (e.g. lighting column) that can cause harm or loss. Harm or loss can be physical, financial or economic, strategic, or be time-based, or any combination of these.	Highways England/Transport Scotland/Welsh Government/Department for Infrastructure publication: TD 19/06 Requirement for Road Restraint Systems

Those that responded negatively were asked: *If you answered "No" please indicate how an assessment of roadside hazards or obstacles is undertaken?* The information provided is included in Table 4.

Table 4: Hazard/ Obstacle Assessment

Definition	Country
This is often done empirically through maintenance and inspection crews, through the results of a black spot study and based on best practices	Cyprus
Assessment of maintenance service or in coordination with tree inspectors	Germany
General Directorate for National Roads and Motorways is using: https://www.gddkia.gov.pl/userfiles/articles/z/zarzadzenia-generalnego-dyrektor_2677/documents/Wytyczne_Bariery.pdf but these guidelines are not commonly used on other roads	Poland

Roadside Features and/or RRS Becoming Hazards after the Design Phase

The respondents were asked: *Do the roadside safety standards / guidelines within your jurisdiction provide any guidance, with regards to roadside features and/or Road Restraint Systems (RRS) becoming hazards after the design phase, due to reasons such as: incorrect RRS installation, growth of vegetation, weather effects, RRS durability, RRS not performing with modern vehicles, etc.?* Figure 20 shows the responses received (33):

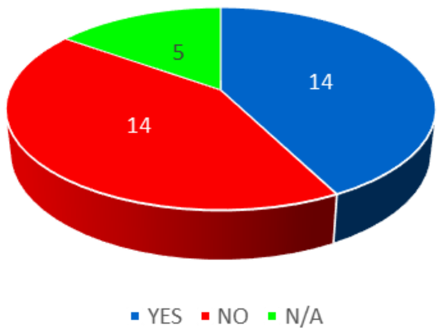


Figure 26 – Roadside Furniture as Hazards

Those that responded “Yes” were asked to provide examples of guidance, with regards to roadside features and/or Road Restraint Systems (RRS) becoming hazards after the design phase, due to reasons such as: incorrect RRS installation, growth of vegetation, weather effects, RRS durability, RRS not performing with modern vehicles, etc. The responses received (14) included:

- A guideline inspection protocol is used to monitor the obsolete guardrail constructions and to schedule maintenance. In addition, the road must be redesigned in the case of new construction and reconstruction must be in accordance with the current ROA VIB guideline. In this way, RWS ensures that obsolete designs meet the current guidelines when reconstructed. RWS also has a guideline on how to deal with emergency damage in order to repair the damaged guiderail constructions and verges.
- ZTV FRS, Umgang mit Reparaturen, Forderung nach Dauerhaftigkeit 25 Jahre fur FRS [Handling repairs, requirement for durability 25 years for Vehicle Restraint Systems]. This document gives guidelines on whether it is necessary to repair a RRS, e.g. a steel barrier has to be replaced if a deformation is more than 30cm. If a deformation is less than 30cm the RRS can be repaired. A deformation could be the result of an accident or caused by a slope slide, a tree falling down after a storm, etc. A system made of concrete has to be repaired if a scratch is deeper than 3cm, a fragment of more than 2 kg is missing, there are more than 3 cracks within 1 element or if the system is displaced by more than 10% of the dynamic deflection measured by testing with an HGV.
- Regulations are mentioned in an official letter of the federal Ministry of Transport and Digital Infrastructure (ARS 11/2013, BMVI).
- If VRS are not installed properly, such as unprotected ends of parapets.
- Incorrectly installed or maintained.
- Boundary fences are now considered as hazards within the clear zone.
- The vegetation sometimes develops differently than predicted.

Those that responded “No” were asked whether there are other processes in place to ensure these hazards are detected at stages following the design phase. The responses received (14) are summarised as:

- No processes in place.
- Part of asset management processes.
- Assessed as part of RSI.
- Reporting by the general public.

Evaluation and Selection of Design Options

This section of the questionnaire was designed to gather information relating to the evaluation and selection of design options in each jurisdiction to determine whether there are common processes or processes that could be applied across all Member States.

The respondents were asked: *Where a hazard or obstacle is present is there a guideline and/or standard which sets out a process to determine if the hazard or obstacle should be removed, relocated, redesigned, requires a road restraint system or other?* Figure 21 shows the responses received (33).

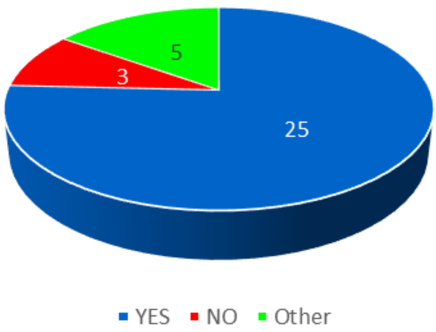


Figure 27 – Process to determine if a hazard should be removed, relocated, redesigned, requires a RRS or other within design guideline and/or standard

It can be seen that the majority of countries have a process for dealing with hazards either by way of a dedicated standard/guideline or alternative as per the detailed responses below. The countries that indicated that they have no such process were Italy, Poland and Portugal.

Those that responded "Yes" were asked: *is an order given in the guidelines which prioritises the measures i.e. Empirical relationship with crashes (described in guidelines), International Best Practice, Cost Benefit Analysis, Other (name)?* Following a review of these responses (25) the general order of preference appears to be:

1. Remove the hazard.
2. Reduce the hazard severity, in the event of a collision.
3. Redesign by way of moving the hazard.
4. Protect with a VRS.

Those that responded "Other" were asked: *If you answered "Other" please provide the definition.* Their responses (5) can be summarised as follows:

- Maintenance and inspection crews apply their knowledge and experience when making an assessment.
- Each case is assessed individually.
- There is guidance which states that removing, relocating, redesigning, etc are acceptable options to the designer. However, there is no guidance about which one is more preferable.

Typical Problems Associated with Roadside Safety

This section of the questionnaire was designed to gather information relating to typical problems associated with roadside safety in each jurisdiction. It was also intended to gather information relating to data collection for single vehicle and run off road crashes as well as crashes with objects/hazards in the roadside.

The respondents were asked: *Please list (typical) problems associated with roadside safety within your jurisdiction and give reasons (i.e. hazards within the verge or median, sealed/unsealed shoulders, shoulder drop-offs; lack of maintenance, etc)* The responses received (33) have been categorised by the sector from which they were received as follows:

National Road Authority

- Hazards within the verge.
- The amount of money needed to make the roadside comply to the current standard, including maintaining the roadside.
- Insufficient maintenance
- Old guardrail installations.
- Unsealed shoulders, too narrow shoulders, worn shoulders.
- Very long sections with acoustic screens have been built, which causes great fatigue while driving.
- Road restraint systems (RRS) providing inadequate containment levels, insufficient length of the RRS, insufficient working space for the RRS, inadequate transitions and end treatments (terminals, implementation details).

Regional Road Authority

- Narrow cross-sections.
- Collapse-endangered structures (cantilevers with or without impact base)
- Lack of maintenance and control of vehicle restraint systems.
- Insufficient space for obstacle-free zone.
- Retrofitting the existing network.
- Landscape and environment protection.
- Roads have developed for many years. The road became more crowded, vehicles are driving faster, cars/trucks become bigger, but the roadsides didn't develop with it.
- Inadequate sight lines, service poles, fencing and walls.

Research Institute, road operators, consulting engineers and universities

- Roadside hazards.
- The necessity of installations of poles in the context of the digitalisation of Germany is a challenge.
- Shoulder drop-offs on minor roads, inclination of slopes.
- No respect of clear zones as mandatory by national law.
- Lack of maintenance of entrances - vegetation on regional roads in particular.
- Vehicle restraint systems not conforming with EN 1317
- Vertical alignment, sight distances.

It can be seen from the above that unprotected hazards, with specific mention to trees, at the roadside is an issue across all sectors surveyed. Insufficient space for obstacle free zone/clear zone has also been identified across most sectors. Incorrect use of VRS and substandard/non-compliant designs has also been highlighted as an issue.

The respondents were asked: *Does your organisation collect data on run off road crashes, single vehicle crashes and crashes with objects/hazards in the roadside?* Figure 22 shows the responses received (33)

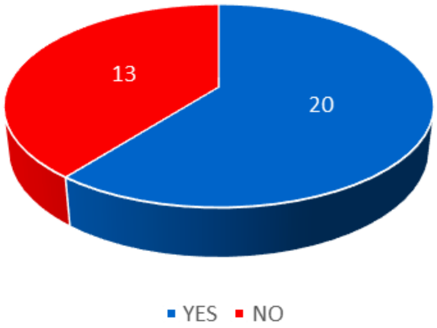


Figure 28 – Data Collection – Incidents

Those that responded positively (20) were asked to provide this information. The responses received were as follows:

- www.bast.de (Federal Highway Research Institute) publishes information relating to road traffic counts and traffic and accident data or www.destatis.de (Federal Office of Statistics) which publishes road accident statistics for Germany.
- Besides data from the national crash database (registered by the police), SWOV analyses each crash on national roads, contributing factors to the crash and the severity of injury.
- Stats 19 and Crash and Highways England Fatal collision records.
- Part of national accident statistics (detailed dataset) https://www.statistik.at/web_de/statistiken/energie_umwelt_innovation_mobilitaet/verkehr/strasse/unfaelle_mit_personenschaden/index.html
- Data acquired from ISTAT give us some of that information, in particular data of run off road crashes, and single vehicle crashes. For crashes with objects/hazards, we know if the car hit an accidental obstacle on the carriageway, but we don't know if the obstacle was in the middle or at the edge.
- The data below refer to 2016 in Ireland. We have official data only on accidents with injuries and/or deaths, without distinguishing between minor and serious injuries:
  - Fatal 11.9 % on national primary roads
  - 8.1 % on national secondary roads
  - Serious 14.4 % on national primary roads
  - 9.2 % on national secondary roads
  - Minor Injury 14.8 % on national primary roads
  - 10.4 % on national secondary roads
  - Material Damage Only Data on MDO not currently processed for this time period
- This information is available from our national road authority, who provides all the data to Viastat.

- Data is collected during in-depth studies for fatal accidents.
- For the period 2012-2016, 55% of the total sum of serious and fatal accidents on rural state roads in Iceland, were single-vehicle crashes, and in addition 3% were crashes were a vehicle crashed into a fixed object.
- Report on the state of road traffic safety for national roads for which the traffic management body is General Director of National Roads and Highways.

The respondents were asked: *Please provide an estimate (%) of the severity levels associated with run off road incidents.* Figure 23 shows the responses received:

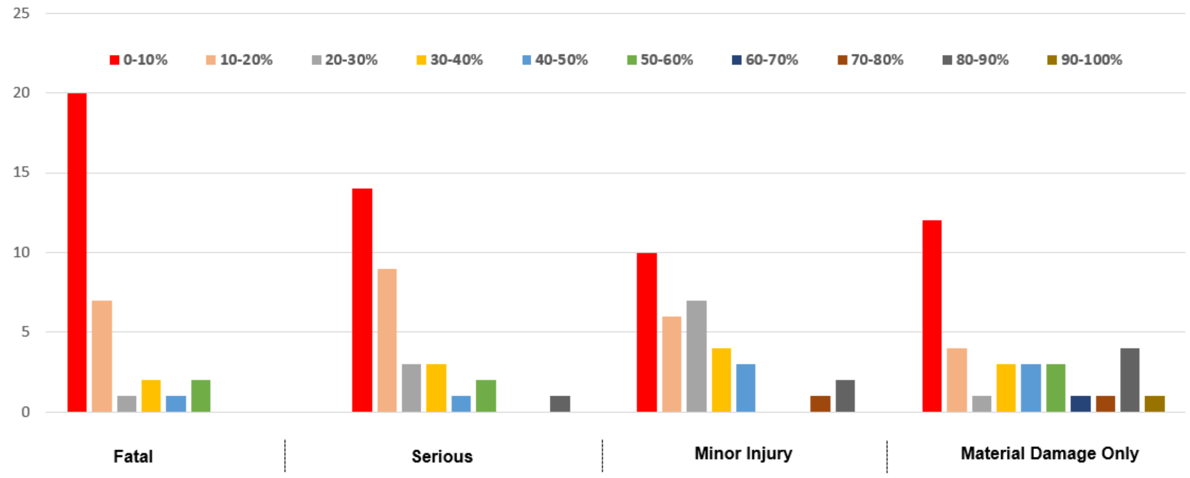


Figure 29 – Data Collection – Run off Road crashes

It can be seen from the responses received that the 20 of the 33 respondents indicated that between 0 – 10% of run off road crashes result in fatality/fatalities. This figure may appear to be low when compared to the European Transport Safety Council publication "Reducing Deaths in Single Vehicle Collisions (2017) which states *"In the EU as a whole, deaths in single vehicle collisions represented 30% of all road deaths in 2014, a proportion unchanged since 2006* [10]. It is noted however that the 30% figure quoted above relates to all urban and rural road types across the EU and that the majority of single vehicle collisions are run off road collisions. As a result, it may be the case that 10% figure may be appropriate.

The respondents were asked: *Provide examples that are relevant to roadside safety, but for which there is insufficient regulation within the existing guidelines.* The responses received have been categorised by the sector from which they were received as follows:

<u>National Road Authority</u>

- Maintenance of VRS. Retrofit. Repair.
- Severity levels associated with ROR incidents are not monitored in Luxembourg.
- Wooden Boundary Fencing (recently found to be very high risk but regulations do not yet recognise it as high risk and therefore they are often not shielded by barrier).
- Inspection of barriers not being done properly.
- Not enough guidance about proper VRS installation.

- Difference between the ground conditions during VRS impact test and the installation on site.
- Effects of using different VRS anchorages than those used during the impact test.
- Changes in VRS material between test and installation.
- Changes in vehicle structures over last few decades and the date and age vehicle at the time of testing. For example, some test houses in Europe are still using Fiat Uno's from 1980s (pre-dating UN regulations and NCAP), which do not represent today's vehicle fleet. Completely different structure. When a modern vehicle hits the same barrier, it goes through.
- No guidance or available VRS product to contain SUVs.
- Transitions between different manufacturers products.
- Fake CE certificates and copying of products.
- Outdated Requirements
- Over-reliance on manufacturers to provide information about their products.
- Roadside Advertising.

Regional Road Authority

- Application of restraint systems along water for distributor roads.
- In practice it's difficult when trees and slopes, canals and ditches are close to the roadside.

Research Institute

- Recommendations on the type of action for different hazards and proper recommendation to decide for specific actions (cost-benefit, etc).
- For RRS a general problem exists: The current European regulations are covering the test conditions for the determination of the performance data of RRS. These requirements have been developed 20 years ago taking different boundary conditions as well as traffic safety into account. Based on these regulations RRS are developed targeting the optimal economical results. This leads to the fact that the rest-capacity of the systems is limited.

Road Operator

- Depends on Road Category and speed.
- No national standards are available to evaluate clear zones and related roadside design.

Consulting Engineer

- Regional and Local Road Design.
- A lot of cases are covered within the guidelines. This limits the possibilities to develop specific solutions where necessary.

It can be seen from the responses received that there appears to be concern relating to insufficient information provided in the design standards regarding maintenance or repair of existing VRS, a lack of guidance relating to installation, outdated design standards, lack of design standards for the lower order roads and also concern regarding the requirements of

EN 1317 when compared to the change in the vehicle fleet on European roads in the last 20 years.

Typical Problems (Dilemmas) Associated with Applying the Guidelines and/or Standards (in all Design Stages)

This section of the questionnaire was designed to gather information relating to typical problems associated with applying guidelines and/or standards in order to determine whether common problems exist amongst those surveyed. It was also intended to gather information relating to the maintenance of roads following construction and problems identified during RSI, which are undertaken on existing roads.

The respondents were asked: *From the following list, please select the three most important difficulties that you have encountered when attempting to apply guidelines and/or standards relating to roadside safety within your jurisdiction.*

- *Cost implications (i.e. poor rate of return, lack of initial funding etc).*
- *Guidelines do not align with the typical road layouts.*
- *Insufficient space available to install a RRS.*
- *Lack of information in the guideline.*
- *Proposed scheme is fixed.*
- *Other.*

The responses are presented in Figure 24:

Figure 30 – Roadside safety - the three most important difficulties encountered

It can be seen that “Cost implications (i.e. poor rate of return, lack of initial funding etc)” creates the most difficulty amongst those surveyed followed by “Insufficient space available to install a RRS” and “Other”.

The respondents were asked: *Please list typical roadside design problems that have been identified by Road Safety Audits and whether these problems have been addressed.*

The responses received have been grouped and are as follows:

Cross Section Constraints

- Lack of land take to provide sufficient clear zone
- Insufficient space for working width
- VRS installations often runs into problems concerning inspection chambers, groundworks, cable ducts etc.
- Detailed planning of VRS starts after the road design has already been finalised and it's often too late to make necessary changes

Visibility Constraints

- Junction visibility
- Sightline requirements not met
- Sight restrictions caused by RRS at intersections

Inadequate Design/Installation

- Not accurate RRS design relationship with other construction details
- Selection of RRS
- Guard rails too low / high / inclined / sank in progress
- Inadequate end treatments (transitions, terminals)
- Insufficient length of the RRS
- Road restraint systems (RRS) providing inadequate containment levels

Other

- Shoulder not load bearing
- Lining standards, footpath continuation
- Everywhere are trees which many times should stay because they belong to the landscape
- Retrofitting the existing network to provide forgiving roadsides
- Including proper lane widths and weaving lengths, pedestrian and vulnerable user safety, bridge parapet heights
- Space for pedestrians, Non-Motorised Users
- Recognisability of the driving situation

The respondents were asked: *From the following list, please select the three most important difficulties that you have encountered when attempting to apply guidelines and/or standards relating to road maintenance within your jurisdiction.*

- *Insufficient consideration of maintainability*

- *Insufficient planning and design activities*
- *Insufficient funding available*
- *Traffic overloading (compared to projected traffic loading)*
- *Untimely maintenance*
- *Lack of inventory gathering*
- *Other*

The responses are presented in Figure 25:

Figure 31 – Road maintenance - the three most important difficulties encountered

It can be seen that "Insufficient funding available" and "Lack of inventory gathering" create the most difficulty amongst those surveyed followed by "Insufficient consideration of maintainability", "Insufficient planning and design activities", "Untimely maintenance" and "Other".

The respondents were asked: *Please list typical roadside design problems that have been identified by Road Safety Inspections and whether these problems have been addressed.*

The responses received have been grouped and are as follows:

<u>Cross Section Constraints</u>

- Distance between tree-road
- Narrow median on motorways
- Cycle paths too close to the roadways, lack of space is the problem
- Service poles, fencing and walls in clear zone

- RRS with too low containment level too close to bridge pillars in the median
- Vehicle barrier too close to edge paving while space is available
- Obstacle-free zone not properly applied in relation to the design speed

Maintenance Issues

- Maintenance not undertaken

Inadequate Design/Installation

- Old insufficient RRS are identified
- Incorrect type of RRS
- Starting points guard rails insufficiently bent out
- Guard rails too low / high / inclined / sank in progress

Other

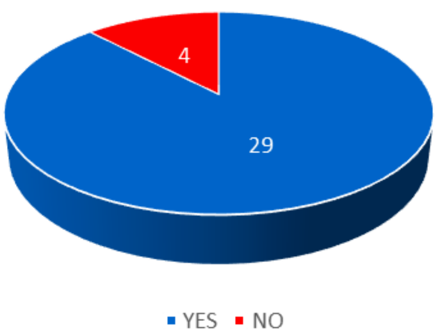
- Surface holes, water, trees, short term not long term
- Tunnel portal areas with access to maintenance buildings
- A typical problem is that not all identified problems can be addressed, as the contractor often will consider this as extra work and the budget to allocate extra funds might not be enough to fix all the problems
- Numerous different types of VRS from the past different from current
- Discussions with organisations which want to protect trees and environment.
- Junction visibility
- Lack of data concerning roadside inventory.

Opinions Related to Clear Zones versus Application of Guardrails/RRS

This section of the questionnaire was designed to gather information relating to design approach with regard to the philosophy of forgiving roadsides versus the application of RRS.

Forgiving Roadside Philosophy

The respondents were asked: *Within your jurisdiction is a forgiving roadsides philosophy promoted?* Figure 26 shows the responses received (33).



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

Figure 32 – Forgiving Roadsides Philosophy Promoted?

The responses received suggest that Cyprus, Hungary, Italy and the UK do not actively promote a forgiving roadsides philosophy.

Those that answered positively were asked: *If you answered "Yes" please provide the definition for a forgiving roadside.* Table 5 includes the responses received:

Table 5: Forgiving Roadside Definitions Received

Definition	Country
"roads designed with specific emphasis on it preventing and limiting damage to people and goods in the event of accidents" (Translated)	Belgium
"roads designed to prevent or reduce damage to people and goods in the case of an accident."	
"A roadside that allows for human error without severe consequences for humans and the environment. "	
"Obstacle-free side room" (Translated)	Germany
Roadside with adequate safety zone, in which there are no hazards, such as rocks, steep slopes or deep water.	Iceland
"A self-explaining road with forgiving roadsides should: a) Assist the driver in making the correct decision. b) Be forgiving of driver error. c) Lessen the consequences if a collision occurs."	Ireland
A self-explaining road with forgiving roadsides should: o Assist the driver in making the correct decision. o Be forgiving of driver error. o Lessen the consequences if a collision occurs.	
The principles of Forgiving Roadsides are to minimise the risk and severity of driving errors. It seeks to reduce the number of fatalities and serious injuries associated with run-off road incidents through the design of safer roads and roadsides that: o Minimise the risk of vehicles leaving the carriageway without resorting to safety barriers as a first resort (e.g. via delineation). o Provide adequate recovery space when errant vehicles do run off the road. o Ensure that any collision that does occur in the roadside will be with objects that limit the impact forces on vehicle occupants to minor levels (no serious injury outcomes)	
Forgiving shoulders (2m) and slowing down surface in a width of more than 4 m (80 km/h (50mph))	Netherlands
When encountering danger zones in the cross section, the RWS employee must once again follow the philosophy of the ROA VIB. This is: 1. Removing the danger zone. 2. The crash-friendly execution of the obstacle. 3. Shielding the danger zone. Typical challenges are the height differences between the edge of the pavement and the shoulder, the maintenance work that is not carried out or not carried out correctly, and the design of the starting point of the guide rail construction (maximum bending or applying obstacle protector).	
The road that minimises the consequences of mistakes made by drivers	Poland

It can be seen from the responses received that the concept of forgiving roadsides is understood, however, it may be of use to develop a common definition for use across all Member States.

Obstacle Free Zone Provision

The respondents were asked: *Within your jurisdiction is it policy to provide an obstacle free zone before a guardrail/RRS is installed?* Figure 27 shows the responses received (33).

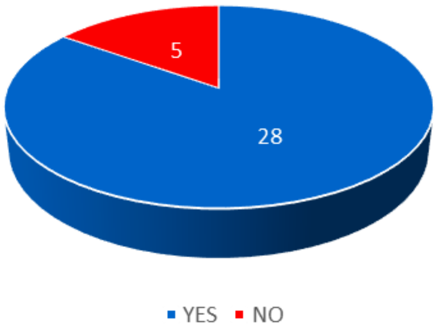


Figure 33 – Obstacle free zone provided before RRS is installed

The responses received suggest that NRAs in 10 of the 15 countries represented view RRS as a hazard in the event of a collision and that an obstacle free zone, when provided, presents less of a collision risk and associated injury risk to the occupants of errant vehicles.

Guardrail/RRS Placement

The respondents were asked: *When are guardrails/RRS placed as standard?* The five circumstances given were:

1. When a clear zone cannot be provided.
2. When there are roadside hazards/obstacles that require protection.
3. On road bends.
4. Where shoulders and verges are soft.
5. Other.

Table 6 includes the responses received (33). The countries from which the responses were received are included in brackets.

Table 6: Circumstances when guardrail/RRS placed as standard

Circumstance	Yes (Countries)	No (Countries)
When a clear zone cannot be provided	28% (11)	5% (4)
When there are roadside hazards / obstacles that require protection	31% (13)	3% (2)

On road bends	10% (8)	23% (7)
Where shoulders and verges are soft	1% (1)	32% (14)
Other	5% (4)	28% (11)

Respondents that answered "Other" were asked to provide further information. A summary of their responses is included below:

- Protecting hazards including water, embankment slopes, third parties and height differences >2m.
- When it is not possible to provide an adequate clear zone.
- On road bends: not necessarily, further aspects must be taken into consideration.
- On bridge structures.

RRS Promoted Over Clear Zone or Vice Vera

The respondents were asked: *Is there a policy within your jurisdiction that promotes RRS over clear zones or vice versa?* Figure 28 shows the responses received (33).

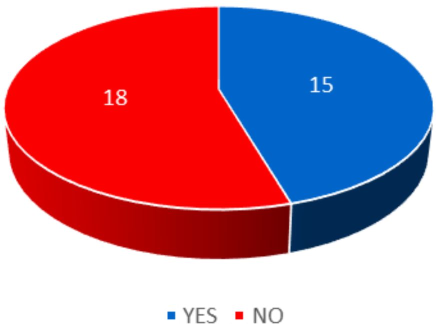


Figure 34 – RRS Promoted Over Clear Zone or Vice Versa

From the responses received it can be seen that there is no clear majority regarding policy that promotes RRS over clear zones or vice versa.

Additional Questions

The respondents were asked: *On new road schemes is the area of land available either side of the road typically sufficient to provide the required forgiving roadside by a clear zone/obstacle free zone*? Figure 29 shows the responses received (33).

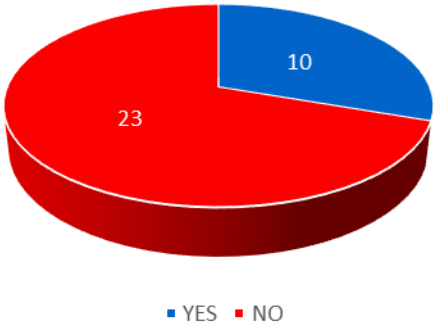


Figure 35 – Area of land available either side of the road typically sufficient to provide the required forgiving roadside by a clear zone/obstacle free zone

From the responses received it can be seen that the majority of respondents believe that the area of land available for the provision of clear/obstacle free zones within the footprint of the road is typically insufficient. This suggests that the clear/obstacle free zone in not considered at an early enough stage in these jurisdictions and that the works are being carried out in pre-defined corridors.

The respondents were asked: *On new road schemes is the area of land available either side of the road typically sufficient to provide the required forgiving roadside by a RRS most commonly used?* Figure 30 shows the responses received (32).

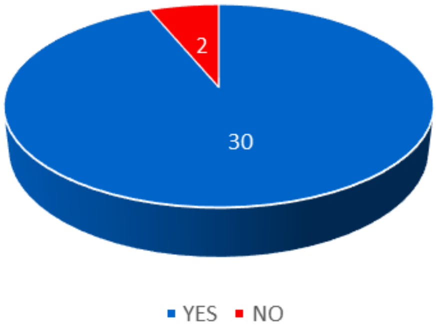


Figure 36 – Area of land available either side of the road typically sufficient to provide the required forgiving roadside by a RRS most commonly used

From the responses received it can be seen that in almost all cases the area of land available either side of the road is typically sufficient to provide a RRS.

The respondents were asked: *Have you experienced difficulties when attempting to install RRS due to poor ground conditions, existing utility ducting etc?* Figure 31 shows the responses received (33).

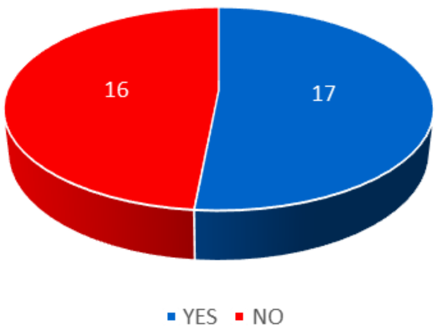


Figure 37 – Difficulties experienced when attempting to install RRS due to poor ground conditions, existing utility ducting etc

There was an almost 50/50 split between those that have experienced difficulties and those that have not. In several cases responses received from those in the same country varied which suggests that the responses received were personal views rather than based on quantitative data.

Those that responded positively were asked: *If you answered "Yes" is there a process whereby a designer can develop a proposal for installing a bespoke system which is subject to the approval of the overseeing authority?* Figure 32 shows the responses received (33).

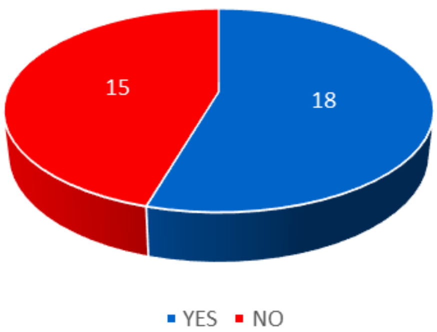


Figure 38 – Is there a process whereby a designer can develop a proposal for installing a bespoke system which is subject to the approval of the overseeing authority?

The responses received suggest that there is an understanding within most Road Authorities that restraint systems cannot always be installed as tested.

Those that responded positively were asked: *If you answered "Yes" please provide an example of how this process operates.* A selection of responses received are summarised below:

- There is a fixed procedure with the Road Authority which involves the designer submitting proposals for review/approval.
- Contractors/suppliers are requested to provide solutions.

The respondents were asked: *What RRS is predominantly used and to which standard is this applied?* The responses have been grouped and are as follows:

Rigid

- In-situ cast concrete and precast concrete - compliant to EN 1317

Flexible

- Steel restraint systems with containment levels ranging from N2 to H2
- Wire rope restraint systems
- A combination of wood and steel (mostly steel covered with wood)

Other

- Historically Highways England designed, developed and tested national systems. Now we moved fully to CE marked systems so there is no preference.

Funding Constraints and Costs

This section of the questionnaire was designed to gather information relating to the potential impact that funding constraints and costs can have upon the provision of safe roadsides at design level.

The respondents were asked: *Are funding constraints and/or construction costs a factor when assessing whether to provide forgiving roadsides via the introduction of clear zones/obstacle free zones?* Figure 33 shows the responses received (33).

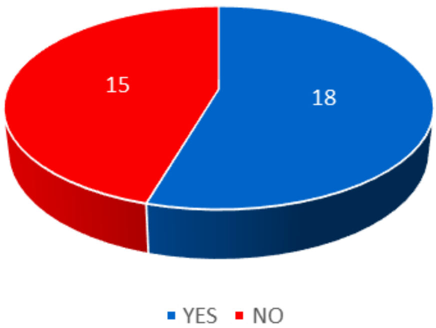


Figure 39 – Are funding constraints and/or construction costs a factor when assessing whether to provide forgiving roadsides via the introduction clear zones/obstacle free zones?

The responses received suggest that funding constraints can be a factor when assessing whether to provide forgiving roadsides via the introduction of clear zones/obstacle free zones.

It has not been determined however, whether such funding constraints relate solely to the cost of an enlarged scheme footprint and associated land acquisition costs or whether a benefit/cost analysis is undertaken.

The respondents were asked: *Are funding constraints and/or construction costs a factor when assessing whether to provide forgiving roadsides via the introduction of RRS?* Figure 34 shows the responses received (33).

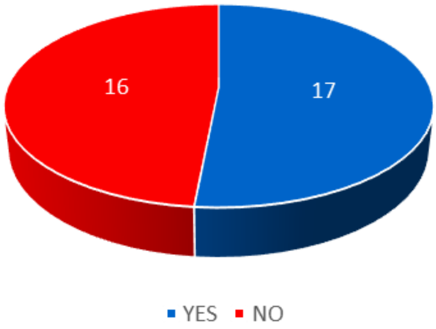


Figure 40 – Are funding constraints and/or construction costs a factor when assessing whether to provide forgiving roadsides via the introduction of RRS?

There was an unexpectedly high number of “Yes” responses to this question. The project team anticipated a low number of “Yes” responses considering the relatively low cost of constructing RRS when compared to the cost of providing a clear/obstacle free zone.

The respondents were asked: *Are funding constraints and/or construction costs a factor when assessing whether to remove an obstacle / a hazard versus implementing RRS?* Figure 35 shows the responses received (33).

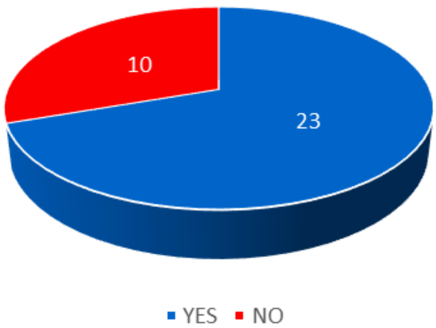


Figure 41 – Are funding constraints and/or construction costs a factor when assessing whether to remove an obstacle / a hazard versus implementing RRS?

It is clear from the responses received that funding constraints and /or construction costs are a factor for the majority of respondents when assessing whether to remove an obstacle / hazard versus implementing a RRS. In most cases it will be cheaper to construct a RRS than remove a hazard and create a clear/obstacle free zone due to land acquisition costs.

Role of Contractors and Consultants

This section of the questionnaire was designed to gather information relating to the role that contractors and consultants play, if any, in the development and revision of standards and/or guidelines.

The respondents were asked: *If you are part of a roads authority do you engage with consultants or contractors who regularly work with the standards to take part in updates to standards and/or guidelines?* Figure 36 shows the responses received (23).

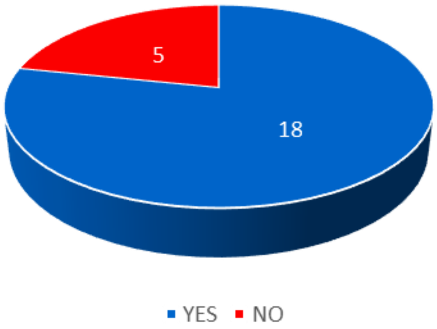


Figure 42 – Road Authority Engagement with Consultants and/or Contractors

From the responses received it can be seen that the majority of road authorities engage with contractors and consultants as their "on the ground experience" can be invaluable when revising guidelines/standards.

The respondents were asked: *If you are a consultant or contractor is there a mechanism for providing feedback to the roads authority or author of design standards and/or guidelines?* Figure 37 shows the responses received (4).

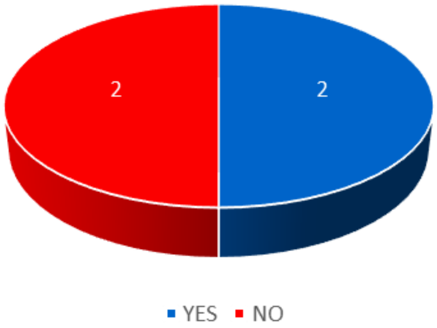


Figure 43 – Consultant/Contractor Feedback to the Roads Authority

Successful and Innovative Roadside Safety Risk Mitigation Measures (Individual Site Level)

This section of the questionnaire was designed to gather information relating to successful and innovative roadside safety risk mitigation measures, at individual site level, which when assessed could be recommended for implementation in other jurisdictions.

The respondents were asked: *With reference to any supporting material such as research papers, journals or articles etc. can you please provide examples of roadside safety risk mitigation measures adopted in your jurisdiction, which are shown to be successful in decreasing the number and severity of roadside safety incidents? These can be:*

1. Measures adopted to deter vehicles from leaving the carriageway (such as rumble strip installation, public awareness campaigns targeting in-vehicle distractions, mandating lane keep assist system for all new cars, etc.),
2. Measures adopted to decrease likelihood of errant vehicles reaching hazards (such as hazard elimination, provision of wider clear zones, etc),
3. Measures adopted to decrease consequences of reaching roadside hazards (such as use of energy absorbing terminals, passively safe support structures, etc.)
4. Other

The responses received are presented in Table 7.

Table 7: Successful Mitigation Measures

Reference	Mitigation Measures	Country
1	Measures adopted to deter vehicles from leaving the carriageway (such as rumble strip installation, public awareness campaigns targeting in-vehicle distractions, mandating lane keep assist system for all new cars, etc.)	Austria, Belgium, Germany, Hungary, Ireland, Netherlands, Poland, Sweden, Cyprus, Iceland, Portugal
2	Measures adopted to decrease likelihood of errant vehicles reaching hazards (such as hazard elimination, provision of wider clear zones, etc)	Austria, Netherlands, Sweden, Iceland
3	Measures adopted to decrease consequences of reaching roadside hazards (such as use of energy absorbing terminals, passively safe support structures, etc.)	Austria, Belgium, Germany, Ireland, Italy, Sweden, United Kingdom, Iceland
4	Other	
	Public Awareness Campaigns targeting in-vehicle distractions and the dangers related to the use of mobile phones	Iceland Portugal

	Geometric Improvements to include junction realignments, improved pedestrian facilities, signing and lining, crash barrier improvements, sight distance improvements (Road Safety Remedial Measures Programme - Evaluation of Programme 9 to 11 Schemes Implemented between 2004 - 2006), Gravel beds are installed on exits of highway interchanges	Ireland Luxembourg
	Road lighting improvements to include measures to improve road visibility in darkness as well as other improvements. The majority of improvements were shown to have had an associated reduction in collisions.	Ireland Netherlands

It is noted that only one response included a reference to supporting material.

The respondents were also asked: *Can you please provide examples of new and innovative roadside safety risk mitigation measures, which are being trialled in your jurisdiction?* The responses received are presented in Table 8.

Table 8: Innovative/ Mitigating Roadside Safety Risk Measures (Individual Site Level)

Mitigation Measures	Country
"rumble strips, average speed cameras"	Belgium
"The Flanders road authority decided years ago that passively safe lighting columns would be the standard choice for lighting supports. Only in specific cases classic supports are allowed."	
Have been installing warning signage at the motorway junctions at entry/exit points to avoid Ghost Driving/Wrong Entry Driving, as well as special road restraint systems, end assemblies on guardrails, crash cushions and monolithic bollards/musoirs.	Cyprus
"rumble strips, profiles marking"	Germany
"RRS with underrun protection installed in 450 curves in Hesse (Criterion: 2 Accidents within 5 years"	
"RRS as a single object protection. Motorcyclist underrun protection at RRS" (Translated)	
"Basically, the accident risk in Germany is on a very good level, compared to other European Countries. Essential for this is, that measures to decrease the likelihood of accidents such as improved alignments and cross sections as well as measures to decrease the severity of accidents such as RRS. In the product-oriented area of RRS innovative construction methods generally mean developments driven by companies. BASt is supporting these developments by e.g. the development of appropriate test methods for the targeted confirmation of the specific performance. The latest examples are the development of a system to be used at junctions, the development of formalities for the use of specific solutions in order to protect trees and constructions and the confirmation of the performance of concrete safety walls constructed with in-situ concrete.	

Points of discontinuity within the given network are detected and solutions for these points are developed (e.g. restoration of concrete safety walls) as well as necessary changes of traffic composition by innovative vehicle concepts. All investigations and measures in total lead to a decrease of the accident risk within the network. Related information can be found at different places at the homepage of BASt (www.bast.de)."	
safety barriers for motorcyclists	Iceland
No rumble strips - Not approved by TII anymore, only for roundabouts	Ireland
make the road course better visible in the dark (reflectors, vertical beacons in curves, lighting at intersections and in dangerous places)	Netherlands
Forgiving shoulder made of concrete shoulder construction (without use of cement, sustainability goal)	
With in-car measures such as Flister, an attempt is made to alert road users to incident locations at an early stage.	
"Bridge Pillars/ Barriers"	Sweden
Slope barriers located at the inner slope ~1 m from road edge.	
"High Friction Surfacing applied on almost all bends on single carriageways and junctions. This is shown to be a successful measure. There are shoulder rumble strips applied along almost the entire length of the Motorway and Trunk Network. In the UK we have big push for converting motorways into Managed Motorways. In Managed Motorways we can change the speed of lanes or close lanes (through overhead variable message signs) to reduce the risk of people leaving the carriageway under high risk situations such as flooding or hazards on the road or secondary impacts. In the UK we have a National requirement for installation of H1 level rigid concrete barriers on all dual carriageways with average daily traffic over 25,000 vehicles per day. This reduces the need for maintenance and repair. Reduces road worker casualty as they are much less needed on the road. Decreases cross over incidents. Lasts twice as long. Less prone to installation errors. Highways England is currently trialling Paraprotek, i.e. an innovative temporary parapet repair system, which is modular and designed to be attached to different types of old parapets following an impact. Repair of historic parapets (which we have a lot of) is a big issue due to different sites having different installations (i.e. beam heights changing from one installation to another). It takes time to manufacture replacement parts, which are copies of the damaged ones. With this product, following an accident, the resulting gaps on bridge parapet can be closed very quickly before a matching piece can be manufactured. Highways England is currently trialling the MBT mobile work zone protection vehicle."	United Kingdom

This section of the questionnaire was designed to gather information relating to successful and innovative roadside safety risk mitigation measures, on a network wide level, which when assessed could be recommended for implementation in other jurisdictions.

The respondents were asked: *With reference to any supporting material such as research papers, journals or articles etc. can you please provide examples of new and innovative processes adopted by your organisation, which are shown to be successful in improving the roadside safety in your jurisdiction? These can be:*

1. *Processes adopted to improve roadside safety at design stage (such as mandatory economic analysis, national roadside risk assessment software, adoption of new crash test requirements to cater for all road users, etc.).*
2. *Processes adopted to improve roadside safety at installation / construction stage (such as, mandatory training for VRS installers, national requirements for VRS foundations, VRS material property checks, etc.),*
3. *Processes adopted to maintain roadside safety over lifetime, i.e. at monitoring stage (such as, periodic in-depth roadside accident data analyses, monitoring crash performance of historic VRS when impacted with modern vehicles, etc.).*
4. *Other.*

The responses received are presented in Table 9.

Table 9: Successful and Innovative Roadside Safety Management Processes (Network Level)

Reference	Mitigation Measures	Country
1	Processes adopted to improve roadside safety at design stage (such as mandatory economic analysis, national roadside risk assessment software, adoption of new crash test requirements to cater for all road users, etc.)	Belgium, Hungary, Netherlands, United Kingdom,
2	Processes adopted to improve roadside safety at installation / construction stage (such as, mandatory training for VRS installers, national requirements for VRS foundations, VRS material property checks, etc.),	Belgium, Italy, Netherlands
3	Processes adopted to maintain roadside safety over lifetime, i.e. at monitoring stage (such as, periodic in-depth roadside accident data analyses, monitoring crash performance of historic VRS when impacted with modern vehicles, etc.)	Germany, Ireland, Netherlands
4	Mandatory economic analysis, training for RRS installers, RRS material property checks, periodic in-depth roadside accident data analyses	Austria

	TII has adopted a training course for engineers involved in design, specification, installation, supervision, maintenance of VRS. It is a 2-day course that covers most aspects of VRS from testing to roadside and all aspects of roadside safety.	Ireland
	Introduction of a Danger Liquidation Plan. Places are based on the density of accidents.	Poland

It is noted that no response included a reference to supporting material.

The respondents were also asked: *Can you please provide examples of new and innovative roadside safety management processes, which are being trialled in your jurisdiction?* The responses received are presented in Table 10.

Table 10: Successful and Innovative Roadside Safety Management Processes being Trialled (Network Level)

Mitigation Measures	Country
Main process includes the promotion and implementation of Road Infrastructure Safety Management procedures such as Road Safety Audits and Road Safety Inspections.	Cyprus
"GPS Video UBIPIX" used in all Road Safety Inspection drive throughs	Ireland
Plan-based approach to roads: improvement measures in accordance with sustainable safe guidelines	Netherlands
In the formation and further updating of the Framework Design process, the designing party must also submit the designs of the safe verge to the client first.	
"CEDR and professor meetings"	Slovenia
"Scotland has been extensively using average speed cameras successfully to reduce speeding related accidents. We have a list of approved products which make sure designer can know what products are available with the peace of mind that they have been appropriately tested. We have an independent assessment scheme for non-harmonised products. Products have to go through independent third-party checks to ensure manufacturers or test houses didn't cheat on impact tests. All roadside designs are done by using the RRRAP tool. Use of RRRAP automatically generates an audit trail and a list of hazards on the network. This way we have network level audit trail for all barrier installations or the decision for not installing one. We have a sector scheme training for barrier installers – This is a one-day training course which includes both generic and product specific training. There is a good method of reporting defects, anyone from public or organisations can easily report defects to Highways England.	United Kingdom

We have a Truck Mounted Attenuator Testing Agreement (TMATA) scheme. This is a six-monthly inspection scheme for Truck Mounted Attenuators to ensure they are always in good condition for an impact. This is believed to be decrease the overall risk for road workers. Asset Management Visualisation Tool (AVIS) is being used for asset management. "	

Pilot Projects

This section of the questionnaire was designed to request potential pilot projects that may be suitable to trial the tool which is being developed as part of this research package.

The respondents were asked: *Does your organisation have proposed or upcoming highways projects that may be suitable for assessing and optimising roadside safety using the tool which will be developed in a later work package (highways projects at all design stages are welcome)?*

Five respondents suggested proposed projects as per Table 11.

Table 11: Potential Pilot Projects

Pilot Project	Country
Antwerp ring road	Belgium
Roadside safety, run off acc., roadside vegetation, statistical model	Germany
Elimination of black spots on a motorway (central reserve and the edge of the carriageway)	
Minor improvement works	Ireland
Existing upgrade works	Sweden

A copy of the full survey responses (with identifiers removed) is available on request.