

"PRAISE": Preventing Road Accidents and Injuries for the Safety of Employees

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REPORT

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Thematic Report 6

Road Safety at Work Zones

ETSC PRAISE Project

PRAISE is a project, co-funded by the European Commission and implemented by ETSC, which focuses on Preventing Road Accidents and Injuries for the Safety of Employees (PRAISE). The project aims to advance work-related Road Safety Management and provide the know-how to employers who have to take on that challenge. It also aims to present the work-related road safety standards of EU Member States and carry out advocacy work at the EU level: work-related road safety is an area of road safety policy that clearly needs renewed political commitment.

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Part 1: State of Play

1.1 Introduction

The focus of this thematic report is improving safety for both employees and road users in relation to work zone areas on and adjacent to roads. The road work zone (RWZ) is defined as the part of a road facility influenced by works occurring on or near it. The report sets the context by outlining the nature and scope of the problem of road safety at road related work zones including identification of the most significant risk factors and causes of collisions and incidents. The Report then takes a specific look at the various stages involved in working on or near roads namely planning, operation, installation and removal of the works. At each stage key issues in terms of safety are identified and discussed. Subsequently good practice solutions or approaches in terms of RWZ safety have been identified and recommendations for the EU, National governments and Employers in terms of contributing to improved worker safety are suggested. This topic is pertinent across all Member States where increasing road traffic puts added pressure on road infrastructure potentially increasing the incidence of maintenance works required and, specifically for new Member States, where new and replacement roads are being planned.

There are a range of employees whose place of work is the road way or road side and who are exposed to significant risk as a direct result of this. This group includes not only those engaged in road construction and/or renewal but also those working in road maintenance, utilities management (electricity, communications, water, and gas), service maintenance (drains, tree and verge cutting) and traffic management. In the broader context the report offers principles that should apply to all people working on or near the road and also needs to consider third parties, not only those in their vehicles (cars, trucks, buses and motorcycles) but also cyclists and pedestrians, as the most vulnerable road users, and persons living in the surroundings of the road.

This report focuses on the specific risks at RWZs that are the result of the competition between workers and normal road users for the limited space available. However, the issue of safety is interrelated with broader health impacts and risks. The nature of the majority of road related works activities and the

characteristics of their location pose increased risks to workers for example in terms of the negative impact of prolonged exposure to weather (e.g. sun or cold exposure), traffic noise and fumes or the physical strain of repeatedly operating machinery or dealing with heavy loads. Road workers can also be exposed to increased stress as a result of negative reactions from other road users. Such exposure can impact on the level of safety afforded to road workers at any given time and approaches to ensuring the health and safety of road workers should be considered in an integrated manner.

There is debate and uncertainty surrounding the scale of the problem which is difficult to gauge due to lack of specific data collection in relation to RWZ related collisions. However there is a general consensus and recognition of the higher risk exposure associated with road side working as opposed to other occupations. In this context there is also acceptance of the fact that deaths and serious injury at or adjacent to RWZs are a major social issue and efforts are needed to reduce them as much as possible.

The level of risk will depend on the type of works to be carried out, the duration and the location – classification of the road and volumes of traffic. It is important to recognise that there are crucial differences between road types (rural, urban and motorway) that require varying approaches in terms of safety provision. Similarly, the type of road work will influence the safety measures and approach that best fits i.e. whether the works are mobile, short, medium or long term.

The type of the work zone in terms of function, area and duration can vary greatly as can the type of work being progressed and the environment in which the work zone is located. In turn, these variations impact on the type and nature of risk present and on the steps that can be taken to minimise this risk. Different work zone types also present different driving conditions to other road users which have implications for safety and are a critical consideration when planning and operating the work zone.

1.2 Defining the Environment: Types of Work Zone, Types of Roads

The ARROWS¹ and PREVENT² Handbooks defined three categories of work zone types (based on duration of works) as common in most countries namely Long-term, Short-term stationary and Mobile. Long-term referred to works staying in place at least overnight, short-term to works staying in place for at least half a day but no more than one day and mobile referring to works that travel. Since publication of these reports a more common four category definition of work zone types has become generally accepted in the industry as follows:

- Long-term stationary work is defined as construction or maintenance work that occurs in a single location with duration of more than three days.
- Intermediate-term stationary work occurs in a single location for more than one daylight period (up to three days) or night-time work lasting more than one hour.
- Short-term stationary work is construction or maintenance work that lasts for more than one hour, but is completed within a single daylight period.
- Mobile work is construction or maintenance work that moves intermittently or continuously

These Handbooks also underlined that, while there are variations in the duration of road works, there are also variations in the types of roads on which they take place and the interactions between these two variables set the context for the design of the road work, the impact on other road users and the risk to safety. The ARROWS project defined five categories of road type as follows:

- Motorway and dual carriageway

- Rural primary
- Rural secondary
- Urban main
- Urban local³

In general, varying national definitions of road classes can be adequately accommodated under this broad classification of road types⁴.

The various road types and work zone types interact to produce dynamic environments which are made increasingly complex with the introduction of workers, road users and changing weather and local environment. This serves to highlight the fact that in many ways each road work scenario is unique – it will have unique characteristics working together with the potential to create risk and means that a ‘one size fits all’ approach to providing for safety is not appropriate. The dynamic nature of works in or adjacent to roads needs to be remembered by all those involved in their design, management and use.

In the context of the above it is clear that issues relating to safety will also vary from work zone to work zone and that individual risk assessments which allow for the identification of location specific risks will be required in order to develop a comprehensive approach to providing effective safety measures. However, the difficulties in dealing with ever unique situations can be lessened with the identification of high-level safety principles, aimed at improving safety, to be applied at all stages of road works from planning through to removal. Such principles will ensure that achieving a high level of safety is then inherent in all decisions taken in terms of safety measures, work zone design and operation.

1 <http://www.ntua.gr/arrows/finalhb6a2.pdf> ARROWS was a European Commission funded research project aimed at improving the safety of road users and workers at RWZs. Its main output was a Handbook intended for highway authorities, designers, contractors and other individuals and organisations responsible for traffic safety at roadworks

2 <http://www.hit.certh.gr/prevent/media/Deliverables/Handbook.pdf> Building on the findings of ARROWS the PREVENT project (also funded by the EC) developed an educational programme aimed at improving traffic behaviour at road works and training schemes for highway repair and maintenance worker personnel, and driving instructors.

3 <http://www.ntua.gr/arrows/finalhb6a2.pdf>

4 Ibid

1.3 Scope

A significant amount of research has been carried out in Europe and further afield which highlights the fact that work on or near roads results in increased risk for both workers and road users. However, the majority of this research has been piecemeal focusing on single countries or specific types of roads and concentrating on single issues such as road worker deaths or occupational health. As such, it is difficult to gain a holistic view of

1.3.1 Risk to road workers

In terms of risk faced by road workers a recent study in the Netherlands (2006–2007) estimated from data on fatal crashes that the risk facing road workers is significantly higher than that faced by general construction workers⁶. Similarly in the UK it is noted that the average death rate for road workers continues to be one of the highest for employment

1.3.2 Risk to road users

An international review on collision studies carried out as part of the European project ARROWS 'revealed that work zone areas have, typically, higher (road traffic) collision rates in comparison with equivalent non-works sections'⁹. In Austria, yearly about 120 collisions and 4 deaths occur at roadwork zones on national roads. Currently the proportion of road construction related collisions compared to all road collisions is approximately 4%¹⁰. Studies in Finland and Slovenia showed that 'motorists are up to five times as likely to get hurt when travelling through a work zone'¹¹ while in Germany research has shown that approximately one quarter of collisions happening on national routes occur at work zones. One exception is a study carried out on behalf of the UK Highways Agency that reviewed the safety performance of traffic management at major road works – the fourth such study over the period from 1992¹². The study showed 'no significant difference in the rate of Personal Injury Accidents (PIA) when road works were present on the motorway.' When

the true scale of road work related incidents. Despite this, the existing research serves to underline that there are significant safety issues surrounding road works which have the potential to result in negative human, economic and social consequences. Moreover, the European Commission adopted a new target to reduce road traffic deaths by 50% by 2020 in its new "Road Safety Policy Orientations 2011-2020"⁵.

sectors reported by the Health and Safety Executive⁷.

A survey released by the UK Highways Agency in 2006 suggested that 'up to 20% of road workers had suffered some injury caused by passing vehicles in the course of their careers and 54% had experienced a near miss with a vehicle'⁸.

compared with the 1992 results the 'with' works accident rate had reduced from 0.174 to 0.101, the same as the national average PIA. 'The conclusion of this study is that due to the increased number of safety measures and practices over the past decade, the risk (in terms of Personal Injury Accidents) when road works are present is similar to the risk when no road works are present.'¹³

One of the limitations currently encountered while assessing safety in RWZs is that little detailed information exists about the change in collision risk and costs associated with works activities. Whilst many countries routinely collect information on the number of collisions at works these do not in general allow an estimation of the increased risk. Research to date is limited but demonstrates firstly that the presence of work zones increases risk on the roads, secondly, that working on the roads is one of the most dangerous occupations and thirdly, that improved safety practices can reverse these scenarios.

5 http://ec.europa.eu/transport/road_safety/pdf/com_20072010_en.pdf

6 http://www.virtualriskmanager.net/main/aboutus/niosh/poster_venema-anita_1.pdf

7 http://www.highways.gov.uk/knowledge/documents/Road_worker_Safety_Strategy.pdf

8 http://www.highways.gov.uk/knowledge/documents/Roadworkers_Safety_Report_Phase_One_Final.pdf

9 <http://www.ntua.gr/arrows/finalhb6a2.pdf>

10 http://www.asfinag.at/c/document_library/get_file?uuid=ccd7dbb6-3e9f-4ad0-9f6b-842f3651acfd&groupId=10136

11 European Union Road Federation (2007) Safety on motorway Work zones, Discussion Paper.

12 <http://www.thenewspaper.com/rlc/docs/04-tr1595.pdf>

13 Ibid

1.4 Nature of the problem

From a road safety viewpoint the risks involved with RWZs can include risk of collisions between general road users (vehicles, cyclists, pedestrians) and barriers, equipment, vehicles or personnel associated with the RWZ as well as collisions involving only road users due to the disturbance induced by the RWZ to the normal traffic flow (e.g. side sweep crashes due to sudden lane changes, rear-end crashes due to sudden braking). Identification of the exact causes of collisions is often difficult to ascertain as a combination of factors may interact to culminate in a collision. As such it is difficult to ascertain when the presence of a work zone on or near a road or its characteristics has directly resulted in road traffic collisions. From the worker safety viewpoint the risks involved with RWZs can include risk of collisions in or outside the work zone, or when the worker enters or leaves the work zone. The collisions can happen with passing vehicles or work vehicles. The worker can be a pedestrian or driving a vehicle.

The dynamic and fluid nature of road related work zones has the potential to result in a deterioration of safety and an increase in risk factors. RWZs represent unexpected and uncharacteristic changes to the road network and present immediate and unavoidable scenarios for drivers thereby contributing to driver confusion and error. Work zones are a deviation from the normal road scenario in terms of functionality, legibility, speed and space. By their very nature the interaction of 'work tasks' carried out by employees with the general public in the form of road users presents an added risk scenario.

A number of studies have been carried out attempting to provide clarity in this area and to inform the development of safer processes and approaches around work zones through the identification of causes of collisions. Research has shown that roadworks that are carried out over a longer period and that cover a longer work zone seem to have a

lower crash rate than short term works and that the actual operational area where physical works are occurring appears to be more risky at the access and egress to the work zone¹⁴. In rural areas, roadwork's crashes often occur in the vicinity of approach roads and exits and are often rear end collisions where road blocks are present¹⁵. Intersections where traffic from side road joins a main road with a work zone have been identified as relatively dangerous in urban areas. 'The work zone is sometimes closed off badly, it is not always clear which adjustments in behaviour are required of cyclists, and the sign 'cyclists dismount' is sometimes applied incorrectly'¹⁶.

Driver perceptions and actions are a significant contributory factor to collisions at road side work zones. Speed is the number one cause of road traffic deaths¹⁷. In this regard the PREVENT study stated that 'the most consistent finding is that speeding is common at roadworks... (and)...the majority of drivers drive too fast when approaching roadworks'¹⁸. A study in France demonstrated that 44% of road users were speeding in the vicinity of road works (excess speed at least 20 km/h) while 20% were failed to ensure the provision of safe distances with other vehicles.¹⁹ Road users fail to realise the extent of their vulnerability or to perceive the increased risk around presented by the presence of works on or adjacent to roads.

The cause of real concern regarding driver behaviour at RWZs is the fact that drivers believe that they take sufficient caution. 'Experimental studies have shown that the majority of drivers in fact approach road works zones driving too fast for the circumstances, and usually well above the posted speed limit. Moreover they do not decelerate until just before an abrupt change in the conditions...and then in an extremely abrupt manner'²⁰.

On the other hand a Dutch study into RWZ safety

14 http://www.swov.nl/rapport/Factsheets/UK/FS_Road_works.pdf

15 <http://www.ntua.gr/arrows/finalhb6a2.pdf>

16 http://www.swov.nl/rapport/Factsheets/UK/FS_Road_works.pdf

17 <http://www.etsc.eu/documents/ETSC%20PIN%20Annual%20Report%202009.pdf>

18 <http://www.hit.certh.gr/prevent/media/Deliverables/Handbook.pdf>

19 http://www.seine-maritime.equipement.gouv.fr/IMG/pdf/Dossier_de_presse_cle2a2a21.pdf

20 <http://www.ntua.gr/arrows/finalhb6a2.pdf>

showed that RWZs are not always guarded appropriately, resulting in confused road users entering the work zone and road workers working at the very edges of and even outside the RWZ²¹.

Work on roads complicates the driving task and can lead to driver error or/and violations. Driver behaviour resulting in RWZ collisions includes:

- Excessive speed before or adjacent to the work zone
- Changing lanes too late
- Inappropriate following distances

1.5 Quantification

There is a need for more comprehensive and harmonised data collection in relation to RWZ collisions, their causes and their consequences in order to inform the development of safety enhancing measures. In this regard clear definitions and reporting arrangements need to be established. 'Traffic volumes, speed before the work zone and in the work zone, weather conditions, time and day of accident, lighting and road surface conditions and general road infrastructure (number of lanes before and after work zone, type of road) are the external factors that could be included in accident records to give the general idea of the conditions in that an accident has occurred'.²²

The situation is further complicated when third parties are involved as reporting mechanisms do not support identification of third party involvement in incidents relating to RWZs. In the UK employers are required to report any injuries that occur at work; however, incidents which occur on roads are excluded from

- Losing control of the vehicle

In the context of the above it is clear that work zones on and adjacent to roads are an additional threat to road users and workers alike as well as to the mobility on European roads. The increased risk at RWZs needs to be recognised by the EU, National governments as well as employers and steps taken to reduce this risks and associated deaths and injuries. Occupational health and safety needs to be integrated into the overall road works planning and execution process.

the workplace reporting requirements. Accidents at road and street works have, historically, been under reported, with a lack of data on works related incidents.

Some good practice approaches of more detailed data collection do exist. In Germany for example, there is official data relating to road works and in-depth collision analyses that can allow for the identification of road works typology and potential collision causation factors. In Ireland police have agreed to collect collision data that facilitates identification of the context of road use of people involved in road collisions. The changes will specifically identify people engaged in driving for work or working on or near the road and non-workers involved in collisions with the latter.

In general data collection is piecemeal and lacking in detail with no means of comparing across the European Union.

21 Venema, A., et al. (2008). Aanrijdgevaar wegwerkers; Eindrapport. Van den Berg Infrastructuren, Zwammerdam.
22 <http://www.ntua.gr/arrows/finalhb6a2.pdf>

Recommendations

Employers

- Carry out studies to identify change in collision risk associated with works activities.
- Develop systems to record work zone characteristics and incidence occurrence and share this information.
- Carry out before and after studies to identify change in collision risk associated with works activities.
- Carry out risk assessment before every road work activity
- Monitor road work collisions, incidents and near misses

Member States

- Change collision data collection to facilitate the identification of collisions occurring in or near work zones and the primary causal factors, including police reporting procedures.
- Carry out before and after studies to identify change in collision risk associated with works activities.
- Finance further research focusing on the behaviour of workers at work zones.
- Finance further research on the vehicle type, pedestrians and cyclist interaction with work zone areas.

EU

- Support the revision of police reporting procedures at the national level to facilitate the identification of collisions occurring in or near work zones
- Facilitate changes to collision data collection and identify good practice in this area.
- Support studies to increase the knowledge of the issues at stake, coordinating traffic and occupational health and safety policies

1.6 Existing Guidance and Regulations

At both European and Member State level a range of legislation and guidance exists that is relevant to the issue of safety in the context of working on or near roads either directly or indirectly. At the European level a number of Directives have been developed that have implications for this area in terms of provisions for standards and procedures.

Directive 92/57/EEC²³ relating to 'Temporary or mobile construction sites' sets out minimum safety and health requirements for temporary or mobile construction sites (i.e. any construction site at which building or civil engineering works are carried out) and intends to prevent risks by establishing a chain of responsibility linking all the parties involved. While Annex I of the Directive does not explicitly state that it applies to road works, several of the mentioned activities are a part of road construction. In Belgium,

for example, the Royal Decree transposing this directive includes temporary road works when more than one contractor is involved (which is almost always the case. In the UK, construction work is defined to include road works.

Safety Framework Directive 89/391/EEC²⁴ underlines the onus on employers to protect their employees and states that they should evaluate the risks to the health and safety of their workers and take measures necessary for the safety and health protection of workers. This requires a risk assessment based approach to safety management.

The Personal Protective Equipment Directive 1989/686²⁵ applies to any device or appliance designed to be worn or held by an individual for protection against one or more health and safety hazards (as defined in the Directive).

23 <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:1992L0057:20070627:EN:PDF>

24 <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31989L0391:EN:HTML>

25 <http://ec.europa.eu/enterprise/sectors/mechanical/documents/legislation/personal-protective-equipment/>

Directive 2008/96/EC²⁶ on Road Infrastructure Safety Management introduces a comprehensive system of road infrastructure safety management and is also highly relevant. It addresses projects for the construction of new road infrastructure or substantial modifications to the existing network which affects the traffic flow within the trans-European road network. The Directive also includes the obligation of Member States to adopt guidelines on temporary safety measures applying to roadworks under Article 6. Member States' guidelines will be made available on a public website. Article 6 also states that safety inspections shall comprise of periodic inspections of the road network and surveys on the possible impact of roadworks on the safety of the traffic flow.

The Directive aims to promote the objective that safety must be integrated in all phases of planning, design and operation of road infrastructure. It must be regarded in its own right and separately from economic and environmental analysis. Member States were also encouraged but not mandated to apply the provisions of the directive to national road transport infrastructure, not included in the trans-European road network. In this regard the European Commission has funded the PILOT4SAFETY project which aims to apply the Directive's approaches related to training and certification of Road Safety Experts for the application of Road Safety Audit and Road Safety Inspection procedures to selected secondary roads, in the EU Regions represented in the project. The idea is to share good practices and define common agreed training curricula and tools for qualification of road safety personnel.²⁷

The majority of Member States have also developed legislation and/or guidance relating to road works or at least some aspects of this. In some countries a legislative approach has been taken through which those carrying out certain types of road works are obliged to follow a standard approach in terms

of issues such as design, layout, equipment and other relevant issues while in other countries a 'recommended' guidance based approach had been taken which is not mandatory. Many Member States also have more than one type of guidance or set of regulations that applies to standards of work zone management and/or operation depending on the typology or road or road works. It is important for Member States to consider the approach to work in or adjacent to roads in a comprehensive and clear manner and to ensure that, where multiple documents exist, they are harmonised, logical and consistent.

There tends to be a greater focus on long term work zone management as this requires more comprehensive traffic management and forward planning efforts. While guidance in the area of short term and mobile work zones is also available, the approach put forward is largely sign based rather than process based. The reliance on signage alone is unlikely to maximise safety for workers. A priority should be to decide when barriers or another protection tool such as vehicles with barriers should be used to physically protect personnel in the installation and removal stage. It is important, for all types of works to facilitate a process based approach to the carrying out of works in or adjacent to roads that includes risk assessment, mitigation and monitoring.

It is evident that there is still work to be done in ensuring a comprehensive approach to safety provision for road works based occupations. There is a focus on the use of equipment to reduce risk which may not always consider fully the optimal approach in terms of ensuring the health and safety of employees. Mandatory guidance should be provided at the national level that sets out a process based approach to safe working on or near the road, putting people at the centre of procedures.

26 <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32008L0096:EN:NOT>

27 <http://pilot4safety.fehrl.org/>

1.7 Case Studies

UK

In the UK the Department of Transport has published the Traffic Signs Manual: Chapter 8: Traffic safety measures and signs for road works and temporary situations.²⁸ This document provides guidance for those responsible for the design of temporary traffic management arrangements which should be implemented to facilitate maintenance activities or in response to temporary situations. It contains advice relating to traffic safety measures, and the identity and location of the traffic signs needed to guide road users, including pedestrians, safely past obstructions in temporary situations. It is structured to facilitate and reflect the design process for temporary traffic management, from the initial broad brief to details of signing provision. It raises the principal issues that need to be considered in temporary traffic management design and provides advice about their resolution. The document deals with the design of

temporary traffic management arrangements on single carriageway roads and dual carriageway roads separately.

The Department for Transport has also published the Safety at Street Works and Road Works; a Code of Practice which sets out the principles to be followed when signing, guarding and lighting works on all highways and roads except motorways and dual carriageways with hard shoulders. This is known as the "Red Book" and is fully consistent with Chapter 8. Its purpose is to ensure that road users and operatives at sites remain safe when works are taking place in the highway. It has been written and published in a size suitable for operatives to carry in a van or tool box and so is readily available to consult on site. The Department for Transport has just completed a consultation exercise to review and update this Code of Practice.

Germany

The German Statutory Accident Insurance (GUV Unfallkasse), the professional association for the construction industry (BG Bau) and the German Road Safety Council (DVR) published in 2008 a booklet on traffic safety at roadworks²⁹. The booklet identifies the legal basis

for such work, with the particular issues of construction methods and the consequences for the safety of workers into the foreground. Acceptance, inspection and maintenance of the roadwork site itself is covered looking at, for example, how often the site has to be inspected.

The Netherlands

The Netherlands have guidelines for the uniform preparation of work zones which place an emphasis on being simple and clear and stress that distance

and/or division between road workers and traffic / other users is important. The guidelines however, do not have a basis in law.³⁰

Italy

In Italy a mandatory legislation exists since 2002 (Decree of the Ministry of Transportation and Infrastructure, 10.07.2002) focused predominantly on signage provision and workers visibility requirements as a safety mechanism. Specific attention is paid in defining the protection of pedestrians in urban work zones. On the other hand, no details on the physical

protection of work zones are currently included in the Decree. Since 1996 (National Law 494/96 recently updated with National Law 81/2008) a Coordination Safety Plan, prepared by a qualified work zone safety expert, is required as mandatory for any public work but a specific module on road related work zones is usually not offered in the official training courses.

28 <http://www.dft.gov.uk/pgr/roads/tss/tsmanual/tsmchap8part2.pdf>

29 <http://www.bgbau-medien.de/bau/baustverk/inhalt.htm>

30 http://www.crow.nl/nl/Meta_Navigaton/over/Over_CROW.html

Ireland

In Ireland, specific legislation and guidance exist including the 'Guidance for the Control and Management of Traffic at Road Works' which provides

design guidance for temporary traffic management at road works on single carriage road ways.³¹

Switzerland

In Switzerland there are legal framework directives and a control body called Suva, which is competent for safety at work. Roadwork zones, signings,

markings are regulated in the VSS (Swiss Association of Road and Transportation Experts). There is also a "Bulletin for safety of workers during road works".

Recommendations

Employers

- Work proactively with Member States to produce more process focused rather than equipment focused guidance and legislation
- Utilise guidance as standard practice in carrying out work

Member States

- Develop legal standards for working on roads
- Produce guidance that is process based rather than signage based
- Produce guidance that focuses on the human factor as well as the traffic factor
- Produce legislation that is clear and enforceable to ensure that it is applied
- Produce guidance including decision making tools that aid those responsible for planning and managing work zones to achieve integration between the traffic management and safety objectives
- Apply the principles of the EU Infrastructure Safety Directive (2008/96/EC), not only to the TEN-T network but, to the rest of the road network.

EU

- Work towards harmonisation of standards and guidance nationally and across the EU
- Collate various approaches and disseminate good practice
- Support common EU curricula for road safety professionals (auditors/inspectors)

³¹http://www.transport.ie/upload/general/12714-GUIDANCE_FOR_THE_CONTROL_AND_MANAGEMENT_OF_TRAFFIC_AT_ROADWORKS_SECOND_EDITION_2010-0.PDF

Part 2: Planning

2.1 Minimising Works Strategically

Safety, including the safety of workers, should be a key consideration at all stages in the life cycle of any road related works project whether it be long, medium or short term or mobile. Project planning, including the tendering process carried out by clients, should incorporate work zone safety risk assessment, impacts and mitigation measures as a matter of course. Consideration of the safety of those working in the work zone solely by the contractor or direct employer is an approach that does not facilitate adequate consideration of safety issues. Clients, including Highways Agencies and/or local authorities, should be proactive and visible in attempting to improve the safety of those working in and around roads as well as that of road users.

The issue of maintenance should be considered from the outset of the design stage in terms of new roads or proposed amendment/renewal of existing roads. In this regard designers should investigate means of engineering out the need for maintenance and engineering in measures that support safe maintenance from the outset.

Design of roads to facilitate safe operation and maintenance of the road long before any works are required needs to be ensured. The design of roads should be based on the principle of minimal intervention which tries to ensure that minimal changes to the original road structure will be required. Design that contributes to legibility and reduces the need for roads users to modify their behaviour should be a primary aim.

The risk posed by road works could be minimised by aiming to develop 'zero maintenance' roads. While this would not impact on all types of work occurring on or adjacent to roads it offers the potential to almost completely negate the need for traditional road works thereby achieving huge risk reduction to both workers and general road users.

'It is...a reasonable objective for road transport safety to reduce downtime due to construction

and increase the level of service. Research includes concepts to increase durability and reduce maintenance interventions and costs by advanced asset management approaches. The challenge is to unify expectations and lifecycle cost reduction by at the same time increasing availability, quality and reliability of the road infrastructure network. This and traffic safety concepts especially in road construction areas will aid in reducing collision risk. Safety of road workers and concepts to reduce the risk of collisions involving road workers is of specific interest' .

While zero maintenance roads may not be achievable in the short term and maintenance is envisaged, designers should consider this need at the design stage. Agencies should realise the importance of life cycle costing rather than initial costing in determining design and building of projects as this has the potential to reduce the duration and frequency of work zones.

Roads Authorities should adopt a life-cycle approach to planning and operating roads infrastructure using 'asset management' as a tool to maintain existing infrastructure in an efficient way, ensuring that it meets safety standards and optimising its use. Such an approach can facilitate reduced maintenance needs by allowing a more targeted approach. 'Good asset management tools must be developed to support decision making by road authorities with respect to maintenance strategies and reserving funds for conservation of the road networks. Monitoring systems to quickly establish the condition of the infrastructure, performance models for structures, materials and maintenance techniques to forecast' should be developed and utilised. The ability to reduce maintenance needs will reduce overall risk on the roads to both workers and other road users.

'Smart maintenance techniques are developed to reduce 'downtime' of the road, for example surface treatment sprays to revitalise surface properties and prefab surface layers (pavement on a roll) allowing partially and rapid replacement and upgrading of

32 ERTRAC 2010 Proposed Roadmap on Safer Road Transport, Working Group – Road Transport Safety and Security, Draft Paper
33 FEHRL New Road Construction Concepts; Vision 2040 nr2c.fehrl.org/?m=23&mode=download&id_file=1070 p

pavements. New prefab methods of road construction are used to build new roads or upgrade existing ones. Prefab constructions provide high quality because of the high level of production conditions and the introduction of new techniques and materials.



Other smart solutions like temporary 'bridges' are used to roof over maintenance work, thus relieving congestion, reducing the need for diversions and creating safe conditions for the workers³⁴.

Opportunities also exist to reduce the risk posed by road works by designing in safety measures such as lay-bys, pull-of maintenance areas and ensuring minimum widths of verges or medians that will provide a safer working environment. Planning should consider the broader business case of including social benefits and the value of workers as assets as well as the long-term savings to be made through initial higher spends on methods of engineering out maintenance requirements rather than the narrow approach focused on upfront cost and traffic management impacts.

Recommendations

Employers and Member States

- Design out the need for maintenance - work towards 'zero maintenance' roads (research and innovation in advancing materials, constructions techniques, etc)
- Design in mechanisms to support safety maintenance when required
- Utilise asset management and life cycle approaches to target, coordinate and minimise the number of maintenance interventions required

EU

- Support the development of maintenance free roads
- Support a life cycle approach to infrastructure construction and maintenance

³⁴ Ibid p 17

2.2 Procurement

'European contracting rules and tender procedures tend to give the contract to the construction company who does the work at the lowest costs. Occupational health and safety is generally not an important issue in these procedures'³⁵. Risks increase due to limited road spaces that are appointed to the road workers as well as limited time slots that are available (road works on major roads are preferably carried out during the night). Tenders for road construction projects are generally won by those companies that can work without hindering traffic mobility³⁶. This is an area that should be addressed in order to provide safer working environments and reduce the risk associated with RWZs.

At the European level Directive 2004/18/EC³⁷, on coordination of procedures for the award of public works contracts, public supply contracts and public service contracts applies to the construction of roads and installation of signage. The inclusion of the need to take account of safety aspects into this Directive should be considered within the ongoing revision.

Governments can bring about change by setting an example. They can influence demand through their own public procurement policies. There is in fact great potential to do this. All non-private customers, such as governmental bodies, local authorities and companies can play an important role by including specific requirements to achieve high levels of safety at roadworks in their tendering processes. In doing so, they can improve the balance between safety and efficiency at road works and work towards the inclusion of comprehensive safety measures as standard practice.

Organisations and companies both on the client and contractor side should consider the use of safety related performance goals as a mechanism to facilitate improvement. Such goals could focus not only on reducing work zone related collisions but also more specifically on reducing worker injury rates. Clients should also utilise the contracting procedure by specifying safety improvements in relation to

required procedures or equipment use. Such an approach has the potential to raise the importance of safety considerations in RWZ planning and shift the focus from congestion and cost based approaches.

The focus on bids which appear to be most economically advantageous and those which offer least impact on traffic flows or disruption is often at the cost of any robust risk assessment and provision of adequate safety measures relating to work zones. As such work zone stakeholders may have a negative incentive to disregard or neglect safety issues. This problem is exemplified as subcontracting occurs with pressure on employers and employees alike to meet restrictive time and budget deadlines. 'A perverse incentive is frequently created to disregard safety rules in favour of engineering considerations or to avoid late finish penalties'³⁸.

Time allocations reserved to do road works are generally too short and the offer to contractors of possible bonuses to finish within schedule is an additional risk. This approach is not recommended from a safety point of view. A more progressive safety conscious approach that is being utilised in some public-private partnership arrangements is to link safety criteria to payment so that a percentage of money that is going to be paid depends on the safety results (lack of incidents) of the project. Such an approach is particularly relevant to government authorities. Contractor performance should also be judged in terms of safety, not just time and cost.

The number of stakeholders potentially involved in a RWZ, their objectives and defined responsibilities can cause further problems to the detriment of safety. In many cases road work related companies are contracted by government/roads authorities or sub contracted by large companies. A number of 'contractors' often work together at a single work zone. Cross organisational cooperation is also required in terms of specifying safety procedures and setting high safety standards. Cooperation should also form the basis for a risk assessment where

35 SAFEROWOZO. Safe Road Work zones. Project proposal. Venema, A & Van der Vorm, J. TNO, Hoofddorp, 2009

36 Venema, A., et al. (2008). Aanrijdgevaar wegwerkers; Eindrapport. Van den Berg Infrastructuren, Zwammerdam.

37 <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:134:0114:0240:EN:PDF>

38 ERF (2007) Safety on motorway Work zones, Discussion Paper.

companies or contractors are operating in a single work zone or within the vicinity of each other. This is necessary to ensure that there is a coherent and effective approach to reducing risk and ensuring safety. There is a need for sharing of information between highways agencies and utilities providers in relation to the forward planning of projects and maintenance requirements.

Tendering processes should stipulate that cooperation occurs in terms of risk assessment and safety planning.

Recommendations

Employers

- Engage in a competition to meet high standards of safety during the procurement process.
- Regardless of their size, develop a policy with supporting procedures aimed at preventing collisions at work zones and ensuring worker health and safety.

Member States

- Develop further guidance on setting safety related performance goals and ensuring safety measures through contractual obligations and budget.
- Ensure all tenders include criteria relating to provision for safety and safety standards specifically for workers as well as other road users.
- Investigate the possibility of setting up formal agreements for coordination between contractors.
- Include risk assessment of employees and subsequent training and qualification checks during procurement process.

EU

- Revise the EU Directive on Public Procurement to addresses safety aspects

2.3 Planning the Work zone

During the work planning phase, fundamental decisions about the RWZ are made which dictate levels of safety either directly or indirectly. 'When determining the timing, form and type of road works, a balance should be achieved between the following:

- Safety of road users and workers
- Traffic flow and road user inconvenience
- Efficient work zone scheduling and economical traffic operation
- Environmental impact and other quality requirements

Other prerequisites could also be set down during the tendering process and tied in through contracting arrangements such as specification of the need for worker/live traffic separation devices.

Training should also be one of the points to be checked during the procurement process. The transport contractor should include training and qualification requirements of the employees chosen to undertake the work. Here governments too can do more in term of instructing and educating their own employees.

The impact of the roadworks as regards space, time and cost should be minimised as far as possible; at the same time, safety, environmental and other quality standards must be met'.³⁹

More work needs to be done in achieving this balance with traditional approaches focusing largely on ensuring the efficient flow of traffic failing to adequately balance this with safety of workers. To-date integration between existing frameworks for workers and frameworks for road users isn't achieved.

³⁹ <http://www.ntua.gr/arrows/finalhb6a2.pdf>

Strategic level initiatives that have the potential to help redress this balance have been outlined in the Section above including zero maintenance roads, lifecycle management, procurement procedural changes and integration of occupation health and safety consideration into planning. At the lower level other initiatives can also be applied to reduce maintenance requirements and to reduce risk.

Steps should be taken to reduce the number of road works required through forward planning and cooperation between relevant organisations (highways agencies, local authorities, utility operators). Cooperation should ensure that, where safe and practical, works required in an area can be combined and carried out at the same time rather than separately. This has the potential to avoid the use of numerous short work zones and thereby reduce the safety risk.

“Road works and other works that can affect the availability of the road should be coordinated. Different works on the same site should as much as

possible be combined to limit the period of reduced availability of the road...This would limit interference between works and traffic and increase the security of workers. Additionally, it should be avoided that traffic trying to avoid road works on one site, ends up in another work zone”⁴⁰.

To reduce the risk exposure of both road workers and road users the use of strategies including road closure or night time working may be considered which can limit the actual time required to carry out work and the interaction between a live work zone and the general public. Further research is required in order to identify the costs and benefits of such approaches not only in terms of money and time but also in terms of the safety of the workers and the safety of other road users. Such research including collecting and analysing data would be useful in order to aid decision making at the planning stage as to when such strategies should be adopted. In this regard there is a need for a more formal approach or set of guidelines on when to use such strategies which fully incorporate worker safety in the decision making process.

Recommendations

Employers and Member States

- Develop processes to ensure coordination and combining of works
- Stimulate research to provide a greater understanding of the balance between traffic impact and safety of strategies such as road closures, lane closures, night-time working
- Develop a more formal, evidence based guidance on deciding when to adopt the above strategies

2.4 Safety Appraisal, Risk Assessments and Safety Plans

A safety appraisal is a systematic and critical examination of the workplace for the purpose of identifying hazards, assessing the risk and recommending controls to reduce the risk, where appropriate. Risk is a measure of the likelihood of a collision occurring coupled with the potential severity of the injury or loss. When the safety appraisal identifies a hazard, it is necessary to assess the risk in order to determine what control measures should be introduced. The risk assessment assesses both the probability of an incident occurring and the consequences of the incident.

Safety appraisals and risk assessment should be carried out prior to all proposed works in or adjacent to roads. The level of detail involved should reflect the complexity of the work proposed and the local environment and should cover both issues relating specifically to employees as well as all other road users: pedestrians, cyclists, public transport, HGV's and cars as different hazards risks and subsequently mitigation measures may emerge.

Measures to remove or minimise risk should be developed and integrated with the transport management plan to ensure safety is paramount

40 NAVB-CNAC Witboek wegenwerken-Livre blanc Travaux de voirie <http://navb.constructiv.be/nl/Welzijnsinfo/Publicaties.aspx?Page=46>
Short summary in English provided by Kris Redant

at all times. This will require an iterative process in order to reach a balance between safety provision and transport efficiency (See Section 2.10 below). To ensure that this takes place it is important to designate a person responsible for safety in relation to each work zone and to put in place systems of checks or reporting mechanisms to be used at the operational, installation and removal stages. In Belgium the appointment of a safety coordinator is mandatory; however, this is not always applied by contractors. As such enforcement of inspections needs to be addressed⁴¹. In Italy a qualified expert responsible for the work zone safety has to be appointed by the contractors in every public work according to the National Law 81/2008 (former 494/1996).

Risk Assessment should be carried out by all those involved in working on or near roads regardless of the size or company or works to be progressed. In this regard the risk assessments procedures can be targeted and tailored to match the complexity of the situation. Overall, it is important for organisations considering employee training to have an effective

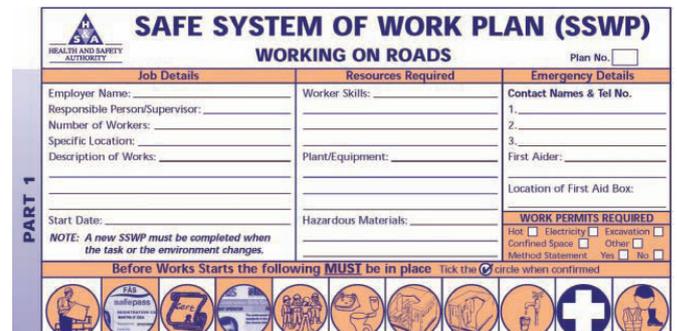
2.4.1 Case Studies

Ireland

In Ireland the Health and Safety Authority has developed a Code of Practice aimed at Contractors involved in Roadwork and Road Maintenance⁴⁵ activities where three or less persons are employed as part of its broader Safe Systems of Work procedures⁴⁶. The aim of this Code of Practice is to improve the level of safety and health among small-scale employers and contractors (employing up to three employees) engaging in road works and to assist them in putting a Safety Statement in place. The Code provides guidance to employers on how to plan and work safely on site. In implementing the Code employers can use a 'Safe Systems of Work Plan' (SSWP) provided by the HSA which is a simple tool to aid risk assessment and safety planning.

risk assessment-led process under the Framework Directive 89/391/EEC⁴². Under Article 6, within the context of their responsibilities, the employer shall take necessary measures for the safety and health protection of workers, including prevention of occupational risks and provision of information and training, as well as provision of the necessary organisation and means. Article 12 on the training of workers states that, the employer shall ensure that each worker receives adequate safety and health training. Also training should take place in the event of the introduction of new work equipment or a change in equipment, or in the event of the introduction of any new technology.

Risk assessment should also cover whether or not personnel are capable of understanding and acting upon instructions, have good hearing and eyesight. They should also assess that safety is not compromised by them suffering from specific conditions or illnesses⁴³. PREVENT WP3 developed tools for the training for workers, supervisors and inspectors⁴⁴.



Part 1 provides for recording descriptions of the workplace, the work activities and the skills and resources needed to carry out the work. Details must also be provided of who is in charge of the works

41 NAVB-CNAC Witboek wegenwerken-Livre blanc Travaux de voirie <http://navb.constructiv.be/nl/Welzijnsinfo/Publicaties.aspx?Page=46>
Short summary in English provided by Kris Redant

42 <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31989L0391:EN:HTML>

43 <http://www.dft.gov.uk/ha/standards/ians/pdfs/ian115.pdf>

44 <http://www.hit.certh.gr/prevent/media/Deliverables/D2.pdf>

45 <http://www.dft.gov.uk/ha/standards/ians/pdfs/ian115.pdf>

46 http://www.hsa.ie/eng/Publications_and_Forms/Publications

and emergency contact details. Part 2 provides for the identification of hazards and control measures to deal with these and a check mechanism to ensure that measures are put in place before work commences. Part 3 allows those who are going to

work on the activity to sign off on the SSWP and should be completed by the person who prepared the SSWP and the workers to confirm that the SSWP has been brought to their attention.

Austria

ASFINAG plans, finances, maintains and tolls the entire Austrian motorway and expressway network covering 2,175 kilometers and has recently published a Road Safety Programme to 2020⁴⁸ which includes comprehensive collision prevention measures aimed at making Austrian roads safer. Part of the plan specifically targets practices surrounding road works zones putting in place new procedures to improve efficiency, reduce cost and improve safety. The procedures include the development of a handbook to set standard practice and the use of checks and inspections to ensure that safety planning is implemented and maintained. In relation to risk assessment, safety planning and monitoring, the Road Safety Programme provides for the following in relation to RWZs:

- New roadwork zones will be inspected together with the police and undergo intense observation in the first days after traffic approval.

- During the entire duration daily road safety checks will be performed and fines given out to construction companies if defects are caused by them.
- Observations about defects from ASFINAG Pilot and via the ASFINAG Service Centre are handled with the highest priority.
- The Road safety checks of roadwork zones are performed in accordance with the European Infrastructure Directive
- New Roadwork Zone Handbook is prepared (in accordance with the RVS 05.05.42).
- At roadwork zones that have a significant influence on the traffic flow Road Safety Audits (RSA) are performed in advance.
- In terms of work safety the project manager will write a protocol of all work collisions and their consequences, from start to approval of the roadwork zone.

Recommendations

Employers

- Understand that safety measures are necessary for every type of RWZ. Even when the work zone has a very short duration, occupies a very short length, or is located on the hard shoulder or the roadside - the potential implications for safety should be always considered⁴⁸.
- Develop safe systems of work procedures
- Carry out a safety appraisal and risk assessment for all proposed works
- Provide a safety statement or plan for each work zone
- Designate a competent person with specific responsibility for safety for each works project
- Monitor the implementation of the Safety statement / plan throughout the work duration

Member States

- Assist in the development of standard practice safe systems of work procedures
- Consider the need for an authority/3rd party/regulator to audit/check the planning for works in terms of meeting safety criteria prior to the commencement of works

EU

- Support the inclusion of a "work zone safety management" in a common EU curriculum for road safety auditors/inspectors
- Disseminate best practices on Road Safety Audits and Risk Assessment on work zones

47 http://www.asfinag.at/c/document_library/get_file?uuid=ccd7dbb6-3e9f-4ad0-9f6b-842f3651acfd&groupId=10136

48 <http://www.ntua.gr/arrows/finalhb6a2.pdf>

2.5 Personnel

Inherent in the planning procedure relating to road works is the need to redress the balance between traffic management and employee safety. The risks for workers are not always recognised.

Occupational health and safety must be integrated into the overall road works planning and execution process. Changes to the procurement process as suggested above can work towards achieving this however more can also be done by employers in terms of internal arrangements.

A change in focus is required away from the impact on journey times and the traffic network towards the value of employees and the moral and legal

2.5.1 Case Studies

UK

The UK Highways Agency are progressive in their commitment to improving the safety of their road worker employees, having adopted an 'Aiming for Zero' approach to health and safety including eliminating all deaths and serious injuries to road workers maintaining the road network. Central to the approach is a goal of 'Exposure Zero' 'to eliminate the need for road workers involved in routine maintenance of (the) road network to be on foot on the live carriageway' as this is when they are most at risk. In attempting to deliver the goal they have carried out a review of operations that require road workers to be exposed to live traffic, with a

2.6 Training

There is a requirement for compulsory training on safety and health issues (Article 12 of Framework Directive 89/391/EEC). Training should be risk assessment led or based on a needs analysis. People planning and managing work zones need to be qualified and as such standard practice training programmes should be developed specifically focusing on working on or adjacent to roads in order to embed safety into work processes. Training must focus on work methods (deciding what safety measures to implement, how and when) as well

obligation to work towards a vision of zero risk for those working on the roads. Companies and authorities with employees that carry out work on or adjacent to roads should develop specific policies and procedures to ensure the upmost safety in this, area.

Organizations should aim to adopt a 'vision zero' for RWZ related collisions. The absence of a true safety culture amongst road authorities and private contractors with specific targets elevates risk associated with road works zones even before the complexities of interactions with the general public and operation of the zone are considered.

view to reducing risks, and a revision of maintenance priorities to reduce the number of visits and ad-hoc repairs and maintenance to cut the need for road workers to be on the network⁴⁹.

One of the most likely ways of achieving Zero Exposure is through the development and use of new technologies which mechanise some of the high risk tasks involved in road maintenance. The Agency has also been trialing new technology and ways of working which aim to remove the road worker from the roadway as much as possible.

as equipment usage, covering signage, barriers, clothing, safety inspection procedures and planning for what happens in case of an incident. Workers also need to be specifically trained in the operation of traffic control devices. At the international level there also exists an OHSAS 18000 (occupational health and safety management) document through which companies can receive certification according in this area. OHSAS 18000 is management system specification. National governments should take a leading role in setting standards for training in

49 http://www.highways.gov.uk/knowledge/documents/Road_worker_Safety_Strategy_Action_Plan_2009-11.pdf and http://www.highways.gov.uk/knowledge/documents/Road_worker_Safety_Strategy.pdf

this field and ensuring uptake. In Belgium a system of training and certification has been developed⁵⁰ while in Germany the DVR organises seminars for workers and safety officers of companies on how

to deal with work zones. In UK, Sector Schemes are used to agree training levels required by work type, together with the relevant industry representatives.

2.6.1 Case Studies

Ireland

Ireland has recognised that, in order to stay safe in construction, everybody working in the sector must have specific training. A system of mandatory training and registration requirements for workers under safety and health legislation has been developed and also applies to those working in road maintenance in order to ensure that competent people are carrying out the works.

Workers must hold a valid Safe Pass qualification⁵¹ and must renew this every four years. The training modules cover safety culture, duties and responsibilities at work, collision reporting and prevention, and special working situations such as working at height and excavations. Safe Pass also covers personal protective equipment (PPE), use of hand-held equipment, tools and machinery, safe use of vehicles, noise and vibration, manual handling, and health and hygiene.

A more specific Construction Skills Certification

Germany

The German construction industry (BG Bau) and the German Road Safety Council (DVR) have developed a seminar covering training⁵³. The seminar is aimed at all those responsible for site safety- from planning approval through to implementation. The current laws and the requirements of the 1995 revised

Italy

In Italy a training course is mandatory to become a qualified expert in RWZ safety according to the National Law 81/2008 (former 494/1996) but specific modules on RWZs are usually not included with

Scheme (CSCS)⁵² provides for the training, assessment, certification and registration of construction workers undertaking certain tasks. The CSCS aims to raise standards of safety and health awareness, and so reduce risks and collisions throughout the industry. In relation to working on or adjacent to roads CSCS registration is specifically required for

- Signing, lighting and guarding on roads
- Locating underground services
- Assisting in the implementation of health and safety at roadworks

Operators who successfully complete an approved CSCS training and assessment programme are awarded certification from a national organisation and are added to a register. Under national Regulations, project supervisors must ensure that persons are in possession of the relevant CSCS card and safety awareness card before undertaking work in connection with roadworks.

“Guidelines for the safeguarding of jobs on roads” (RSA) are covered and the course is designed with different building blocks and can be used flexibly. The seminar can be conducted as a one- or two-day course. A brochure “Road Safety at Worksites” was also published in 2006 to accompany the course.

limited exception of course organised specifically for road authorities (as the ANAS training course which includes such specific module).

50 <http://www.besacc-vca.be/fr>

51 <http://www.fas.ie/en/Training/Employee+Training/Safe+Pass/>

52 <http://www.fas.ie/en/Training/Employee+Training/Construction+Skills+Certification+Scheme/>

53 http://www.dvr.de/site.aspx?url=html/betriebe_bg/seminare/baustellen.htm

Recommendations

Employers

- Ensure integration of occupational safety issues into the overall road works planning and operation process through the development of company policies and procedures
- Develop a goal driven approach focused on health and safety issues
- Develop a standard practice of carrying out risk assessment, including occupational risk assessment in relation to all works projects
- Develop a standard practice safety planning for all works projects
- Ensure implementation of a good safety plan with the employment of well-trained personnel on all levels is essential to achieve high safety levels. (Skills Certification Scheme)
- Ensure that there is a clear line of responsibility and that staff are competent and trained
- Ensure that workers behaviour is part of the process to ensure acceptance of the need for safety mechanisms

Member States

- Support the development of training including qualification of trainers and topics covered in the training
- Help authorities/contractors to develop specific procedures for carrying out risk assessment for work zones
- Include specific modules on RWZs in national training programmes for RWZ safety experts

EU

- Act as a catalyst for the development of EU wide training standards

2.7 Infrastructure: Transport Management Planning

Traffic Management is central to the planning phase and plays a vital role in providing continuity of safe and efficient road user flow and worker safety when a work zone occurs. The safest work area is one which is completely closed to traffic, however this is not possible without major impact on the road network in terms of traffic management requirements. A balance needs to be struck between consideration of the health and safety of workers and the efficiency of the network/safety of other road users. To date this balance has not been achieved to the detriment of those who work in and around roads. Planners and engineers need to take a more active role in relation to maintenance in order to reduce the impacts of work zones and improve their safety for all.

The traffic management plan should be location specific and will require the collection of information and data relating to the project (type of works to be carried out, phasing approaches/plans, number of actors involved) as well as characteristics of the transport network including the road alignment; vehicular volumes, patterns and composition; presence of pedestrians, cyclists and vulnerable

users, collision data; existence of permanent traffic control devices and other equipment; and alternative transport routes. Information on any other projects within the vicinity should also be compiled to assess the combined/cumulative impact of works.

Potential impact of planned works on the wider transport network for all modes should be assessed and, where possible, transport models should be used to provide an analytic assessment. The assessment should be evaluated not only in terms of congestion and journey time impacts but also in terms of overall safety on the network should proposed maintenance works be carried out. The risk exposure in surrounding areas may be changed as a direct result of migration of road users from around a work zone area. A multidisciplinary approach is required for input into the traffic management plan which should include personnel trained in the areas of road and occupational safety.

The traffic management plan and the design of the work zone should be of the same high standard

as for permanent roads and should incorporate the Principles of Sustainable Safety⁵⁴. These were developed originally in 1992 in the Netherlands, and have become part of European road design and safety since then. These principles include:

- **Functionality** (the road / street / work zone should be designed to fit its purpose, e.g. cycling)
- **Legibility** (the road, junctions and conflicts should be obvious to all road users, and the resolution of conflict should be mutually understood by all road users and workers)
- **Forgiving Environment** (if an collision should occur, the outcome is as benign as possible for both workers and road users)
- **Homogeneity** (it is safer to mix traffic of similar mass, speed and direction thereby limiting exposure of workers to live traffic)
- **Self Awareness** (road users and workers should be aware of their competence)

Traffic management planning should also include a strategy for communications with the public that informs affected road users, the general public, area residences and businesses, and appropriate public bodies about the project, the expected work zone impacts, and any foreseen changing conditions. For larger road maintenance and construction projects interaction should commence at the planning stage with consultation and may include the following measures:

- Use of websites to allow the general public to access information on work zone activity and possible impacts to their travel routes which should be updated on a regular basis if not providing real-time information
- Encouraging people to move to other modes of travel such as bus and train where possible to minimise their interaction with RWZ
- Other media attention such as announcement on local radio, newspaper adverts
- Consultation at the design stage for larger projects with the general public
- Work zone awareness campaigns
- Material to educate the public on safety

issues relating to working on or near roads

For smaller road works warning in advance of installation of road works may be sufficient and more appropriate than consultation.

A number of Member States have already taken steps to ensure that communication is a central part of planning for road works. In Germany consultation with the public is a requirement and in the Netherlands, for major road works, companies must have a website setting out details about the works. In some countries roads authorities are also taking the initiative and have developed real-time websites to provide the public with information about road works, associated traffic conditions and possible diversions or alternative routes (UK Traffic England⁵⁵ and Highways Agency⁵⁶).

At the planning stage the traffic management plan should also detail what measures will be taken to convey on site information about the road works during the installation, operation and removal periods and what measures will be used to make it clear to other road users what is expected of them in terms of behaviour. 'The plan should show the type and location of signs, closures, vehicles and other devices at each work site, and be done according to the regulations in force. Part of the plan is also a script for the setting up, the maintaining and the dismantling of the work zone. The plan establishes the responsibilities of road workers, road directors and safety inspectors. A trained official must approve the plan and should monitor the implementation of the plan.'⁵⁷ It is critical that the traffic management plan is clear and unambiguous both from the point of view of road users and road workers.

Handling speed and speed reductions should be central in the development of the traffic management plan. As previously noted, speed has been identified as the main cause of collisions at works zones.

54 http://www.swov.nl/rapport/Factsheets/UK/FS_Sustainable_Safety_principles.pdf and <http://www.crow.nl/nl/Publicaties/publicatiedetail?code=REC26>

55 <http://www.trafficengland.com/disruptions.aspx?ct=true#ds>

56 <http://www.highways.gov.uk/traffic/traffic.aspx>

57 <http://www.ntua.gr/arrows/finalhb6a2.pdf>

During the planning process particular attention should be paid to agreeing on speed limits. These should be set based on the need to protect workers rather than to solely keep traffic flowing. A recommended technique is to use stepped speed limits, in properly-spaced steps of no more than 20 km/h. Speed limit changes should be implemented

before traffic is detoured, through the work zone, or adjacent to unprotected construction workers⁵⁸.

Technology is important in both informing road users about required changes to their behaviour and in enforcement (See Section 4.7).

Recommendations

Employers

- Ensure that, at the planning level, suggestions about road safety are discussed with colleagues and other involved persons. A multidisciplinary approach is required.
- Ensure that designer visualise safety measures from the eyes of the road users, especially older drivers and other vulnerable users. Messages should be adequate and easily comprehensible.
- Ensure that signing and layout of road works are flexible, following changes and different phases of the work⁵⁹.
- Assess the potential impact of planned works on the wider transport network for all modes, not only in terms of traffic impact but all impact on safety.
- Ensure that the traffic management plan and the design of the work zone should be of the same high standard as for permanent roads and should incorporate the Principles of Sustainable Safety.
- Communicate with others. 'The existence of a work zone should be announced to parties directly or indirectly affected or concerned, such as the police, emergency services (e.g. first aid or fire brigade), traffic information centres and authorities responsible for the management of adjacent roads'⁶⁰.

58 <http://www.ntua.gr/arrows/finalhb6a2.pdf>

59 Ibid

60 Ibid

Part 3 Installation and Removal of Work Zones

The second stage of a work zone is that of preparing the area for work. This involves identifying the personnel needed for the work, the area for work and the equipment necessary for this part of the process. Different procedures have to be taken into account for urban, rural or highway road works. The installation of a work zone can be seen

as a small short term work zone before the main works begins. The last part of a work zone is the removal part which should be seen as the reverse of the installation and covers carefully taking away the extra signage and barriers before leaving the carriageway over to live traffic.

3.1 Personnel

Training for personnel must include the installation of a work zone. Workers need to be informed about the organisation and operation of the site, including all safety aspects, as well as about the emergency plan⁶¹.

the different contractors is mandatory. During the installation stage client leadership is very important in ensuring that there is the correct balance of risk between road workers and users.

One of the key issues in installing the work zone is the importance of co-ordinating between different people involved in the work as usually different contractors are involved. In some Member States (Germany, Ireland, UK) such co-ordination between

A priority should be to decide when barriers or another protection tool such as vehicles with crash cushions should be used to protect personnel in the installation and removal stage. A decision tool should be used as to help inform the work zone managers on this.

3.2 Infrastructure

'The installation of road works must be signposted in accordance with general principles governing proper signposting, i.e. they must give road users gradual, consistent and comprehensible warning of the type of obstructions and guide them on how to proceed in a safe manner'⁶². 'Installation of the work zone should take place at a time which is characterised by a lower traffic flow. The introduction of the new temporary work zone road markings should be well timed. When road works are carried out, the existing permanent markings should be covered to avoid confusion. Once the work is finished temporary markings should be removed without leaving any trace'⁶³. 'Buffer zones and physical protection of workers are needed even during the preparatory phase. Traffic cones and other guidance and delineation equipment are no substitute for continuous physical protection measures'⁶⁴.

smooth transitions between the normal roadway and the work area, as well as the provision of adequate space (buffer area) for separating the travelled way from the road works. This is also an important element to take care of when installing and removing the work zone. 'Before opening the work zone it is preferable to conduct both an internal and external check'⁶⁵.

Elements of physical design include⁶⁶:

- Lead-in taper and exit taper, providing a smooth change in lane width
- Longitudinal and lateral buffer width

Speed restrictions should be introduced as soon as the installation phase of the work zone goes ahead. Especially but not only during the installation and removal phase ITS can introduce information to drivers on more differentiated speed limits and these can be enforced accordingly.

The physical design of RWZs aims at the provision of

61 Ibid

62 EUROPEAN UNION ROAD FEDERATION (2007) Safety on motorway Work zones, Discussion Paper

63 http://www.etsc.eu/documents/FINAL_Fact_Sheet_Conspicuity.pdf

64 Ibid

65 <http://www.ntua.gr/arrows/finalhb6a2.pdf>

66 Ibid

3.3 Vehicles and Equipment

Truck mounted attenuators (TMAs) mounted at the back of work trucks offer an extremely convincing means of protection from errant vehicles and construction workers, particularly during short duration works and when carrying out mobile lane closures – they are now mandatory in several EU Member States.



3.4 Informing the Road Users

Advance warning of upcoming road works including the preparatory phase can also help drivers avoid the area. Special care should be taken when the lanes for the start of the work are opened and closed. Overhead gantries can't be used on their own for the purpose of informing the road user on the approach to road works, signs must be used to support the messages as well.

The provision of information about prospective road works can also be combined with travel management information encouraging the use of alternative routes and the use of other modes of travel such as public transport to reduce the volumes of vehicles passing through the work zone. Risk can be avoided through timely information to other road users.

3.5 Case Studies

Ireland

In Ireland, the site is prepared in such a way that signs, lights and guarding are put in place in parallel. Irish authorities also communicate to the public that works will be starting in a number of weeks in order to influence road user route choice and travel planning. Regulations were amended in 2008, this also covered the specific need for training in deciding

what signs and barriers are required. One decision maker is nominated on the site in terms of setting and moving signs. Ireland also has a construction skills certification card including specific training for road works and more detailed supervisory level training available.

Recommendations

Employers

- Ensure for co-ordination between the different contractors to take safety into account during the installation and removal phases.
- Ensure that there is a person responsible for safety on each site.
- The signs, markings and other safety measures used should point out clearly the travel paths to be followed by drivers. Existing signs, markings and safety devices should be replaced, covered or altered if they are inconsistent with those paths.
- Place RWZ signs at the normal signing height.
- Provide sufficient height to give appropriate visibility to oncoming drivers and, in urban areas, for passing pedestrians.

- Avoid the use of flashing lights in the RWZ in order to maintain their attention-raising effect.
- Ensured that safety barriers are visible, especially during the night-time and in bad weather. It is preferable to use barriers with visual (retro reflective) leading elements.
- Apply traffic markings using yellow retro reflective paint or tapes. The use of thermoplastics or cold plastic is not advisable because of the short time scale of the works.
- Use only well-maintained material at work zones. It should be ensured that signs and beacons cannot fall over, slip away or be blown away by the wind.
- Place signs and other traffic control devices moving in the direction of traffic flow (downstream)⁶⁷.
- Use safety devices (such as barriers, TMA's) as described in the instructions accompanying these devices.

Member States

- Ensure that legislation on work zone management includes co-ordination between the different contractors to take safety into account.
- Ensure that contractors also start to communicate with the road users about upcoming roadworks during the preparatory stage.

Part 4 Management of the Work Zone

The aim of managing a work zone should be adopting measures that will achieve as close to vision zero for deaths and serious injuries. Timing for works is crucial, delays reserved to do works are too short in general and the offer to contractors of a possible bonus to finish within schedule can lead

to an additional risk. The next section covers safety of personnel, vehicles and equipment and the work zone infrastructure management. It also includes a section on communicating with the public and managing speed at work zones.

4.1 Safety of Work Zone Personnel

There are five key principles that should be respected to protect road workers cited by ARROWS 1998⁶⁸:

1. Avoid exposure of workers to traffic.
2. Make workers visible to road users, both by ensuring adequate visibility for drivers and by providing suitable clothing for road workers.
3. Provide physical protection of workers from traffic. Even in short-term RWZs, buffer zones should be foreseen as a minimum
4. Protect workers from collisions involving works vehicles. The movements of works vehicles should be adequately perceived by workers.
5. Avoid excessive work hours. European and national legal requirements regarding work hours must be observed. Fatigue can contribute to increased risk for road workers.

One of the goals of safer work zone management should be to remove personnel from live traffic. The ideal situation is to work towards using machines using overhead gantries or vehicles without people in them. If workers are on the road then measures must be taken to protect them from moving traffic. This includes installing physical barriers and ensuring proper visibility and appropriate training. Personnel should work facing oncoming traffic, wherever practicable. The loading and unloading of tools and equipment should not be undertaken from the live traffic side of the vehicle. This also means undertaking rigorous planning. The Framework Directive 89/391/EEC should be the starting point. It states that employers shall, taking into account the nature of the activities of the enterprise, evaluate the risks to the safety and health of workers.

⁶⁷ Arrows (1998) <http://www.ntua.gr/arrows/finalhb6a2.pdf>

⁶⁸ <http://www.ntua.gr/arrows/finalhb6a2.pdf>

Rear end collisions are one of the main risks. Caution should be taken by drivers when reversing. Guidance recommends that drivers at worksites should find safe alternatives to reversing if at all possible and that they should walk around the vehicle and look for obstacles or hazards before moving. If reversing then, it is important that drivers reverse slowly and avoid reversing over a long distance. If possible, drivers should reverse or 'pull-through' into parking spaces rather than out of them⁶⁹. Works vehicles should also include rear-view cameras or audio warning devices⁷⁰.

Pointing out the risks of roadworks should encourage safer behaviour of road workers. Most road workers and other involved staff are not conscious of the high risks while working at a road work. This lack of awareness should be overcome by appropriate action at a general and a project-specific level⁷¹. Subsequent to the risk assessment evaluation the employer must implement the resulting preventive and protection measures, in particular the training needs required to the situation.

Giving clear instruction to personnel is a crucial part of managing personnel in a work zone. It is recommended to instruct all employees at the beginning of each road works project. Such instruction should incorporate adequate information about road works in general, as well as the specific project worked upon. All relevant information related to the operations should be shared between all parties concerned. This includes not only the workers directly involved in the maintenance task,

4.2 Vehicle and Construction Equipment

Vehicles and construction equipment should also be chosen adhering to safety criteria. The section above details the importance of ensuring that personnel are trained and able to use them. When employers are planning their work zone careful consideration is needed to determine in advance which equipment is needed.

but also those likely to be affected by it or who may be working in the vicinity⁷².

Preventative measures can be identified and implemented according to the results of the risk assessment. It is important to apply the principle of the prevention hierarchy (elimination-substitution-engineering-administrative controls-use of personal protective equipment) at all times⁷³. Employers must ensure that personal protective equipment is supplied and used at work wherever there are risks to health and safety. Equipment should be used to manage a risk that cannot be adequately controlled using other measures such as engineering solutions. This includes using equipment that complies with the Personal Protective Equipment Directive (PPE) 1989/686⁷⁴. Employers must make sure that PPE is properly assessed before use, is maintained and stored properly and that employees are provided with instructions on how to use it safely and that it is used correctly by employees.

In order to prevent a collision involving a road worker maximum effort must be made in ensuring that the worker and the equipment that they use makes them as visible as possible. Workers should wear high visibility clothing that is produced with high quality materials and comply with European standards (EN 4714 standard). One producer of construction equipment, Volvo, took the initiative of promoting the use of reflective vests amongst the operators of their machines by distributing vests to their customers.

According to ARROWS road equipment can be distinguished into three main sub-categories depending on the function of the measures:

- warning/information
- closure/guidance
- protection

69 Murray, W. Reducing Risks: improving the reversing safety of commercial vehicles. Public Service Review: Freight, Issue 9, 2005/6, www.publicservice.co.uk.

70 Arrows (1998) <http://www.ntua.gr/arrows/finalhb6a2.pdf>

71 Ibid

72 <http://osha.europa.eu/en/publications/factsheets/90>

73 Ibid

74 <http://ec.europa.eu/enterprise/sectors/mechanical/documents/legislation/personal-protective-equipment/>

The first two sub-categories are, essentially, a complement to physical design and traffic control⁷⁵.

4.3 Barriers and Markings

Generally traffic cones and barriers are used to demarcate the work zone but cannot be used as a barrier to protect workers. Good practice now aims to reduce as much as possible workers activity in work zones. This includes the point when workers are very vulnerable, especially when they are setting out road signs. This should be done by actively exploring alternatives to the placing of advance warning signs, cone tapers and lengths of cones for delineation of road works, by use of fixed and mobile gantry signs, high level nearside signs and use of lane-blocking vehicles.

Research also recognises that: ‘traffic cones and other guidance and delineation equipment (such as water-filled “barriers”) are no substitute for continuous physical protection measures. At worst, they simply lull drivers and the workforce into a false sense of security. Work should not even begin before all the foreseen safety measures have been installed’⁷⁶.

Physical protection devices serve primarily to prevent the entrance of vehicles or pedestrians inside the work area and to reduce the consequences of collisions involving vehicles running off the roadway. ‘Those currently in use include temporary barriers, temporary crash cushions and truck-mounted attenuators (TMAs)’⁷⁷. Temporary barriers are generally not fixed to the ground and are tested to

the same rigorous EN1317 standards as permanent fixtures (though with specific containment classes). Crash cushions are steel closure devices laid on the road surface at the entrance of the work area. This energy absorbing device offers protection in the case of head on collisions at work zone entrances⁷⁸.

Impact attenuators are primarily used to protect road workers (SWOV 2010). Attenuators mounted at the back of work trucks offer an extremely convincing means of protection for errant vehicles and construction workers, particularly during short duration works and when carrying out mobile lane closures. TMAs are now mandatory in several EU Member States (e.g. TD 49/07 specification in the UK⁷⁹ and Belgium⁸⁰).

Belgium has prepared specific instructions for signage and usage of TMAs on roads with a speed limit above 90 km/h. It states that no cones will be placed between the protection vehicle and the work zone and that protection vehicles will be used for protection only. For works on non-motorways on a lane with continuous traffic one protection vehicle (TMA) will be used and provided with proper signing and will be placed at 50 m in front of the work zone. On motorways two protection vehicles (TMA) will be used (MOV Instructions for use of TMA in MOW AWW 2009).

75 Arrows (1998) <http://www.ntua.gr/arrows/finalhb6a2.pdf>

76 EUROPEAN UNION ROAD FEDERATION (2007) Safety on motorway Work zones, Discussion Paper

77 EUROPEAN UNION ROAD FEDERATION (2007) Safety on motorway Work zones, Discussion Paper & Arrows (1998) <http://www.ntua.gr/arrows/finalhb6a2.pdf>

78 EUROPEAN UNION ROAD FEDERATION (2007) Safety on motorway Work zones, Discussion Paper

79 Ibid

80 <http://navb.constructiv.be/nl/Welzijnsinfo/Publicaties.aspx?Page=>

4.4 High Visibility Vehicles

Vehicles used by workers should also be made visible. Studies have investigated the relationship between vehicle and road worker conspicuity⁸¹ (UK 2011). Visibility can also be achieved at a low cost by taking simple measures such as ensuring that vehicles are kept clean, especially the conspicuity markings and lights. Different studies showed that trucks can be rendered much more conspicuous by marking their sides and rear using retro reflective marking tape. Conspicuity marking tape is a high performance retro reflective tape which reflects most of the light falling onto it back towards the light source. The tape, mounted on the rear and sides of the vehicle,

enables the driver to identify the truck as an object on the road as well as its height and length. The truck is therefore made visible to other road users thereby reducing collisions, specifically rear and side impacts into large vehicles. The UNECE Regulation 104 sets out an international specification for retro reflective marking tape. Vehicles fitted with tape to this standard can be sold and circulate freely in UNECE countries. Another UNECE regulation (R48) sets out the requirements for the installation of lighting and light signalling devices on vehicles: this regulation currently allows (but does not mandate) the installation of conspicuity markings.

4.5 Infrastructure Measures during Work Zone Operation

Any change to a configuration of a road poses a risk. Changing the usual habits of drivers is an added risk such as for example narrowing lanes for road works. Thus, one of the main categories of safety measures covers physical design of road works. Taking account of maintenance should also be included as early as the design stage of all new infrastructure per se. Thus, including requirements such as the width of lane, emergency access, and the ability to open the median of the road every few metres should be part of all new infrastructure design.

In general, the basic safety principles governing the design of permanent roads should also govern the design of the RWZ areas. These aim at the provision of smooth transitions between the normal roadway and the work area, as well as at provision of adequate space (buffer area) for separating the route for traffic from the road works. Compliance with national Guidance and the EU Infrastructure Directive is paramount.

Elements of physical design include⁸³:

- Lead-in taper and exit taper
- Longitudinal and lateral buffer width.

4.6 Work Zone Layout

The ARROWS project aimed to produce harmonised proposals for RWZ layouts for possible application across Europe. It found that: 'for long-term work zones there is a higher degree of convergence among European countries' practices; thus it was possible to prepare detailed layouts for each one of the four Areas (I, II, III and IV) defined along the work zone. Area I: advance warning area, Area II: transition area, Area III: activity area and Area IV: termination area. For long-term work zones on motorways (and dual-carriageway expressways), full-scale layouts can be produced by combining four basic elements: Area

I, Area II, Area III and Area IV. On the other hand, the diversity of national practices as regards layouts of other types of RWZs (short-term, rural-road and urban-road) did not allow for the same detailed treatment to be applied to those types'. However, Arrows recommends using the basic principles of long-term work zones using a simpler set of safety measures. For examples of the layouts see the Arrows Handbook Figures 2-41⁸³.

Arrows further outlines six general prerequisites for effective roadwork measures. They should be:

81 Highways Agency, UK, Road Worker Conspicuity Daytime and Night Time http://www.highways.gov.uk/knowledge_compendium/publications/F0751754DB1E406290A7ACB476DE3C0D.aspx

82 Arrows (1998) <http://www.ntua.gr/arrows/finalhb6a2.pdf>

83 Ibid

1. Accurate. The presence of workers should be clearly indicated. They should provide all the necessary and critical information in a credible manner.
2. Properly-spaced and properly-timed. The sequence of RWZ safety measures should be positioned with enough separation to enable road users to process the messages, decide and react.
3. Perceptible and “readable”. The RWZ should be self explanatory; its layout should make it obvious how to interact with workers and other road users.
4. Comprehensible. Safety measures should make obvious to the road users how they should act. Nonverbal information messages are preferable to text.
5. Ensuring alertness. It is important to design the approach to the work zone so that drivers are notified that they are entering a road section requiring more “active” driving. The actual start and end of the work zone must be identified by appropriate elements (e.g. signs).
6. Reasonable. It is essential to prevent divided attention, distraction and mental overload of road users. A fundamental principle is to use “as few signs as possible but as many as necessary”.

Physical Design Check⁸⁴

- The minimum distances between consecutive work zones should be such that the flow of traffic can return to normal between them. The separation should permit fast-moving traffic to overtake slow-moving vehicles so that platoons can be dissipated and traffic normalised.
- The basic safety principles governing the design of permanent roads should also govern the design of the RWZ areas. Geometry and traffic

control devices should be comparable to those for non-works situations. Where lane layout is altered it should provide radii that conform to the same criteria used for normal design.

- Frequent and abrupt changes in geometry, such as lane narrowing, dropped lanes or main roadway transitions requiring rapid manoeuvres, should be avoided.
- To minimise the extent of the disruption to traffic, the work zone should be kept as small as possible while providing adequate safety for workers.
- The length of work zones with narrowed lanes, i.e. with limited capacity, should be generally restricted so as to be acceptable by motorists.
- At work zones where congestion is likely, make provision for incident management, including having recovery vehicles permanently on site or available on immediate call-out for dealing with collisions.
- Make provisions for the safe operation of work or incident management vehicles, particularly on high-speed, high-volume roadways.
- Provide a roadside recovery area for emergency situations and disabled vehicles.
- Equipment, works vehicles and work zone material should be resistant to impact as far as practicable.
- Be especially mindful of obstructions on the central reserve - keep them as far away as possible from the edges of carriageways, and minimise interference with sight lines or with the safety fence.
- Establish well-defined buffer zones, free from workers, equipment and materials.
- Attention should be paid not only to the conspicuity and location of the devices but also to their design and material, to reduce the risk of serious damage in a collision. Do not place adverts in the vicinity of the work zone.

⁸⁴ Arrows (1998) <http://www.ntua.gr/arrows/finalhb6a2.pdf>

4.7 Information to the Public on Roadworks

Drivers should factor in possible road works when they are planning their journeys and try to avoid them. 'A timely warning about road works enables drivers either to cancel the journey, change the route or prepare themselves for delays'⁸⁵. The media should be engaged in increasing public awareness of planned road works and to enable relevant actions. There is a need to influence rules existing in different countries on how information is given and received by the public ahead and during the operation. Site managers should prepare a communication campaign well in advance of the works.

The implementation in GPS navigators of live information on RWZs and cues offers a very important assistance in providing real time and reliable information to the public on the RWZs and their impact on the traffic flow.

4.8 Journey Planning and the Wider Road Network

In the UK, the Highways Agency has developed web-based information services for drivers on when and where road works are likely to be (see www.highways.gov.uk), so that they can be planned for and avoided. Alternative routes should be communicated to the public as well. In some countries such as the Netherlands authorities will not allow works on the

4.9 Including Work Zone Safety in Driver Training and Education

Driving safely through road works should also be included in novice driver training and education. Training should focus on attributes that are most essential to recognise a work zone. The driving curriculum should also cover when to reduce speed, when to change lanes and to which direction. 'Training should also cover the possible negative consequences of speeding and close-following in a RWZ. Drivers should be made aware that the relative perceived benefits of speeding in saving time may be

Roadwork co-ordinators also need to make sure that they inform local residents, shop keepers and businesses as well as road users of upcoming roadworks. It is important that accessibility is assured as much as possible (pavements, keeping access private property, accessibility to public transport). Such information about the RWZs helps make the inconvenience they cause more acceptable⁸⁶.

'It is important to design the approach to the RWZ so that road users are notified that they are entering a section requiring more "active" driving where utmost care is called for'⁸⁷. Road users often disregard signs and speed limits at road works. The importance of obeying rules in work zones and the possible consequences of not doing so needs to be communicated more.

road unless they are closed completely to traffic. This is a clear way of reducing risk for road workers but comes with the need of managing traffic flows. In case of road closure or delays caused by roadworks with drivers avoiding the routes and taking other routes measures also need to be taken to consider managing the impact of transferred risk on adjoining roads.

tiny on a certain stretch of road'⁸⁸.

Employers must take measures to reduce risk of their drivers driving for work and factor in systems to avoid risks and loss of time through roadworks. This includes checking the route in advance and avoiding planned road works. If the route does go through road works then extra journey time should be taken into account.

85 <http://www.hit.certh.gr/prevent/media/Deliverables/D2.pdf>

86 NAVB-CNAC (????) Witboek wegenwerken-Livre blanc Travaux de voirie

87 EUROPEAN UNION ROAD FEDERATION (2007) Safety on motorway Work zones, Discussion Paper

88 <http://www.hit.certh.gr/prevent/media/Deliverables/D4.pdf>

Advice to Drivers⁸⁹ once in the RWZ:

- Take extra care and keep to the posted speed limit.
- Get into the correct lane in good time – and avoid switching.
- Concentrate on the road ahead – not the road

works.

- Be alert for works traffic leaving or entering the road.
- Keep a safe distance – there could be queues in front.
- Observe all signs – they are there to help you.

4.10 Road User Testing of Roadworks

Through EuroTest/TAP, 18 FIA automobile clubs in 17 countries have been evaluating the quality and safety of mobility in Europe since 2000 including since 2005 tests of roadworks. The most recent roadwork evaluation was undertaken in 2010 with a review of roadworks in urban areas. Methodology was based on criteria in the ARROWS 1998 handbook and considered the most important safety issues along with questions regarding layout and quality of a roadwork site. All in all, around 180 inspection items were evaluated in 15 countries. Mostly the Eurotest evaluated that the result was very positive. Signposting and traffic routing were two areas profiled for improvement. Results can be viewed through a city and country by country breakdown and individual rating with evaluation per work site and some city comparisons were made⁹⁰. Specific recommendations for authorities were extrapolated from the evaluation⁹¹ as well as tips for different types of road users⁹².

**EuroTest 2010:
57 City Road Works in 12 European Cities**

Road Work Zone	Signposting				Overall Rating	Road Work Zone	Signposting				Overall Rating
	15%	25%	35%	25%			15%	25%	35%	25%	
Vienna						Madrid					
Handelskai	+	o	++	++	+	Plaza de la Habana	+	+	++	+	+
Breitenfurter Straße – 2	o	o	++	+	+	Calle de Serrano	++	o	o	+	o
Breitenfurter Straße – 1	++	+	o	++	+	Calle de Mejía Lequerica	–	–	++	–	o
Obere Donaustraße	+	+	o	+	+	Calle de los Hermanos Bécquer	++	–	–	+	+
Südtiroler Platz	–	+	o	++	o	Calle de Juan Bravo	–	–	–	+	–
Friedensbrücke	+	o	–	+	o	Paris					
Brussels						Place du Trocadéro et du 11 Novembre	–	+	++	o	+
Boulevard de la Grande Ceinture	+	++	++	+	++	Place Armand Tsank	–	o	+	+	+
Boulevard Léopold III	o	+	++	++	+	Boulevard de Clichy	o	o	–	+	o
Boulevard du Souverain – 1	o	o	+	++	+	Rome					
Chaussée de Gand	–	–	o	++	+	Via Livorno	o	o	+	+	o
Boulevard Louis Mettewé	–	–	o	+	o	Via Anastasio II	+	o	–	+	o
Boulevard du Souverain – 2	–	–	–	+	o	Corso Trieste	–	–	+	o	o
Zurich						Via Nazionale	–	–	o	o	o
Birmensdorfstraße	o	+	++	++	+	Viale del Colli Portuensi	–	–	o	o	–
Härtbrücke	o	+	++	++	+	Luxembourg					
Seebahnstraße	–	+	o	++	+	Rue de Beggen	–	–	o	–	–
Schaffhausenstraße	o	o	–	++	o	Amsterdam					
Pfingstfeldstraße	–	o	–	++	o	Gooseweg	+	+	++	++	+
Berlin						Kreiselverkehr Noordzijde – Oostsoever	o	o	++	++	+
Invalidentstraße	o	+	++	++	++	Rokin	++	o	+	+	+
Taentzienstraße	+	+	++	+	+	Johan Huizingalaan	o	–	++	+	+
Karl-Marx-Allee	o	o	++	+	+	Burgemeester de Vlugtlaan	–	o	+	+	o
Spandauer Damm	–	–	o	++	o	Ljubljana					
Wollankstraße	o	o	–	++	o	Dalmatinska Ulica	+	o	++	+	+
Munich						Želazna Cesta	o	o	++	o	+
Schleißheimer Straße	+	+	++	+	+	Poljanski Nasip	o	–	+	+	o
Landsberger Straße	o	+	o	++	+	Slovenska Cesta	–	+	+	o	o
Luis- Kieselbach-Platz	+	+	–	++	+	Vojkova Cesta	–	o	+	o	o
Einsteinststraße	+	+	o	+	+	Trubarjeva Cesta	++	+	–	o	–
Georg-Brauchle-Ring	o	+	++	–	o	Barcelona					
Barcelona						Ronda del Guinardó	+	+	++	++	++
Avinguda Meridiana	+	+	++	+	+	Avinguda del Doctor Marañón	o	o	++	+	+
Ronda del General Mitre	+	+	o	+	+	Ronda del General Mitre	+	+	o	+	+
Carrer del Comte d'Urgell	–	o	–	+	o	Carrer del Comte d'Urgell	–	o	–	+	o

++ very good + good o acceptable – poor – very poor

4.11 Signage

One of the ways of communicating with the public is signage. Work zone co-ordinators also have a legal duty to comply with Directive 92/58/EEC on safety and/or health signs ensuring that signs are in place where hazards cannot be avoided or reduced. The legibility of signs should be increased using pictograms and messages presented on conspicuous signs. The sequence of RWZs information devices should be positioned with enough separation to enable road users to process the messages, decide and react. Also particular care should be taken to address the risk of reduced work zone visibility at

night, for instance through systematic street lighting. Signing should follow the evolution of time and space- and be removed when and where they are no longer needed⁹³. Overlapping with existing or conflicting signs must also be avoided.

There are various forms of guidance or legal requirements set at a national level that set out how road work signage should be undertaken. One reoccurring question is the extent to which road work managers are using signs. In the planning and installation phase they should make sure that the

89 UK Highways Agency Public Information

90 <http://eurotestmobility.com/eurotest.php?itemno=381&lang=EN>

91 <http://eurotestmobility.com/eurotest.php?itemno=377&lang=EN>

92 <http://eurotestmobility.com/eurotest.php?itemno=383&lang=EN>

93 EUROPEAN UNION ROAD FEDERATION (2007) Safety on motorway Work zones, Discussion Paper

level of signage gives the driver the information they need to know what they are being asked to do but without overwhelming them. Research shows that 'a large number of signs and devices at RWZs does not necessarily lead to better road user behaviour'. A reasonable hypothesis may be that the more

4.12 Using ITS in informing drivers

'Infrastructure to Vehicle' ITS can help to inform drivers about upcoming RWZs and speed limits. Variable message signs (CMS/DMS/VMS) are message boards placed along roadways that notify travellers of incidents, travel time information, construction/road closures, and other potential hazards in or around the work zone.

The use of variable message signs is now in place. For example, if traffic is extremely slow in the work zone, a variable message sign upstream of the work zone might warn of a 10-minute delay ahead; a second sign might then warn drivers to slow to 55 km/h. If traffic speeds decrease further, indicating worsening congestion, the system would automatically change the signs to indicate an even longer delay and advise

4.13 Speed Management

Managing speed should be the number-one concern at road works. Surveys show that a vehicle's speed in the activity area (where work is going on) seems to be related to its initial speed when entering the RWZ⁹⁷.

Speed limits should be credible. If road users pass through a work zone and do not see activity during several days they can be tempted to neglect the imposed speed limits (NAVB-CNAC Belgian White Book). In the Netherlands there is good experience with signing to inform users why a road is closed without visible activity. Such signing apparently increases the acceptability of speed limitations. 'Also there the Dutch Ministry of Transport has introduced new, more credible speed limits for roadworks on

devices, the greater risk that there will be devices missing, misplaced, out of order, misunderstood or not detected⁹⁴. However drivers will decide whether or not to comply with a warning, or generally to show safety behaviour-if the perceived benefits of compliance outweigh the costs⁹⁵.

of slower speeds ahead. The signs can also be used to suggest alternate routes or tell drivers to tune into a radio station which broadcasts further advice. To emphasise the timeliness of the messages, each sign can also display the time the message was posted. Drivers armed with information on traffic ahead are better prepared for changing traffic conditions and thus more likely to have a safe trip. The economic benefits of reducing delays and improving safety at work zones can outweigh the costs of the system by a factor of six or more⁹⁶. Extending this to informing the driver via their in-vehicle ITS systems such as for example navigation devices can also be a way of directing the information. In a further stage vehicle to vehicle ITS can also be used to inform drivers of road works up ahead.

the motorways. The speed limit can be differentiated across lanes and for time of day⁹⁸.

Speed limits in work zones must be set for protection of the workers and also of the drivers passing through them along with the requirement of managing traffic flows. A balance should be achieved.

At present there is an ongoing challenge in reaching the correct balance between considering road worker safety and managing traffic.

There are several reasons why speed limits at work zones should be lower than at non-work sections. Important factors in determining appropriate speed limits are:

94 <http://www.hit.certh.gr/prevent/>

95 Ibid

96 Ibid

97 <http://www.hit.certh.gr/prevent/media/Deliverables/D2.pdf>

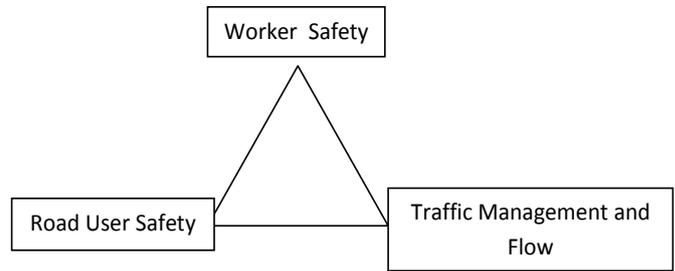
98 http://www.swov.nl/rapport/Factsheets/UK/FS_Road_works.pdf

Adjustment to reduced roadway standards: Narrowed lanes, deviations (e.g. to/from the contra flow) or reduced shoulders are common changes in highway geometry at RWZs, necessitating lower speeds.

Protection of road workers: Even if there is no effect on the geometric standards of the roadway, the presence of workers calls for a reduction in traffic speeds.

Queuing: On motorways and other higher-volume roads, lane closures may result in queuing, which could increase the probability of rear-end crashes.

Commonly, nation specific maximum speed limits for work zones are defined. These can be adjusted downwards if necessary for safety reasons⁹⁹.



4.13.1 Informing the Public of Speed Limits

According to studies carried out on drivers, 'speed behaviour at work sites is largely dependent on the road signs and variable message signs (VMS) they are confronted with'. Also that, 'the likelihood that drivers will slow down when they recognise a sign increases when the signs become more specific'¹⁰⁰. There is a need for better means of reinforcing the lower speed limit message other than with just static signs. Measures can include providing information

to the driver via other media such as the radio and reduced limits set by law. The way the road lay out is designed and set can also reduce the speed. The government in Germany launched in 2010 a new way of informing road users via CB radios which broadcasts: "warning dangerous road section"¹⁰¹. The system is mainly targeting HGV drivers and is broadcast in seven languages. CB radio is still commonly used amongst HGV drivers.

4.13.2 Speed Enforcement at Work zones

Another measure which ideally should go hand in hand with public information to the driver to reduce the speed is the support of a physical Police presence undertaking speed enforcement checks. Due to the special nature of the work zone (e.g. limited space, difficult or even impossible to access) Police officers should be educated and trained on how and when to take measures with regard to violation of traffic rules within the work zone¹⁰². In Italy "Autostrade per l'Italia S.p.A." has been working to reduce roadworks related accidents by means of different measures including the use of mobile laser control (autovelox) for speed control in co-operation with

the motorway Police.

Speed enforcement can also be managed with fixed automated safety cameras including section control which is a method of speed enforcement involving a series of cameras installed over a stretch of road. An image and data are recorded for each vehicle as they enter and leave two points in the system (a section of road). 'Section Control is an efficient speed enforcement method, leading to reductions in speeds across entire sections of roads and reductions in the number of collisions and casualties'¹⁰³. Enforcement of speed limits via average speed cameras is one of the most effective ways of reducing vehicle speeds and

99 Arrows (1998) <http://www.ntua.gr/arrows/finalhb6a2.pdf>

100 EUROPEAN UNION ROAD FEDERATION (2007) Safety on motorway Work zones, Discussion Paper

101 http://www.bmvbs.de/SharedDocs/DE/Pressemitteilungen/2010/mehr-verkehrssicherheit-auf-autobahnen-als-erstes-bundesland-warnt-nordrhein-westfalen-flaechend.html?linkToOverview=DE%2FPresse%2FPressemitteilungen%2Fpressemitteilungen_node.html%3Fgtp%3D36166_list%25253D16%23id24122

102 <http://www.hit.certh.gr/prevent/media>

103 http://www.etsc.eu/documents/copy_of_copy_of_Speed%20Fact%20Sheet%205.pdf

achieving speed limit compliance in the UK. Average speed cameras have so far been used effectively for major (long term) road works. Research into the use of average speed cameras in short term (overnight) works carried out on behalf of the Highways Agency showed that their use is practicable and the cameras do achieve a statistically significant reduction in traffic speed.

Another tool to be considered is that of applying stricter penalties in case of a speeding offence committed in a work zone. This is currently the case in the Netherlands and in USA already and has been debated in the UK.

Immediate feedback is another way of informing drivers of the speed they are travelling at. Radar speed monitoring/display units can also be used. This is a portable system that can be mounted on a sign or located on a portable trailer that uses radar to measure vehicle speed and that informs motorists of their speed. In 2006, the Dutch Ministry of Transport started a new trial to reduce the speed at road works. Road users were given immediate feedback on their speed, while their vehicle registration number was shown. This direct feedback appeared to result in speed reduction¹⁰⁴. Unreasonably low speed limits should always be avoided.

Traffic and Speed Management key issues are:¹⁰⁵

- Try to maintain the number of lanes, using altered layout, narrow lanes, contra-flow or added lanes. If lanes have to be closed, do this as little as possible, leaving at least one lane in each direction, and using narrow lanes or altered layout as far as possible to avoid flow restrictions and diversions. If you have to close a lane on motorway or dual-carriageway road, it is preferable to close the fast lane(s) first and conduct traffic through the slow lane(s).
- If the work zone is short-term and the traffic volumes are low, alternate one-way operation may be used, with either fixed priority or traffic lights (but not with flagging).
- If some limited extra-capacity is needed, diversions to alternative routes may be used, provided that these routes can accommodate the new traffic and are carefully controlled.
- Design the traffic control plan in such a way as to help drivers to make proper choices rapidly, reinforce critical information without being excessive, appear credible, and avoid conflicting information. Traffic management systems should follow the evolution of the works in time and in space, and be removed as soon as they become unnecessary.
- Separate decision points for the driver.
- Minimise any unavoidable reduction of forward visibility, and provide proper warning. Use signing, markings and safety devices that are consistent with intended travel paths. In long-term work zones, replace, cover or alter existing signs, markings and safety devices that are inconsistent with those paths. In short-term work zones, use mainly devices that emphasize the appropriate path. Make realistic estimates of the approach speeds, and choose realistic and justifiable speed limits, to be supported by accompanying measures (reduced width, police presence).
- Do not prolong low speed limits through long stretches.
- Do not position speed limits signs too far in advance - drivers may consider them premature and ignore them when reaching the critical point.
- An emergency plan should be part of the design. It should describe the procedures in case of collisions and define the required actions to be taken (e.g. emergency vehicles and shelter possibilities).

104 http://cardweb.swov.nl/swov/website_uk_detail.html?Zoek=Zoek&display=1&pg=q&q=20070567&start=0

105 Arrows (1998) <http://www.ntua.gr/arrows/finalhb6a2.pdf>

4.14 Case Studies

Belgium White Book

In Belgium the National Committee for Safety and Hygiene in Construction NAVB/CNAC is an organisation that promotes safety and security in the construction sector. They have also developed measures targeting the specific subsector of road works. They have developed a simple White book on Road Works addressing the ten main safety problems and solutions. These include: co-ordination, timing, signalling, wider safety zones, regulation compliance, limited experience of the safety co-ordinator, speed limitations, public private partnerships, social effects and vandalism. The first point they stress is co-ordination between road works and that, if different

works can be combined during a limited period of time, it will probably be more accepted for road users if a section is completely unavailable during this period. They raise the need to ensure that traffic trying to avoid road works on one site may end up in another road work site. The White Book also stresses the legal obligation in Belgium for the appointment of a safety coordinator as in most road works the contractor is working with subcontractors and the appointment of a safety coordinator is mandatory. Safety should also be included in the training and existing certification scheme for safety co-ordinators.

Worker Safety Management System for New Road Construction Projects-Portugal

The Portuguese Road Institute has developed and implemented a worker safety management system for new road construction projects reviewed by the EU OSHA¹⁰⁶. This has led to a documented collision reduction rate of between 30 and 40%; moreover the seriousness of collisions and the number of days of absence were reduced. The aim of the system was to provide a common safety framework for all parties involved in a road construction project. The approach is to systematically establish the health and safety obligations and responsibilities of each party. Contractors also have to have health and safety

systems in place that comply with the IEP's own management system. An effective monitoring system was set up. A safety culture was promoted within the organisation with contractors. The system was also integrated with other management activities such as quality assurance and cost-effectiveness. Part of the implementation and promotion of the new system was training of all of IEP's own employees and different participants in the construction process. To support the introduction of the management system a comprehensive manual was introduced.

Increasing Road Worker Safety in the Netherlands

In The Netherlands, there are non-legally binding guidelines for uniform preparation, indication and signalling of roadworks¹⁰⁷. According to these guidelines, the indications of the work zone and the guidance of traffic must be simple and clear, thus both ensuring that the road users are aware of the roadworks ahead in time and that they know what is

expected of them. Furthermore, sufficient distance or a barrier between road workers and traffic is required. The Netherlands also has legally binding requirements for sign and layout of work zones on national roads¹⁰⁸. However, an evaluation of 50 roadworks locations¹⁰⁹ shows that only few locations follow the guidelines completely. A 2009 Labour Inspectorate evaluation

106 http://osha.europa.eu/fop/netherlands/en/goodpractice/PDF%20map/bouw2_8.pdf

107 CROW (2005). Werk in Uitvoering; Diverse richtlijnen. Publicatierreeksen 96a en 96b. CROW kenniscentrum voor verkeer, vervoer en infrastructuur, Ede. In SWOV 2010

108 AVV (2005). RWS-richtlijn voor verkeersmaatregelen bij wegwerkzaamheden op rijkswegen. Directoraat-Generaal Rijkswaterstaat, Adviesdienst Verkeer en Vervoer, Rotterdam. In SWOV 2010

109 Weijermars, W.A.M. (2009). Verkeersonveiligheid bij werk in uitvoering, deel III en eindrapportage. R-2009-4. Stichting Wetenschappelijk Onderzoek Verkeersveiligheid SWOV, Leidschendam.

showed that the road worker was in danger of being crashed into by a vehicle at almost 30% of the 223 inspected locations¹¹⁰. Furthermore, in 21 situations, risks were so high that the work had to be stopped.

During 2006 and 2007 a study was undertaken in the Netherlands in order to better understand the crash risk for road construction workers during road

works. Based on the outcomes of the study a collision model was developed for investigating collisions and safety promotion materials were constructed for road workers. A video was prepared to make workers and managers aware of their own behaviour. The video uses actors, but the situations were based on actual observations. Also, stickers were prepared for the types of behaviour that can prevent collisions.¹¹¹

Evaluation of the E411 and E25 Roadworks Belgium 2004-2006

A Case Study on the E411 and E25 Roadworks prepared by the Belgian Road Research Centre raises some important findings on improving road safety at road works¹¹². The road works were being undertaken over a three year period and involved long-term operations on significant sections of two key routes. The report provides an abundance of data pertaining to traffic and speed, both before and during the works. The roadworks were ambitious, aiming to repair 127.5 km in the province of Luxembourg (south-east of Belgium), between March 2004 and October 2006. Rehabilitation was considered essential in view of the worrying state of the road surface, severely affected by the “punch-

out” phenomenon. The thorough report concluded with several key findings that can provide some useful lessons for others on how to conduct road works safely. Firstly, that it is essential that sufficient care is taken to ensure that lanes are clearly and unambiguously defined, particularly when using narrow lanes. Secondly, that running with a single lane in each direction can be a good option from a safety perspective provided sufficient capacity is maintained. Thirdly, that it is vital to monitor collisions at the commencement of the works, so that any problems can be identified and rectified quickly and finally, that the use of very long stretches of works can exacerbate delay problems due to collisions and incidents.

UK Campaign on Speeding: Difference when travelling at 50 to 70 mph at Roadworks

The Highways Agency, supported by DfT’s Think! Road Safety campaign, developed two DVDs (with supporting materials) highlighting the need to slow down and respect speed limits at road works. The first, entitled “Respect”, compares the responsibility of the road worker with that of other professionals such as teachers and doctors whose roles are also to make our lives more informed, reliable and safe¹¹³. The consequences of not respecting road workers (by not respecting speed) are made clear and this is then translated to other professions with shocking outcomes. The second, “5 Seconds”, covers the direct

impact of speed and the different consequences of travelling at 70mph and at 50mph¹¹⁴. A speed restriction of 50mph at road works will mean that travelling a quarter of a mile to pass the road works will take 18 seconds. Travelling at the maximum speed of 70mph, to travel the same distance it will take 13 seconds - the difference being only 5 seconds. The DVD features two business colleagues who are on their way to an important presentation but are already running late. We see how a decision made to save just 5 seconds by speeding, can change lives when an incident occurs.

110 Dutch Labour Inspectorate (2010). Risico’s bij werken aan de weg. Inspectierapport 2010. Arbeidsinspectie, Utrecht. In SWOV 2010

111 Venema and Brinkhuis (2008) TNO Quality of Life, Increasing Road Worker Safety in the Netherlands

http://www.virtualriskmanager.net/main/aboutus/niosh/poster_venema-anita_1.pdf

112 http://www.brrc.be/pdf/publications/e41_05.pdf

113 <http://www.highways.gov.uk/knowledge/20639.aspx>

114 <http://www.highways.gov.uk/knowledge/20639.aspx>

UK Highways Agency Health and Safety Toolkit

The Highways Agency has also developed a Health and Safety Toolkit as a means of identifying the many good practices, innovations and ideas which can contribute positively to workforce health and safety that are currently being used on the network. The toolkit aims to act as a vehicle to communicate and share good practice with interested stakeholders to further drive improvements across the industry. The scope of the toolkit covers the four key project stages:

design, maintenance, construction and demolition. Examples so far include the 'Quick moveable barrier' which provides safety to site staff working within temporary lane closures, as opposed to working on live road areas with conventional cones. Other examples include 'Warning Devices for Overhead Structures', 'Mechanical Gully Cover Lifter' and 'Mechanical Kerb Lifter'.

UK Road Workers' Safety Forum

The Highways Agency also plays an active role in the "Road Workers' Safety Forum" (RoWSaF). The Forum has the sole aim of improving safety of road workers and road users while travelling through road works. RoWSaF has supported the development of a range of information DVDs, media resources and printed materials for use by companies and agencies. RoWSaF also has a Trials Team which undertakes

trials and evaluation of innovative techniques and equipments aimed at improving the safety and welfare of operatives working on the Highways Agency's road network. Trials investigations have included "sequentially flashing road danger laps", "remotely controlled signs", and "vehicle mounted VMSs for incident management".

Recommendations

Employers

- Make sure that PPE is properly assessed before use, is maintained and stored properly and that employees are provided with instructions on how to use it safely
- Inform the public of road works via media and websites: including alternative route information.
- Ensure high visibility of workers 24 hours a day even in adverse weather conditions.
- Enforcement is considered essential; it should be ensured that the assistance of the police can be provided as necessary¹¹⁵.
- Park maintenance vehicles safely; work zone delineators should be used around the vehicle.
- Cover RWZ speed restrictions that do not apply outside working hours (for example, in cases where a work zone does not influence traffic flow when not in operation).
- Keep the RWZ clean during the work.
- Replace traffic signs, beacons etc. (that are moved for the purposes of work) to their original position afterwards.
- Remove safety measures when works are complete; abandoned RWZs should be avoided as far as possible.
- Remove signs and other traffic control devices moving against the direction of traffic flow (upstream).
- Recognise that at a general level, appropriate education and training of site personnel at all levels on RWZ safety issues can contribute to the understanding of safety aspects as an object of responsibility, as well as to ensuring the competency of the involved personnel in undertaking their responsibilities on the site. Education and training should not be given "once and then never again"; it has to be repeated and updated. It could be incorporated into certification programmes at a national level.
- At a project-specific level, make the instruction of site personnel an important component of the RWZ implementation process.

115 Arrows (1998) <http://www.ntua.gr/arrows/finalhb6a2.pdf>

Recommendations to Member States

- Comply with requirements set out in the Infrastructure Safety Directive especially adopted guidelines on temporary safety measures applying to roadworks¹¹⁶.
- Recognise that the decrease of traffic congestion from RWZs will have a positive impact on safety, save costs and reduce CO2 emissions.
- Prioritise Labour Inspectorate to enforce legislation protecting safety of road workers' publicise results and give feedback on preventative measures for managing risk to employer carrying out roadworks.
- Increase enforcement of specific laws and set appropriate penalties at RWZs

Recommendations to the EU

- Review progress made by Member States in implementing the Infrastructure Safety Directive's guidelines on temporary safety measures, as applied to roadworks, and support the exchange of best practice.
- Consider the opportunities to work towards further harmonisation in terms of standards on design of road works (design, signing and protection)¹¹⁷.

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