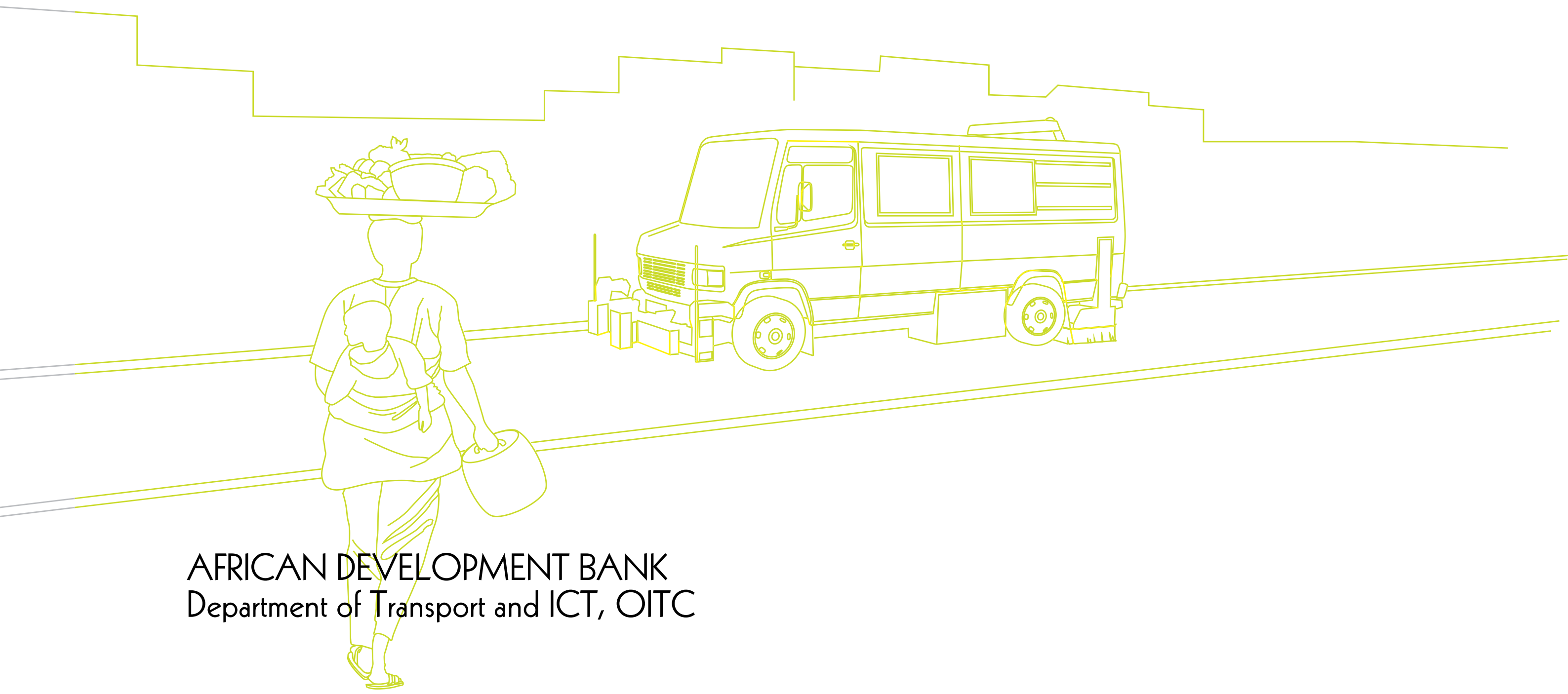
ROAD SAFETY MANUALS FOR AFRICA

# Existing Roads: Proactive Approaches

DECADE OF ACTION FOR ROAD SAFETY 2011-2020

AFRICAN DEVELOPMENT BANK GROUP

Transport and ICT Department
July 2014



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# Foreword

Every day thousands of people die, hundreds of thousands injure, and enormous amount of resources lose in road crash worldwide. Developing countries account for the overwhelming part of these losses. Africa takes the highest share of the road crash burden relative to its low level of motorization and road network density and experiences the highest per capita rate of road fatalities. The characteristics of road crash victims in the region signifies that over 75% of the casualties are of productive age between 16-65 years; and the vulnerable road users constitute over 65% of the deaths. Road crash costs African countries 1-5% of their GDP every year. These figures clearly indicate the direct linkage and the impact of road crash in worsening poverty in Africa. The regional features such as road network expansion and improvement, rapid motorization, population growth, urbanization, unsafe vehicle fleet and mixed traffic inevitably will worsen road crash deaths and injuries unless African countries invest on road safety. The situation demands African countries to increase their level of investment and attract international cooperation for financial and technical support on crash prevention and reduction measures.

Africa is investing a great deal on road infrastructure to enhance competitiveness and realize sustainable socioeconomic development. The African Development Bank (AfDB) is widely engaged in national and multinational road infrastructure projects in African countries. Alongside with the road infrastructure financing, the Bank has mainstreamed road safety to scale-up and consolidate its efforts to support comprehensive multisectoral road safety investments to reduce the increasing losses caused by road crashes. The Bank focuses on interventions that generate and transfer knowledge, strengthen capacity, achieve quick and visible results.

In line with this, the Bank developed three road safety manuals for Africa based on the safe system approaches and best practices tailored to African conditions to support road infrastructure safety practices in Africa over the next decade. The developed manuals include: (i) New Roads and Schemes: Road Safety Audit; (ii) Existing Roads: Proactive Approaches; and (iii) Existing Roads: Reactive Approaches. These manuals are designed to enable African countries adequately consider and manage road infrastructure safety during design, construction and operation. The intervention contributes to the achievement of the goal of the African Plan for the Decade of Action for Road Safety 2011-2020. The "Existing Roads: Proactive Approaches" manual is one in a series of three manuals which will be used by road authorities and road safety practitioners to conduct road safety inspection and road safety assessment for existing roads where precise information on road crash locations is not available in order to identify potentially hazardous locations and put remedial measures in place to minimize crashes on the road network.

The Bank recognizes that the development of the manuals alone will not make a substantive difference to road safety unless they are mainstreamed properly into relevant policies and procedures. As a way forward for overcoming this challenge, the Bank plans to embed the manuals into AfDB policy/procedures, disseminate the manuals to create awareness on the use and embed them in African countries, support training of road safety professionals to build capacity, and facilitate knowledge exchange, case studies and evaluation. As part of these endeavours, the first road safety training was held in Abidjan from 7 July to 10 July 2014 and successfully delivered to road safety professionals from seventeen African countries.

At this juncture and in line with the Decade of Action for Road Safety (2011-2020), I am calling on all road and traffic authorities, road safety practitioners from the private sector, and local authorities and other relevant stakeholders in African countries to play their part in ensuring that safety is integrated in planning, design, construction, operation and maintenance of road infrastructure. I believe quite strongly that we can make a difference by developing together safe road networks in the continent of Africa.

**Amadou OUMAROU**

DIRECTOR, TRANSPORT & ICT DEPARTMENT
THE AFRICAN DEVELOPMENT BANK

# Acknowledgements

This manual is one in a series of three good practice manuals for road safety developed by the African Development Bank (AfDB) as part of its overall approach to improving road safety in the region. The manual was prepared under the overall leadership of Mr. Amadou Oumarou, Director of the Transport and ICT Department, and Dr. Abayomi Babalola, Manager of Transport Division for North, East and Southern Africa Region. The African Development Bank acknowledges the generous financial contribution of the Government of India, through the India Technical Cooperation Fund.

The project was undertaken by the Transport Research Laboratory (TRL Limited) with the Belgian Road Research Centre (BRRC). The project Task Team comprised Mr. John Barrel, Dr. John Fletcher and Dr. Suzy Charman, Mr. Tim Sterling from TRL and Mr. Arnaud Houdmont and Mr. Xavier Cocu from BRRC.

The authors are grateful for AfDB's active contribution in the preparation of the manual; in particular the guidance and inputs of Dr. Girma Berhanu Bezabeh who was the Task Manager for this project. Unreserved supports provided by the staff members of the Transport and ICT Department of the Bank, particularly the active contributions of Mr. Stefan Atchia, Mr. Richard Malinga and Mr. Jumbe Naligia Katala are acknowledged.

In writing the Road Safety Inspection parts of this manual the team drew on some foundational work undertaken in the Pilot4Safety project funded by DG MOVE of the European Commission.

For the Road Safety Assessment parts of this manual a number of good practice manuals from Africa and elsewhere were reviewed. These manuals include:

- Road Safety Audit for Projects - An Operational Toolkit - Asian Development Bank (2003)
- Manuel d'Intégration de la Sécurité Routière aux Projects Routiers - Benin (2007)
- Road Safety Audit Guidelines – Chartered Institute of Highways and Transportation UK (2008)
- Manual of Road Safety Audit – Denmark (1997)
- Road Safety Audit Manual (Draft) – Federal Democratic Republic of Ethiopia (2004)
- Manual of Road Safety Audit – Ghana (2002)
- Design Manual for Roads and Bridges Part 1b) Road Safety Audit - Kenya (2009)
- Guide d'Audit –Sécurité des Infrastructures Routières – Maroc (2003)
- Consultancy Services for Road Safety Audit of the Main Road Network Final Report/Servicios de Consultoria Para a Auditoria da Seguranca Rodoviaria na Rede de Estradas Principais em Mozambique – Mozambique (2010)
- Road Safety Audit Guidelines for Safety Checks on New Projects/Guide sur les audits de sécurité routière pour l'évaluation de la sécurité dans les nouveaux projets routiers – PIARC (2011)
- Safety Manual for Secondary Roads – Pilot4Safety (2010)
- Guidelines for Mainstreaming Road Safety in Regional trade Corridors – SSATP (2013)
- A Guide to Road Safety Auditing v7 – United Republic of Tanzania (2009)
- South African Road Safety audit Manual (2nd Edition) – South Africa (2012)

- Road Safety Audit Manual – Uganda (2004)
- Design Manual for Roads and Bridges, Vol. 5, Section 2, Part 2, HD 19/03 Road Safety Audit - UK (2003)
- Road Safety Audits National Cooperative Highway Research Programme Synthesis 336 - USA (2004)

The manual development team would like to acknowledge the assistance of iRAP in giving their permission for using the content of the iRAP Road Safety Toolkit, which was adapted for use in Appendix A.

# Contents

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# 1. Introduction to this Manual

This manual is one of a series of three which deal with distinctive, but related, safety review methodologies. It is recommended that these three manuals should be read alongside one another. The three manuals are:

- New Roads and Schemes - Road Safety Audit (RSA)
- Existing Roads - Proactive Approaches: This manual provides guidance on proactive Road Safety Inspection and Assessment methods
- Existing Roads - Reactive Approaches: This manual provides guidance on reactive methods for the identification and treatment of hazardous locations, roads and routes

The manuals have been developed based on best practice from a number of countries worldwide, including current practices in Africa. They adopt a 'Safe System' approach throughout which is concerned with engineering the road environment so that only low severity crashes are possible when users make mistakes. The approach described in this manual has been tailored for practical application in Africa. It cannot cover explicitly the conditions in every country; therefore users will need to consider local conditions in applying the techniques and processes described throughout this manual.

## 1.1 How this Manual Relates to the other Manuals in the Series

Proactive approaches for existing roads are undertaken to identify road safety deficits across the network before crashes accumulate. This manual describes a two-stage process for the proactive identification and treatment of safety deficits through undertaking Road Safety Inspections (RSIs) (stage 1) and Road Safety (RS) Assessments (stage 2).

An RSI is a proactive approach that involves a systematic review of an existing road by driving and walking to identify hazardous conditions, faults and deficiencies in the road environment that may lead to road user injury. Once a high risk road has been identified through an RSI, a RS Assessment can be undertaken in more detail to determine whether any of the physical deficiencies detected through RSI can be treated. This approach can be undertaken irrespective of the detail and accuracy of collision data that are available. Clearly the accuracy of such data will have a significant impact on assessing the cost effectiveness of any proposed intervention.

This manual relates to the proactive inspection and treatment of existing roads. Similar techniques can be proactively applied to new roads and schemes through Road Safety Audit. This is described in the 'New Roads and Schemes - Road Safety Audit' manual.

Reactive, data-led techniques for identifying and treating high risk locations on existing roads are described in the 'Existing Roads - Reactive Approaches' manual.

## 1.2 How to Use this Manual

This manual has been developed as one of three independent documents covering the main tools for road safety engineering to reduce road crashes on a country's road network through a systematic approach to crash reduction and prevention.

This manual can be read as a complete document, but is more likely to be used as a reference document in relation to specific aspects of proactive approaches. It has been developed to provide a consistent framework for RSI and RS Assessment across the member countries of the African Development Bank (AfDB), and recognises that not every country will be at the same stage of development or application of proactive approaches. It is therefore a document that will be repeatedly referred to as organisations develop their own processes and capabilities.

The manual is set out in the following sections:

- Section 2 details the institutional and managerial steps to be taken to start using proactive RSIs
- Section 3 introduces the proactive approach concept, outlines what RSIs and RS Assessments are, why they are necessary, their costs and benefits and how they fit into wider road safety management
- Section 4 provides guidance on the personnel, equipment and safety requirements for undertaking RSI and RS Assessments
- Section 5 provides guidance on the process for undertaking RSIs and RS Assessments
- Section 6 provides guidance on monitoring and evaluating treatments as they are implemented
- A series of appendices are provided at the end of the manual to provide typical road safety treatments, an RSI form, RS Assessment prompts and a RS Assessment report

The manual can be used by anyone involved in proactive approaches to road safety management; experienced practitioners, those considering the introduction of proactive approaches into their organisation or those responsible for the development of proactive approach procedures for their country.

# 2. Embedding Proactive Approaches

It is necessary to ensure that operational road management systems are established that facilitate the effective introduction and continued application of proactive approaches. The guidance below assumes that RSIs and RS Assessments will be undertaken by the road authority itself. It would however also be possible to procure technical assistance in order to complete RSIs or RS Assessments.

The following steps outline a process for ensuring that proactive approaches become embedded within the national (or regional) and local management process for existing roads.

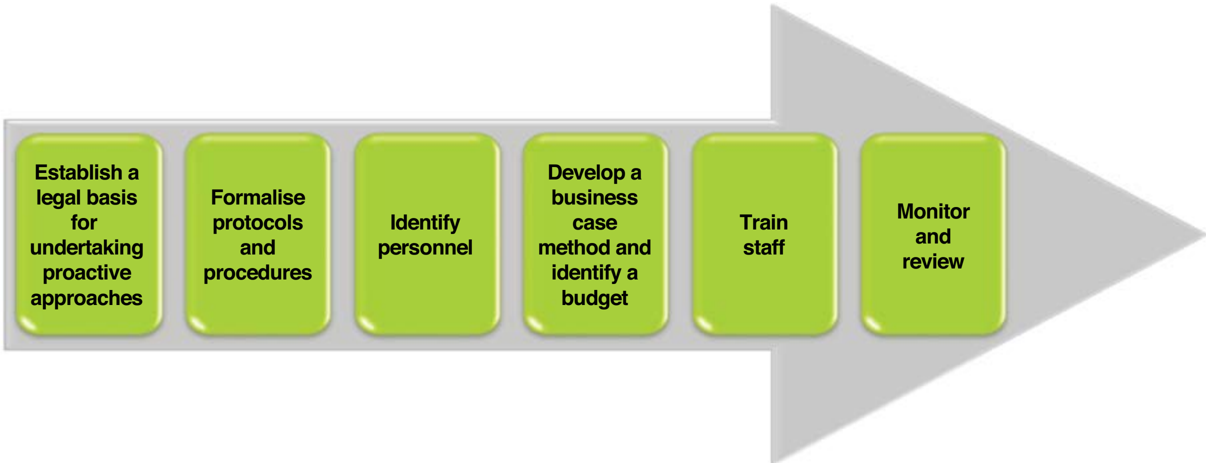



**Figure 1: Embedding proactive approaches**

**Step 1:** Establish a legal basis for undertaking proactive approaches

Many countries have a legal requirement for the road authority to investigate and improve safety problems. RSI and RS Assessment can support this legal responsibility. RSI and RS Assessment responsibility should rest with the relevant authority for safety which must be supported at the highest political level (i.e. President/ Prime Minister) and have clearly defined statutory accountability for any actions or failures of the systems.

**Step 2:** Formalise protocols and procedures

The road authority needs to write and adopt a formal protocol or procedure for undertaking these proactive approaches (RSIs and RS Assessments) for safety investigations on existing roads. This should include specification of:

- The person or department with specific responsibility for investigation of road safety issues. This would normally be the responsibility of a Road Safety Unit (RSU) in a Road Authority. The RSU needs to be a dedicated team of professionals whose focus is entirely on safety issues. They need to be trained and provided with high quality advice and technical assistance until they gain experience.
- The level of resources (financial and personnel) necessary to achieve a focussed improvement in road safety. This will depend on the extent and quality of the road network for which the road authority is responsible. At a very minimum, there will need to be a team of two RS Assessors, one

of whom assumes the role of the 'Manager' in the RSU. The RS Inspectors can be engineers that would normally have other routine duties.

- Training and experience requirements for inspectors and assessors. These are specified in Section 4.1.2.
- The detailed process to be followed as set out in formally approved manuals or guidelines. These documents should specify the approach to be taken in the undertaking of RSI and RS Assessment.
- Requirements for the level of improvement to be achieved and over what period. This may be a numerical target for undertaking safety improvements on, for example, the worst 10% of the strategic or main road network. Longer term casualty reduction targets that can be associated with the improvements can also be developed. Typically these would be in line with aspects of the African Road Safety Action Plan 2011-2020 supporting the UN Decade of Action on Road Safety.
- Mechanisms for monitoring performance. These need to specify how performance should be monitored and evaluated (see Section 6). Potential Indicators are identified in the Africa Road Safety Action Plan under the UN Decade of Action Pillar 2: Safer Roads and Mobility.

**Step 3:** Identify personnel

Various personnel are required:

- Manager to oversee, plan and administrate the RSI and RS Assessment schedule
- Road Safety Inspectors to undertake RSI
- Road Safety Assessors to undertake RS Assessment

Requirements for each of these personnel and their responsibilities are described in Section 4.1.2.

**Step 4:** Identify a budget for the treatment of existing roads

There is no point undertaking RSIs and RS Assessments without the financial resources to implement a planned programme of changes. Therefore an annual budget needs to be established for the treatment of road safety problems identified on the existing road network - irrespective of how these have been identified.

**Step 5:** Train staff in accordance with the protocols/procedures in Step 1

For RSIs it is relatively straight forward to train staff to capture information about road characteristics. For RS Assessments personnel must gain relevant experience as well as receiving training. It is considered essential for new RS Assessors to receive mentoring and for them to shadow experienced personnel until they have reached the requirements specified in Section 4.1.2.3.

**Step 6:** Monitor and Review

Before implementing proposed treatments it is normally necessary to assess their potential impact in order to make a business case for investment. Information on the effectiveness of treatments has generally been compiled from research undertaken in countries in Europe and in USA and Australia. Relatively little is known about the true effectiveness of the treatments under different circumstances in Africa. An understanding of local effectiveness will only be established if road authorities monitor and evaluate the performance of any measures implemented. Organisations therefore need to introduce a system for monitoring and reviewing the performance of any implemented RSI or RS Assessment recommendations. This can then be used to identify the most appropriate safety improvements to incorporate in revised design standards. This is particularly important in any country where development of the road network is occurring at a fast pace and where research concerning road characteristics and their impact on road safety outcomes is not available.

# 3. The Proactive Approach Concept

Proactive approaches can be useful where crash data are not yet available or where details such as precise crash coordinates are not recorded. While proactive approaches are useful, they do not replace the need for good quality crash data to guide and direct road safety practices. They can be used while the quality and availability of crash data is improved, or as a complementary approach to those described in the 'Existing Roads: Reactive Approaches' manual.

## 3.1 An Overview of Proactive Approaches

Proactive approaches seek to assess the safety of the road network and identify deficits that can be treated to improve road safety standards. For most countries it is not possible to undertake detailed reviews of all roads and so a 'two stage process' has been developed and described in this manual:

- **Stage 1:** RSIs are to be undertaken across a significant proportion of the road network every 3-5 years. RSIs are high level reviews of the road network.
- **Stage 2:** RS Assessments are more detailed and are undertaken on roads that have been identified as 'high risk'.

Any existing road can be subjected to an RSI or RS Assessment but authorities may wish to prioritise the inspection regime due to funding or resourcing restrictions. Typically they will concentrate their initial efforts on the busier and key national and transnational corridors that carry the majority of traffic.

Unlike Road Safety Audits, these approaches are specifically applied on existing roads rather than new roads. Unlike maintenance inspections, RSIs and RS Assessments aim to focus on the intrinsic safety of the road rather than the identification of maintenance needs.

A two stage process is recommended in this manual to allow countries to make most efficient use of available skilled resources. The first stage (RSI) is primarily a mechanistic data collection exercise that can be undertaken by trained staff who need not be experienced Road Safety Assessors. They could be part of the general area maintenance teams who then prepare a summary report for consideration by specialist staff experienced in collision investigation or Road Safety Audit to consider the findings and develop the detailed road safety investment plan.

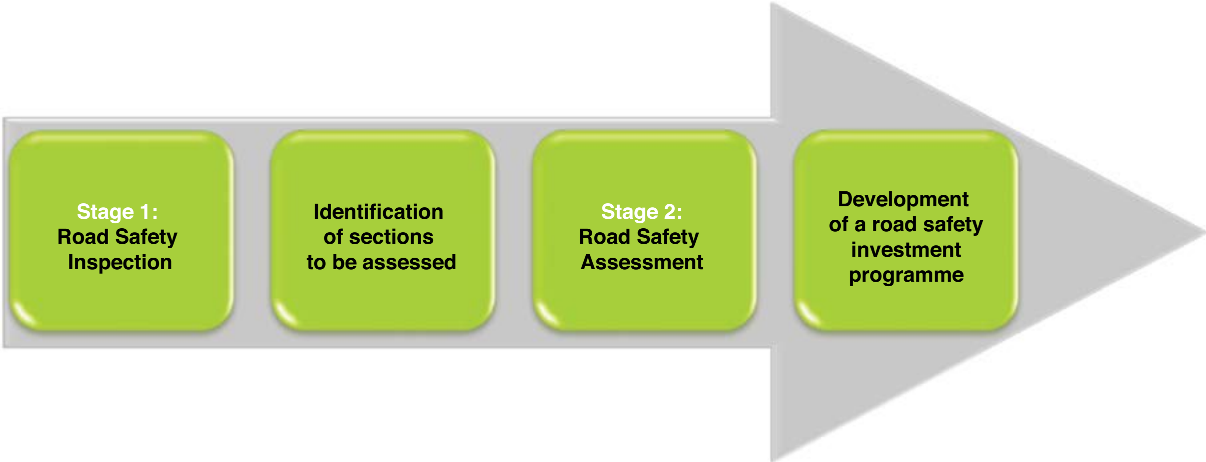



**Figure 2: Two stage proactive approach**

### 3.1.1 Stage 1: RSIs

RSI is a proactive safety management tool. It comprises a routine, programmed and systematic field survey which is undertaken proactively on existing roads to identify risk factors and to achieve enhanced safety. RSI results in a formal report detailing road hazards and safety issues supported with videos and photographs. An RSI is a standardised survey undertaken to collect prescribed data relating to road characteristics (highway and environmental features) of existing roads. This allows the identification of sections of road that warrant further road safety investigation.

The survey is not restricted to the consideration of highway features (e.g. road markings, signage, drainage, road restraint systems, etc.). Rather, during an RSI, information on the context of the road and surrounding development will also be collected (e.g. road alignment, adjacent development etc.). The RSI also records information relating to how an individual might perceive and use the road (e.g. readability and 'self-explaining-ness', monotony of surroundings, speed choice etc.).

Once the characteristics of the road have been recorded, this information can be examined by more specialist safety practitioners who will develop a plan of high priority locations where RS Assessments need to be undertaken.

*When to do an RSI*

**RSIs should ideally be undertaken over the whole road network at least every 5 years. As a minimum they must be carried out on the busiest 10% of the network**

RSIs should ideally be undertaken for each road section every three to five years. Five years should be the maximum permissible number of years between inspections. Ideally all roads would be covered by an RSI, though if budget and resources are limited, a road authority may wish to prioritise the inspection of higher volume roads, roads of strategic importance or roads that are known to be higher risk. It may be preferable to determine a schedule based upon the road hierarchy. For example, RSIs may be undertaken every 3 years for major roads, and every 5 years for secondary and local roads.

In developing an RSI schedule, consideration should be given to:

- Budget and availability of personnel
- The type of roads (i.e. some roads may be particularly susceptible to weathering or other forms of deterioration and it may be appropriate to inspect such roads more frequently)
- Level of development (i.e. if there is slow but sustained development in an area then the traffic situation may change sufficiently rapidly for more frequent inspections to be necessary)
- Planned highway improvement schemes and scheduled road works (i.e. if the highway improvement scheme details have already been finalised and cannot be changed then roads due to be replaced/significantly rehabilitated should be avoided/if there is an opportunity to influence the scheme then they can be included).

### 3.1.2 Stage 2: RS Assessment

**RS Assessments are expert assessments of the road environment undertaken in reaction to an identified road safety issue on the road network.**

RS Assessments involve the expert and in-depth review of the safety of existing roads. As well as identifying safety problems, the Assessment team should seek to identify and recommend viable and cost-effective measures which will improve safety.

RS Assessments are similar in many ways to Post-Opening RSAs which are typically undertaken one year after a new road scheme has been opened to use. Although the assessment techniques and methodologies are very similar, there are important differences between RS Assessments and RSAs and they should not be confused with one another. Specifically, Post-Opening RSAs are undertaken on new roads, or new road improvements, as part of the design and construction process. Roads which are subjected to RSA should therefore conform to current design practices and standards. In contrast, RS Assessments are undertaken on roads which may have been operational for many years and which often do not conform to current design practices and standards.

*When to do RS Assessments*

Proactive RS Assessments though are undertaken on road sections that have been identified as a high priority through an initial RSI. They therefore follow any programme of RSIs. The number of roads that are subjected to RS Assessment in this way will therefore depend on the available budget and number of personnel who are suitably qualified to undertake the assessments.

## 3.2 How Proactive Approaches Fit into Wider Road Safety Management

The objective of Road Safety Management is to integrate all road safety activities such that a systematic approach is taken to reducing death and serious injury throughout the project lifecycle. Effective road safety management programmes need to provide an optimal balance between reactive and proactive strategies.

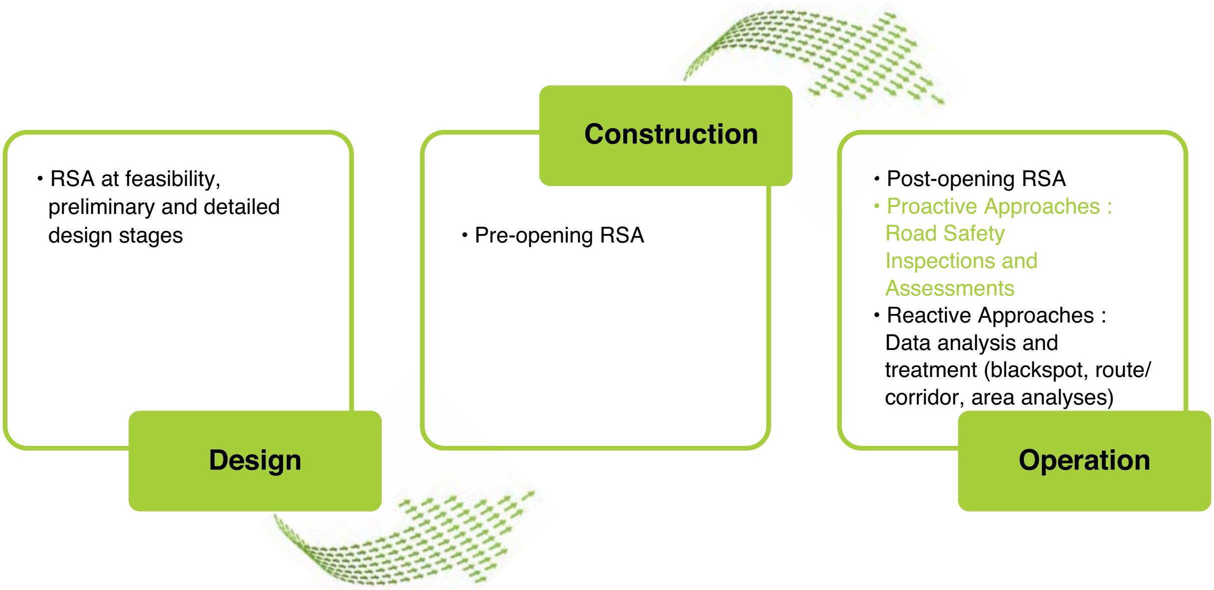



**Figure 3: Road safety management approaches throughout the project life-cycle**

RSI and RS Assessment are used, along with reactive data-led approaches, to manage the safety of the existing road network. The existing road network in most countries will pre-date modern road safety approaches and design standards and so it is important that these roads are assessed and treated to ensure they are as safe as they can reasonably be.

## 3.3 Proactive Approaches and the Safe System

### 3.3.1 Safe System Working

The Joint Transport Research Committee (JTRC) of the OECD (Organisation for Economic Co-operation and Development) produced a report in 2008 titled: 'Towards Zero: Ambitious Road Safety Targets and the Safe System Approach'. This describes the Safe System approach as one that re-frames the way in which road safety is managed and viewed, emphasising the importance of a 'shared responsibility' among stakeholders. It means addressing all elements of the transport system in an integrated manner to ensure that the human is protected in the event of a crash. Importantly the OECD (2008) report suggests that Safe System working is suitable for all countries at differing levels of road safety performance, but that slight variations in the interventions might be appropriate.

The aim is to develop a road transport system that is able to accommodate human error and takes into consideration the vulnerability of the human body. It recognises that even the most law-abiding and careful humans will make errors. The challenge under a Safe System is to manage the interaction between vehicles, travel speeds and roads to not only reduce the number of crashes but, arguably more importantly, to ensure that any crashes that occur do not result in death or serious injury.

The Safe System needs to ensure that road users that enter the 'system' (in an overall sense) are competent, alert and compliant with traffic laws. This is achieved through road user education, managing the licensing of drivers and taking action against those who break the rules.

Once drivers enter the Safe System, there are three core elements that need to work together to protect human life:

- **Safe vehicles:** Vehicles that have technology that can help prevent crashes (for example electronic stability control and Anti-lock Braking System (ABS) brakes) and safety features that protect road users in the event of a crash (for example airbags and seatbelts). This requires the promotion of safety features to encourage consumers and fleet operators to purchase safer vehicles.
- **Safe roads:** Roads that are self-explaining and forgiving of mistakes to reduce the risk of crashes occurring and to protect road users from fatal or serious injury. This requires roads and road-sides to be designed and maintained to reduce the risk and severity of crashes.
- **Safe speeds:** Vehicles travel at speeds that suit the function and the level of safety of the road to ensure that crash forces are kept below the limits where fatal or serious injury results. This requires the setting of appropriate speed limits supplemented by enforcement and education.

The Safe System approach is also supported by effective road safety management and post-crash response.

The Safe System philosophy requires a shift in thinking away from blaming the driver for the mistakes they make. The Safe System challenges those responsible for designing the road transport system to share the responsibility so as to manage the interaction between road users, vehicles, travel speeds and roads.

### 3.3.2 The Importance of Speed

At lower speeds a driver will have greater opportunity to react and avoid a crash. Speed also affects the severity of crashes. Higher speed crashes involve more kinetic energy (kinetic energy is proportional to the speed squared) and the more energy that is dispersed in a crash, the more severe it tends to be.

There are four main crash types that account for the majority of fatal and serious injuries:

- Crashes involving Vulnerable Road Users (VRU's) i.e. pedestrians, motorcycle riders, pedal cyclists, public transport users and road-side vendors.
- Side impact crashes at intersections
- Head-on
- Run-off

Though other crash types do occur across the road network these are less likely to have fatal or serious consequences.

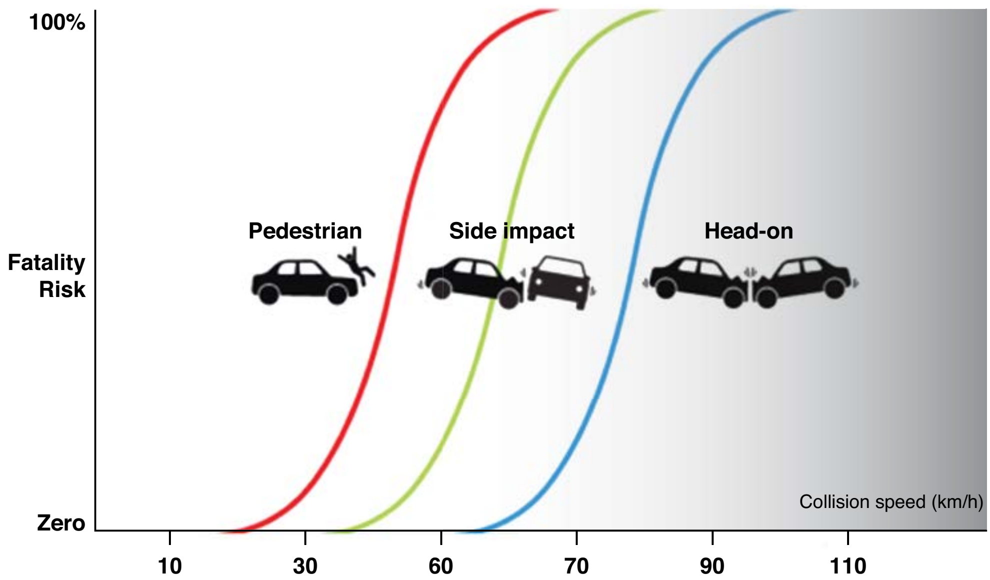



**Figure 4: Crash types and indicative fatality risk at speeds (source: Wramborg, 2005, p14).**

Wramborg (2005) used in-depth crash data to plot collision speeds against fatality risk for three of the main crash types.

As speed increases, the fatality risk increases very sharply for each of the crash types. This leads to several guiding principles for survivability:

- Where conflicts between pedestrians and cars are possible, the speed at which most will survive is 30 km/h - this is represented by the red line
- Where side impacts are possible at intersections (e.g. cross roads and T-intersections), the speed at which most will survive is 50 km/h - this is represented by the green line
- Where head-on crashes are possible (e.g. where there is no median separation), the speed at which most will survive is 70 km/h - this is represented by the blue line

Similar research on run-off crashes has been completed by Stigson (2009). According to this work, a road is considered 'safe' (or survivable) for run-off road crashes if it has a:

- Speed limit not higher than 50 km/h, or
- Safety zone of at least 4 metres and a speed limit not higher than 70 km/h, or
- Safety zone of at least 10 metres and a speed limit higher than 70 km/h.

These principles are not necessarily speed limit suggestions, but a guide to managing conflict points on a road network.

### 3.3.3 Applying Safe System Principles to Proactive Approaches

Safer road design is an important component of the Safe System approach to improved road safety and reductions in casualty numbers and severities. A key notion is that of 'forgiving roads' where new roads can be designed in a way that accommodates human error and the frailty of the human body. The approach promotes the need to manage the energy that is exchanged in a crash impact, such that crash forces are survivable.

The Wramborg (2005) and Stigson (2009) work can be translated into some principles that can be considered during RSI and RS Assessment:

- If a road has a posted speed limit (or better an operating speed) of more than 30km/h and pedestrians or pedal cyclists are expected to use the road, then facilities that separate them from traffic need to be provided
- If the road has a posted speed limit (or an operating speed) of more than 50km/h and has T-intersections or cross roads, then the type of intersection provision needs to be re-considered
- If a road has a speed limit of more than 70km/h and it is undivided, measures should be taken to reduce the likelihood of a head-on crash occurring
- Vehicle restraint systems need to be installed or clearance of road-side obstacles needs to be undertaken if these might threaten survivability of run-off crashes.

The proactive approaches described in this manual work on the basis of identifying road sections where safe system rules have been violated and therefore where there are deficits that could result in fatal or serious injury should a crash occur.

The RSI methodology developed and described in this manual allows these principles to be checked, for example it will be possible to screen a completed form or RSI database to identify instances where there is medium or high pedestrian demand, no segregated pedestrian facilities and vehicle speeds/ posted speed limit are greater than 30km/h. Similarly for head-on crashes it is possible to identify road sections where vehicle speeds or speed limits are greater than 70km/h where there is no median barrier or separation.

During RS Assessment, the expert team can also keep in mind Safe System principles and the importance of speed and the mechanisms underlying typical crash types. The prompts that are provided in Appendix C will help guide the team to take into consideration Safe System concepts.

## 3.4 Benefits of Proactive Approaches

Where crash data are not available, it is particularly useful to use proactive approaches to identify and treat high risk locations.

Proactive approaches are only just beginning to be formalised, and so there is not as much evidence on the effectiveness of these techniques as would be desirable. A study by Austroads (Macaulay and McInerney, 2002) found that for existing road assessments, recommendations had a benefit to cost ratio of 2.4:1 to 84:1.

Although it is not easy to quantify the economic benefits of RSI and RS Assessment, there is strong evidence that such inspections are highly cost effective. Even saving one human life per year as a result of these activities would be a significant benefit in relationship to the cost.

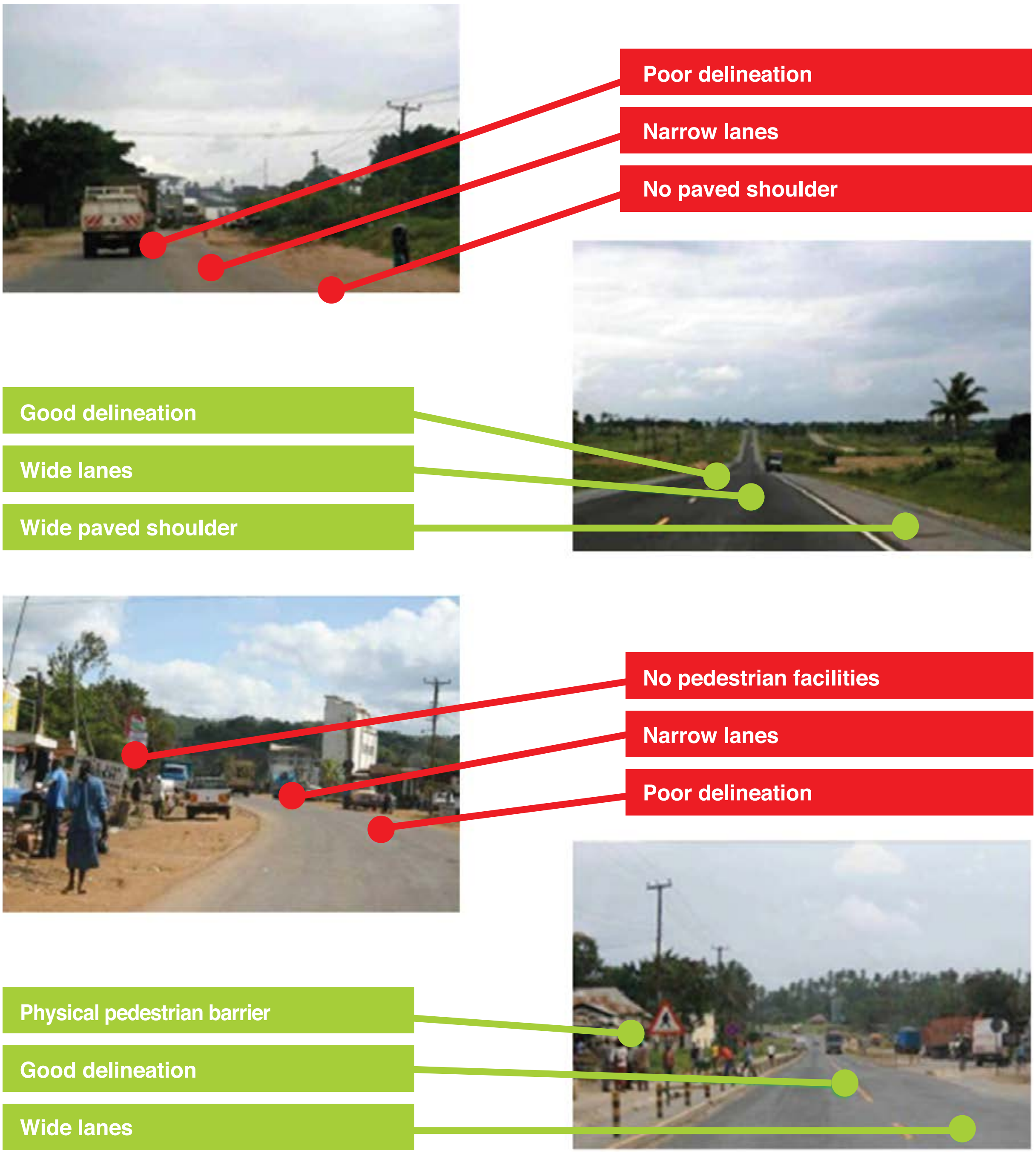



**Figure 5: Some examples of good and bad road design** [1]

1 Images courtesy of iRAP

# 4. Personnel, Equipment and Safety Requirements

This Section provides an overview of the personnel, equipment and safety requirements relevant to Stage 1 and Stage 2 proactive approaches.

## 4.1 Team and Personnel Requirements

Many countries where this manual will be used currently have a limited number of appropriately qualified RS Inspectors or Assessors, if any at all. It is essential for long term sustainability to provide opportunities for African road safety practitioners to increase their experience and skill base in this area.

Where possible, and under the supervision of an experienced and qualified Team Leader, the inclusion of local road safety practitioners in the RSI Team and Assessment Team is to be encouraged. This will have the following benefits:

- Increased capacity among local staff and a greater level of capacity to meet future needs
- A better understanding of 'local' road safety issues and road user behaviour.

Therefore, although some requirements (e.g. for RS Assessment Team Leader) are stringent, other roles require lesser experience in order that development of capability in country can be achieved.

### 4.1.1 Team Composition

*4.1.1.1 Stage 1: RSI*

There are several personnel involved in a Stage 1 RSI:

- The Manager
- RSI Team comprising two Inspectors
- RS Assessment Team

*4.1.1.2 Stage 2: RS Assessment*

RS Assessment (Stage 2) must be undertaken by a Team of qualified practitioners.

**RS Assessment Teams must include two or more people. At least one Team Leader and one Team Member are essential.**

One person alone will not be sufficient to identify all safety issues and it is therefore essential that Assessment Teams are comprised of two or more people. Whereas an individual may miss some issues or have a limited perspective, a second, third or fourth individual may identify safety issues that the other team members have not considered or may be able to more easily provide a different perspective.

One of the team should be designated as the Assessment Team Leader. Other members of the Team can have differing specialisms and, as such, bring a fresh perspective to aspects of the assessment and their comments should not be discounted. Every assessment can serve as a training exercise for inexperienced team members, and be an opportunity for all members of the Assessment Team to gain more experience.

Successful RS Assessors need to be able to adopt the perspective of different road user groups and imagine how they would be able to cope with the road situation, anticipating for instance how easy it would be for the motorist to make the right turn at an intersection or where a pedestrian would want to cross the road.

It is essential to have at least one member of the Assessment Team (Leader, Member, Observer or Specialist Advisor) with good local knowledge as this can assist with understanding how the road is used by the local population and the wider context of the site or road. Non engineering specialists (e.g. Psychologists/ Sociologists) can also help ensure that the RS Assessment deals comprehensively with issues such as road user behaviour.

The specialist skills and size of the Assessment Team depends upon the type, size and complexity of the site or road to be assessed. In addition, traffic police, designers or other specialists (e.g. traffic signals' engineers) may be included if their distinctive perspectives would add value to the assessment.

The following personnel may also be involved as required:

- Police or crash data specialist
- Specialist Advisors to deal with technical aspects such as traffic signal control, traffic signs and markings, street lighting, vehicle restraint systems/barriers etc.
- Specialist Advisors to deal with the needs of different road user groups, these individuals may be specialists in these or a representative of the road user group (e.g. elderly, pedal cyclists, public transport operator, pedestrian)
- Specialist Advisor in traffic behaviour

### 4.1.2 Qualifications, Experience and Responsibility

#### *4.1.2.1 Management*

The purpose of the management requirement is to:

- Provide leadership and support to the approach
- Oversee and facilitate each phase of the approach
- Provide leadership and commitment for the implementation of the outcome recommendations

The need for a formal steering committee, project management team, or a single project manager will vary depending on the scale of inspection being undertaken. For large scale or regional networks it is suggested that a steering committee should be established, whereas for small scale or individual inspections a single manager is all that is required.

The Manager:

- Manages and maintains a list of available inspectors, ensuring sufficient numbers of inspectors are available, trained and retained within the road authority
- Assigns duties to inspectors and assessors and manages an RSI and RS Assessment schedule
- Oversees the quality of RSIs and RS Assessments

The Manager will:

- Commission and schedule RSIs and RS Assessments
- Develop the Inspection Brief including start and end points for each road section to be inspected and determine optimum conditions for the inspection to take place
- Develop and issue Health and Safety Risk Assessments for Inspectors and Assessors
- Hold a database containing RSI data
- Ensure the findings of the RSI are passed to the RS Assessment Team for review
- Work with the RS Assessment Team to make the business case for a proposed treatment programme

This role may be fulfilled by one of the RS Assessment Team.

*4.1.2.2 RSI Team*

A pool of Inspectors needs to be established. For large countries, it may be necessary to have Inspectors in each region. Inspectors may already be employed by the Road Authority as engineers (e.g. traffic management engineer or transport planner) and RSI may just be one duty undertaken as part of their role when required. Some experience with road engineering is desirable.

The RSI Team must be impartial, they should be solely concerned with safety and there should be no conflict of interest.

*Composition*

RSI Teams should comprise two trained Inspectors. RSI is a monotonous task and without regular breaks, Inspectors will make errors and lose concentration. The Inspectors may take it in turns to drive and record information about the road. Or a separate driver may be provided. Even if a driver is provided, it is still necessary to have two Inspectors.

One of the RSI Team should be designated as the Inspection Team Leader. Although the Inspection Team Leader and Inspection Team Member will have the same road safety inspection training, it will be the Team Leader's responsibility to organise the Inspection and perform all liaison requirements with the RSI Manager, including the submission of the RSI Report.

*Responsibilities*

The RSI Team:

- Discuss and liaise with the Manager with regard to preparation – when to visit, optimal site conditions, etc.
- Undertake the inspection in accordance with defined procedures put in place by the Road Authority
- Report to/meet with the Manager and RS Assessment Team

*Training and Experience of the RSI Team*

RSIs should only be undertaken by persons who have received the relevant training and have the experience described in this section. Unlike RSAs and Assessments it is not necessary for the Inspection Team to be specialist road safety engineers, but they must have an understanding and knowledge of Road Safety Principles and hazard identification.

Inspectors need to be familiar with roads in general and with road infrastructure issues associated with safety. They need to be aware of highways design and maintenance issues to assist them with detecting potential road safety hazards. However, they also need to be able to view the road from the perspective of the typical road user (vehicle drivers, motorcyclists, pedal cyclists and pedestrians) who does not share their professional experience and knowledge.

Each Inspector must have at least 2 years' experience working within the highway industry (roles could include traffic engineer, safety engineer, maintenance engineer or transport planner). It is not necessary for the Inspection Team Leader or Team Member to have differing levels of training or experience. Table 1 provides the training requirements for Road Safety Inspectors.

When RSI is being introduced to a country then the Inspection Team would initially be accompanied by an experienced RS Assessor to ensure that the RSI Team is equipped and competent to undertake this task.

**Table 1: Inspection team training requirements**

| Training | Content |
|---|---|
| Road safety principles and hazard identification | Principles of road safety and the four main crash types and their causes<br>Identification of hazards / road layouts that can cause and contribute to road user safety problems |
| Roadside health and safety training | Identification of the dangers associated with working on the road side<br>Risk assessment process<br>Dynamic risk assessment process<br>Safety instructions for types of road |
| Tutored RSI | Accompanied RSI with a qualified Road Safety Audit Team Leader to certify the Inspector's suitability<br>Use of available equipment |
| Continuing Professional Development (CPD) | Demonstrate a minimum of two days CPD in the field of road safety in the last year |

#### *4.1.2.3 RS Assessment Team*

The RS Assessment Team will examine the RSI Report and assess which sections require further investigation through RS Assessment. They will then:

- Undertake the RS Assessment
- Propose a treatment plan
- Develop a business case for investment.

RS Assessments should only be undertaken by persons who have received training and have appropriate experience. At least one of the team must be an experienced Road Safety Engineer.

**The success of a RS Assessment depends to a very great extent on the skills, abilities and experience of the Assessment Team. Selecting the right team is essential.**

**Competence in RS Assessment comes through hands-on experience. Training is helpful at the start but is only a base upon which experience needs to be built.**

RS Assessment is a highly skilled activity which requires an understanding of crash causation, crash investigation (data analysis and incident reconstruction), vehicle performance, highway design and the interaction between the road user, their vehicle and their environment.

The Assessment Team Leader, Members and Observers must meet the essential experience and qualification requirements described in the sections that follow.

It is essential that the process is undertaken by an impartial team who are demonstrably independent of the road management section or division or any other interested parties or stakeholders.

*Team Leader*

The Assessment Team Leader has overall responsibility for carrying out the Assessment, managing the Assessment Team and certifying the report.

**Table 2: Team Leader experience and qualifications**

| | Essential | Desirable |
|---|---|---|
| Qualification | University degree in road engineering, traffic or related road safety field<br>OR<br>10 years' experience in a related road safety field including crash investigation | Higher degree in traffic or road engineering subject |
| Training | 5 days formal crash investigation or road safety engineering training | |
| Experience | 5 years' experience in a relevant road safety, design, construction or traffic engineering field<br>3 years' experience of crash investigation<br>Experience working in the country/region where the Assessment is taking place | 10 years' experience in a relevant road safety, design, construction or traffic engineering field<br>5 years' experience of crash investigation |
| RS Assessment Experience | Must have undertaken 5 Road Safety Assessments within the last 2 years as a Team Leader or Member<br>OR<br>For those with more than 10 years' experience of crash investigation or Road Safety Audit/ Assessment experience, they must have undertaken: 10 Road Safety Audits or Assessments within the last 10 years as a Team Leader or Member<br>AND<br>1 Road Safety Assessment within the last year as a Team Leader or Member | - |
| Continuing Professional Development | Demonstrate a minimum of 2 days CPD in the field of Road Safety Assessment, crash investigation or road safety engineering in the last year | Membership of a recognised local or international Road Safety professional body |

*Team Member*

The RS Assessment Team Member reports to the Team Leader. They contribute to the Assessment via the Team Leader. Ideally they will have local experience/knowledge.

**Table 3: Team memeber experience and qualifications**

| | **Essential** | **Desirable** |
|---|---|---|
| Qualification | University degree<br>OR<br>5 years' experience in a related road safety field including crash investigation | Degree in road engineering, traffic or related road safety field |
| Training | 5 days formal crash investigation or road safety engineering training | - |
| Experience | 2 years' experience in a relevant road safety, design, construction or traffic engineering field<br>1 years' experience of crash investigation | 3 years' experience in a relevant road safety, design, construction or traffic engineering field<br>2 years' experience of crash investigation<br>Experience working in the country/region |
| Continuing Professional Development | Demonstrate a minimum of 2 days CPD in the field of RSA, crash investigation or road safety engineering in the last 12 months | Membership of a recognised local or international Road Safety professional body |

*Observer*

A RS Assessment Team Observer is, for many, the starting point of being involved with RS Assessment. As such, there needs to be a flexible approach to the requirements for knowledge and experience.

**Table 4: Observer experience and qualifications**

| **Essential** |
|---|
| Experience:<br>1 year experience of crash investigation or road safety<br>OR<br>Completion of a recognised Road Safety Engineering course of at least 4 days duration |

*Specialist Advisor*

A Specialist Advisor provides specific independent advice to the Assessment Team concerning aspects of the assessment that are not within the experience and qualifications of the Assessment Team.

Some Specialist Advisors will be brought in to deal with technical aspects of the assessment such as traffic signal control, traffic signs and markings, street lighting, vehicle restraint systems/barriers, road surfacing, drainage etc. Other Specialist Advisors will represent the needs for various road user groups, such as the elderly, pedestrians, pedal cyclists, public transport operators, etc.

The Assessment Team should consider if there are any particular features of the project, such as complex signal controlled intersections, highway design, traffic management or maintenance issues that warrant the inclusion of Specialist Advisors to advise them. A Specialist Advisor is not a formal member of the Assessment Team but advises them on matters relating to their specialism. They should be named in the Assessment Report.

## 4.2 Equipment

### 4.2.1 Stage 1: RSI

Equipment required includes:

- A vehicle (with appropriate high visibility markings)
- Video camera (ideally GPS linked system) (typically these cost around $500 US)
- GPS (can be achieved using a satellite navigation system or smart phone)
- Notepads
- Inspection forms
- Pens
- Personal Protective Equipment (e.g. high visibility clothing and protective footwear)

Optional equipment includes:

- Digital camera
- Dictaphone (optional)

It is imperative that the inspection route/section is videoed. The video and other equipment should not be hand-held and it should be mounted so that it does not impair the driver's field of view. Preferably the video equipment will have geo-referencing capabilities so that the video images can be related to specific locations. In addition, this may allow the logging of the precise location of hazards.

Some road authorities may already have asset management vehicles that are regularly driven around the network for other purposes. If these provide geo-referenced video outputs they can be used for RSI and the recording of the information on the road can be done from the office.

The video will be handed over to the RS Assessor as part of the report package and used to aid review.

Specific equipment and vehicle markings may vary by country and/or region and it is recommended that typical or standard equipment requirements and specifications are decided upon during the process of developing and introducing the RSI process in each country.

**Figure 6: Asset management vehicle**

### 4.2.2 Stage 2: RS Assessment

The Assessment Team will typically be responsible for the provision and use of equipment such as video cameras, GPS, tape measures, maps, digital cameras, spirit levels, notepads, vehicles and personal protective equipment (hard hats, high visibility clothing, etc.).

The Road Authority may choose to provide equipment and support staff (particularly if warning signage or other temporary traffic management is required in order for the Assessment Team to inspect the site safely).

## 4.3 Team Safety

When conducting an RSI or RS Assessment it must be kept in mind that personnel may find themselves in a potentially dangerous situation and therefore a certain level of risk may be involved. As such it is imperative that the appropriate equipment is used when undertaking these activities in order to mitigate risks to themselves or to other road users.

It is essential that site visits are undertaken in a safe manner and that the safety of the Assessment Team, road users and other members of the public is not compromised.

**If a site visit cannot be done safely then it should not be done at all.**

Site visits need to be carefully planned as personnel will need to stop at several locations where safety hazards will be present. A full risk assessment should be undertaken. The risks, and the precautions which are necessary, will vary from site to site. However, general principles include:

- **Planning and administration**
  - The Manager should be notified of any deviations from planned schedules

- A mobile telephone should be provided for emergencies and for checking in with the Manager at the start and end of each day.
- The Inspection/Assessment Team must be equipped with sufficient supplies of drinking water and food.

- **Vehicle safety**
  - Vehicles must be roadworthy and properly equipped with suitable reflective materials and lighting bars. They should generally travel at the prevailing traffic speed.

- **Site/operational issues:**
  - Site visits must always involve at least two personnel - one should act as a look out when the other is preoccupied (e.g. taking photographs).
  - Appropriate traffic management should be requested if it is otherwise unsafe to inspect the site.
  - The Inspection/Assessment Team should park safely so as to not obstruct traffic flow or obscure sightlines.
  - The Inspection/Assessment Team must be aware of risks from beyond the road. For example, the risks of sunstroke, personal attack or animal bites (including insect or snake) should be evaluated.
  - Appropriate Personal Protective Equipment (PPE) must always be worn. Different PPE will be appropriate for different situations but it is likely to include reflectorized vests or jackets and possibly trousers and sunshades. Suitable footwear is essential and might include steel toe cap boots. Hard hats or eye goggles will be necessary in some situations.
  - The Inspection/Assessment Team must never use video cameras, cameras, mobile phones or other equipment while they are driving.
  - Inspections must be made from safe locations such as footways, hardened verges or over-bridges. Inspectors/Assessors should not stand in the road and they should only cross the road in suitable locations and with care.
  - The Inspection/Assessment Team should avoid walking with their backs to traffic where possible.
  - The Inspection/Assessment Team must not expose themselves or other road users to risks during adverse weather conditions such as high winds or heavy rainfall. It is possible however to undertake some observations from a safe place (e.g. pedestrian behaviour in the rain).
  - The Inspection/Assessment Team should not intervene in incidents or direct traffic unless they are specifically trained and equipped to do so. Well-intentioned intervention of this type can make matters worse and it is better to call the Police or other emergency services in such situations.

The RSI and RS Assessment Team should stop work and leave the site if unforeseen risks are identified. They should consult with the Manager to determine a way forward.

# 5. Proactive Process

The Proactive Approach process is broken down into two stages following initial preparations (Section 5.1). Stage 1 involves the undertaking of RSI across the chosen road network (Section 5.2). Stage 2 involves the undertaking of RS Assessment (Section 5.3) on sites/sections that are identified during Stage 1 as being high risk and worthy of in-depth assessment. Following the undertaking of the RS Assessment, a treatment plan will be developed (Section 5.4) and, once implemented, monitored and evaluated (Section 6).

## 5.1 Preparation

Two tasks must be undertaken in preparation for undertaking the proactive approaches described in the rest of this Section.

The first is to determine the road network that will be subjected to RSI. This will relate to an overall policy for RSI and RS Assessment (see Section 3.1.1 for further information).

The second is to develop an RSI schedule. For this the RSI Manager will need to segment the road network into sections. The sections should be:

- Homogenous in character (the section should have similar design features and similar traffic flows)
- Between 10km and 150km in length (and ideally as similar in length as possible) for rural roads (urban road sections may be much shorter)
- Meaningful e.g. road x between junction y and junction z or between two settlements

Note that route/corridor analysis also requires the network to be sectioned in a very similar manner and that there would be significant benefits in using the same sections for both tasks (this would allow one single database to be established with RSI data and route/corridor crash data). The process is described in Section 5.3 of the Existing Roads - Reactive Approaches manual.

Each section should be given a unique identifier and sufficient location details recorded such that the section is identifiable on the network (i.e. latitude and longitude, road numbers or settlement names at the start and end points). Some free-source web-based mapping provides a latitude and longitude information if the location is clicked upon and selected (see Figure 7).

The road sectioning data could look similar to that provided in Table 5 if latitude and longitude references are used.

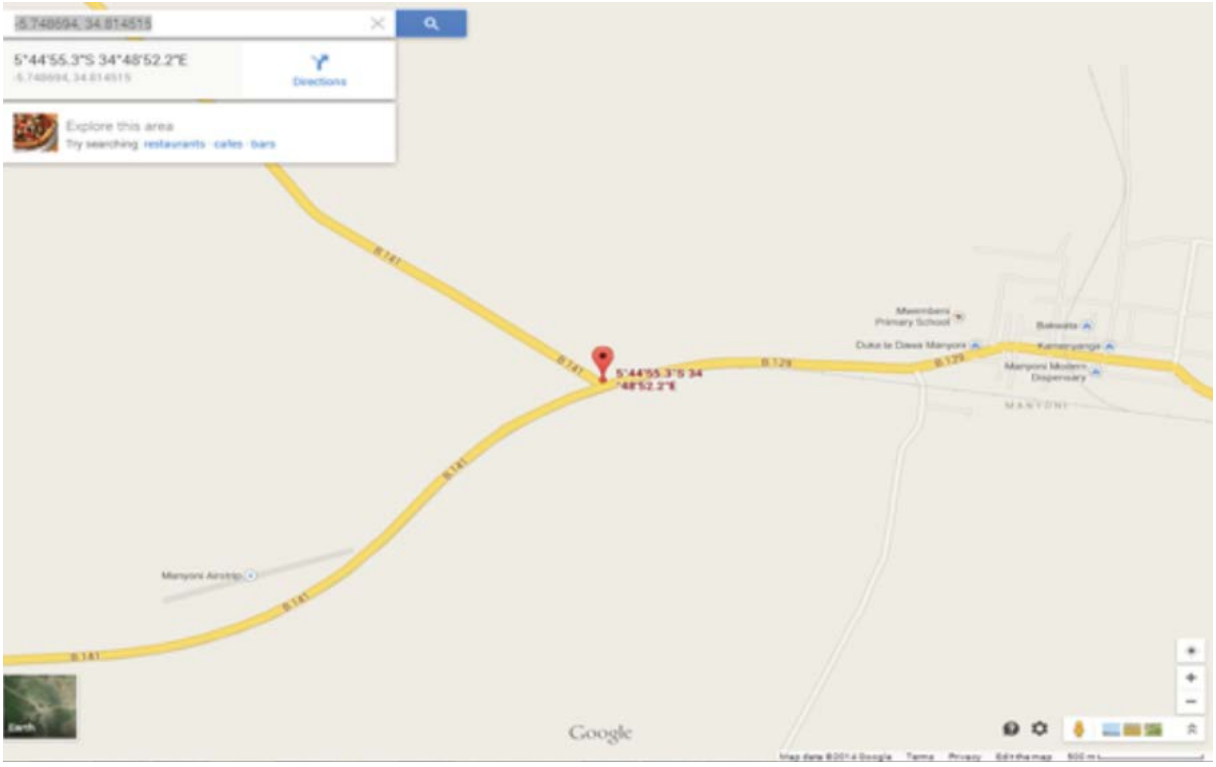



**Figure 7: Latitudes and longitudes using Google Maps**

**Table 5: Road sectioning data**

| Section ID | Road Number | Start Point | | End Point | | Length of section (km) | Road Type |
|---|---|---|---|---|---|---|---|
| | | Latitude | Longitude | Latitude | Longitude | | |
| 1 | B141 | -5.748694 | 34.814515 | -5.710357 | 34.765437 | 7.1 | Single |
| 2 | B129 | -5.748694 | 34.814515 | -5.782108 | 34.900425 | 11.3 | Single |
| 3 | … | … | … | … | … | | … |

A database should be established that houses information about each road section. Information about each section based on the RSI reports can then be entered in the future as the RSI and Assessments are undertaken. This then provides a comprehensive and auditable record of surveys and improvement work undertaken. The RSI Manager should be responsible for maintaining this database.

## 5.2 Stage 1: RSI

### 5.2.1 Process Steps

Figure 8 shows five steps for undertaking RSI and identifies responsibilities for each step.

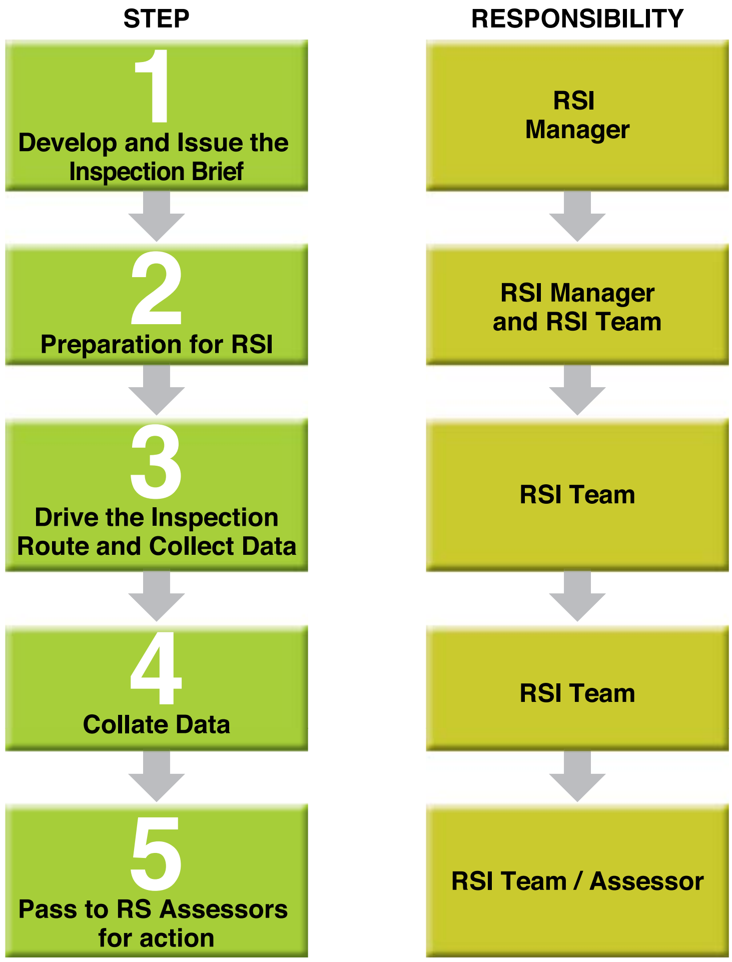



**Figure 8: RSI process flow chart**

*5.2.1.1 Develop and Issue the Inspection Brief*

The Inspection Brief is critical to ensuring the effective management and delivery of an RSI. This will be issued by the RSI Manager to the RSI Team.

The Inspection Brief should contain:

i) The names of the Inspectors
ii) Summary description of the route/area to be inspected - road type, length, location, start points and end points etc.
iii) Road sections within the route/area to be inspected including information as provided in Table 5 (including start and end points for each section, and unique section identifier)
iv) Details of the visit procedure referencing this manual, the time of day for the inspection and the equipment that will be required or provided
v) Contact points for any queries or issues
vi) Time line for completion of the RSI
vii) Health and Safety Risk Assessment and safety guidance.

*5.2.1.2 Preparation for an RSI*

*Route Planning*

The inspection route needs to be planned to ensure efficient coverage of the required sections (note in both directions for dual or divided roads). If long distances are to be covered throughout the RSI, consideration must be given to location of suitable accommodation, rest locations for the driver(s), meals and refreshments. The itinerary for each day should be planned to accommodate these requirements.

An inspection team should be able to complete inspections on around 100 to 150 km of single carriageway road per 8 hour day (note dual/divided carriageways need to be inspected in both directions) depending on complexity of the road environment.

*Safety Checks*

The Inspection must be undertaken safely. The safety of members of the Inspection Team, road users and other personnel must not be compromised by the inspection process. Prior to starting the inspection drive the Inspection Team need to check the safety equipment provided to ensure its adequacy for completing the task. This should include that:

- The vehicle provided is fit-for-purpose and that maintenance checks have been undertaken
- All relevant PPE is available and meets standards
- A mobile phone is supplied and operational

*Equipment Check*

In addition to checking and verifying safety equipment, the Inspection Team also needs to check and ensure that all logistical resources are supplied and operational, these shall include:

- GPS enabled video recording system (to facilitate to the localisation of particular hazards)
- Road Inspection Forms and writing material
- On board odometer (distance measurement device measuring in 100m sections)
- Detailed plans of the route/area
- Digital camera with high-capacity memory card (optional)
- Tape recorder / Dictaphone (optional)

*5.2.1.3 Drive the Inspection Route and Collect Data*

The inspection route is driven by the RSI Team and the form filled in for each section. The RSI form is provided in Appendix B.

At the start of each section of the inspection route, the GPS and video equipment must be turned on and the odometer set to zero. The video must be in operation for the entire drive-through element of the Inspection, some video equipment is GPS enabled and allows the location to be recorded and 'markers set', i.e. when a perceived road safety issue is noted this is 'marked' on the equipment and the GPS location logged. Alternatively, if the video is not GPS enabled then the timing on the video should be noted manually and the kilometre (km) distance also noted. It may be possible to record start and end points for each video section based on smart phone GPS or satellite navigation systems.

In order to note safety issues on the form the Inspectors shall:

- Move within the traffic flow at a suitable speed for correctly recording information (note travelling too slow can also be hazardous)
- Restrict their consideration to road safety issues
- Consider likely traffic flows, mixes and road user behaviours
- Use the video, camera, Dictaphone and other recording information
- Stop when necessary, and when safe to do so, to take photographs and complete the Inspection Form.

After each section has been driven the Inspection Team will park and complete the Inspection Form for that section before driving the next section. If appropriate, additional inspections on foot or from other vehicles will be undertaken before moving on.

The form provides room to record typical features for the section as well as the occurrence and location of specific isolated hazards. Recording the location of the hazards should be done where possible. It may be easier to systematically note road safety hazards as they appear along each section inspected and then, during the preparation of the Inspection Report, the locations of these hazards can be formally recorded for each Inspection section.

It may not be possible to capture all information during one drive-through of the section. If so, it may be necessary to re-trace steps, stop to take photographs in order to add to, or reformulate, observations.

Where possible, the site, or route, should be travelled in both directions to familiarise the Inspectors with the site and so that they can encounter and better understand the road from a driver's perspective. A separate Inspection Form should be completed for each direction of travel; this is considered essential for divided/dual carriageway roads.

This process is repeated for each pre-defined section.

*Best Practice for Use of Recording Equipment*

The use of a video camera to record the RSI, and other recording equipment such as digital cameras and voice recorders, are an essential part of the inspection process and at the minimum inspectors MUST use video recording equipment.

These devices enable images of the site to be recorded along with a spoken commentary of issues. This is extremely useful when later collating the team's observations and the images can also form a very informative part of the Inspection Report. These are important in order to provide:

- The Inspection Team with a reminder of key issues when undertaking the Inspection and when writing the Inspection Report
- A record to the RSI Manager/RS Assessor
- A record of conditions on-site during the site inspection

Videos and photographs must be taken in a systematic manner and good record keeping is essential if the videos are to be reviewed later. At the beginning of each section, the RSI Team can state the date, time and direction of travel. A spoken commentary may also be useful.

Photographs should be taken in a systematic manner so as to assist with subsequently identifying features and locations. For example, if an inspection of an intersection is undertaken by foot, ensure that landmarks are included and always progress around the intersection in a clockwise direction. It may also be helpful to photograph a written card which describes the location prior to taking a sequence of photographs.

*5.2.1.4 Collate Data*

On completion of the RSI, the information needs to be reviewed and collated by the RSI Team. This will involve going through all the individual Inspection Forms to summarise the information collected. At this stage videos and photographs may need to be reviewed to ensure the forms are all complete.

The labelling of videos should be checked at this stage to ensure that the RS Assessor can locate the correct video for each section.

The RSI Manager may wish the RSI Team to enter the recorded information into the RSI database.
A summary report of the key findings of the Inspection will be made with initial indications as to the areas that need further assessment (see Appendix B).

*5.2.1.5 Pass the RSI Report to RS Assessors for Action*

It will not be possible to undertake a detailed RS Assessment on all sections where hazards have been identified and so it is necessary for the RS Assessor to prioritise further investigation. The RS Assessor will therefore need to review the findings of the RSI and prioritise a plan of RS Assessments according to available resources on the basis of:

- Risk - as assessed by the deficits detected during the RSI and degree of violation of Safe System rules

- Importance of the road/section – based on traffic volumes (if known) and strategic importance of the road/route/section.

The RS Assessor can review the RSI videos to help get a good view on which sections RS Assessment should be undertaken. They may also undertake a site visit of the identified sections to assist in that prioritisation, before finalising the list of sites for further investigation.

## 5.3 Stage 2: RS Assessment

A RS Assessment will either be undertaken by an 'in-house' team or by external consultants.

If undertaken by an 'in-house' team within the Road Authority then they need to be planned and an approved programme put in place (based on 5.2.1.5).

If undertaken by an external team of consultants, contracts need to be put in place that specify the scope of the Road Safety Assessments, expected outputs and requirements for the qualifications and experience of the Assessment Team.

Budgetary provision for undertaking RS Assessments, and for addressing any safety recommendations, needs to be considered prior to the Assessments.

### 5.3.1 Process Steps

This section provides guidance on the step-by-step process for completing a RS Assessment. The process steps are shown in Figure 9.

Steps 1, 2 and 3 only apply if a RS Assessment is formally procured using external consultants – these are shown in grey.

If the RS Assessment Team is from within a Roads Authority then they will simply receive RSI reports as they are undertaken. They may also receive the results of crash data analyses or police/community intelligence. Using this information they will need to develop a prioritised programme of RS Assessments that should ideally be approved by the Chief Engineer of the Roads Authority.

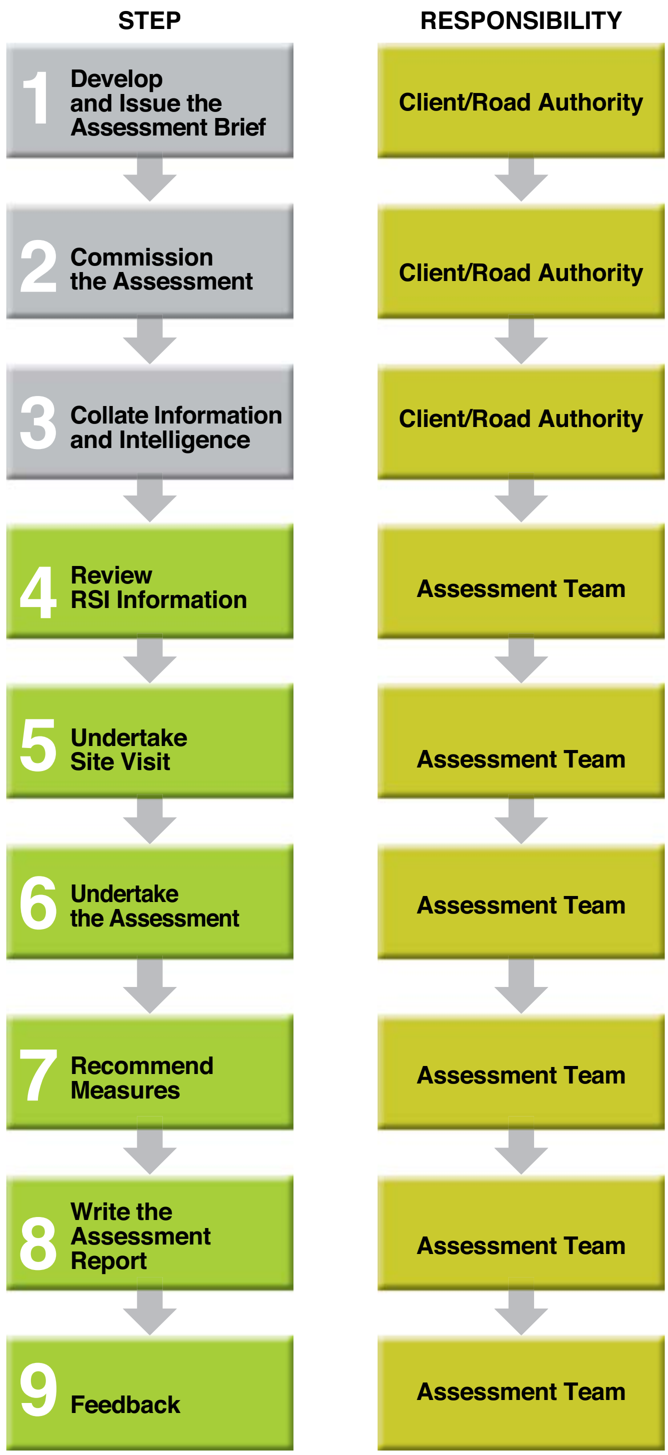



**Figure 9: Assessment process flow chart**

*5.3.1.1 Develop and Issue the Assessment Brief (Formal Procurement of External Consultants)*

The Assessment Brief is critical to ensuring the effective management and delivery of a RS Assessment. The Assessment Brief provides the basis on which to engage an appropriately qualified and experienced Assessment Team in accordance with the requirements specified in Section 4.1.2.3.

It is the responsibility of the Roads Authority to develop the brief. Assessment Teams are often engaged through some form of competitive tendering process or they can be drawn from appropriately qualified and experienced road safety staff within the organisation. Whichever option is adopted, they need to be impartial and separate from the maintaining or design staff involved with the road or area under assessment.

The Assessment Team may have knowledge of the roads that they are being asked to inspect, but they might not and they should not be disadvantaged by an absence of local knowledge. Therefore in order for the Assessment Team to provide a realistic estimate of the time and resources needed for the assessment, it is important that they are given as much information as possible in the initial brief. A clear and accurate proposal or work plan will only be received in response to a clear and comprehensive Assessment Brief.
The brief needs to include:

i. Project title
ii. Summary description of the roads to be assessed – the nature, length, location, etc.
iii. Any manuals or guidelines to be adhered to. This will include:
    a. A specification of the required assessment methodology and reporting system.
    b. Details of necessary meetings, site visits and health and safety requirements.
    c. Confirmation of the reporting format and the level of detail expected for any recommendations that are made.

iv. Background to the Assessment.
    a. Description of the reasons for the assessment (e.g. Crash data analysis, RSI findings, or local intelligence).
    b. Overall layout and location plan (minimum scale 1:1250).
    c. Information about the adjacent network and land uses.
    d. Type and level of other information that will be made available (it is unrealistic to make all information available until the Assessment Team is appointed).

v. Timescales for the Assessment:
    a. Likely timings for the assessment including information about term-times, seasonal traffic or peak traffic conditions to observe or to avoid. Confirmation concerning suitable weather conditions for visits and daylight and night-time visit requirements.
    b. Timescales for notification and mobilisation of Assessment Team (typically 2-3 weeks).
    c. Timescales for completion of Assessment Reports.
    d. Timescales for the development of a treatment programme and for follow-up.

*5.3.1.2 Commission the Assessment (Formal Procurement of External Consultants)*

The formal commissioning of the Assessment needs to take place in a similar manner as for other works commissioned by the Road Authority. The Road Authority's procurement and contractual processes should be adhered to.

Formal notification should be given to any external funding organisation if applicable.

*5.3.1.3 Collate Information and Intelligence (Formal Procurement of External Consultants)*

Following the appointment of the Assessment Team and the formal instruction to commence, the Road Authority needs to provide relevant information as specified in the Assessment Brief.

The Assessment Team can only assess the road on the basis of the information they have been provided. It is essential that all relevant documents are provided to the Assessment Team prior to them undertaking the assessment.

The following detailed information and intelligence should be made available to the Assessment Team:

i. Confirmation of the title of the project and scope of the Assessment
ii. Reporting requirements
iii. A set of plans showing the location of the site and, if available:
    a. Horizontal and vertical alignment
    b. Cross section
    c. Signing and lining
    d. Drainage
    e. Lighting
    f. Road restraint system
    g. Landscaping

iv. A blank plan to mark up any issues
v. Notification of the currently adopted relevant design standards (for any proposed remedial treatment)
vi. Traffic flows, composition (including intelligence on pedestrian/pedal cyclist road usage)
vii. Historical speed data
viii. Key traffic generators and attractors
ix. Intersection control information (including, if available, traffic signal timing information)
x. Key contacts with Client/Road Authority and Police (and possibly other interested parties and stakeholders such as local community groups)
xi. Results of any crash data analyses undertaken, raw data and any other intelligence
xii. Times of day that the roads should be inspected and details of specific days that should be avoided, or observed, due to school holidays, seasonal traffic or other factors
xiii. Health and safety requirements including details of any physical access restrictions or times when the site should not be accessed
xiv. Any other pertinent local knowledge or information

*5.3.1.4 Review RSI Information*

In this step the Assessment Brief (if available) and any additional information available will be studied. Any RSI report and video/photographic information will be studied to understand the issues identified. Where this is done in-house, it is likely to merge with the step identified in Section 5.2.1.5.

Initial consideration of the supplied information is necessary to identify issues for:

- Further clarification from the Client, RSI Manager/Team, or those who have undertaken the data analyses
- Further investigation during the site visit

*5.3.1.5 Undertake a Site Visit*

In order for a clear understanding of the circumstances that impact on the safety of a road, it is essential for the Assessment Team to carry out a site visit.

*Planning*

Site visits:

- Should be undertaken at different times of the day and at night-time. They should be planned at different times of the day such as during busy periods, during the start or end of school, on market days etc. It may be important to avoid (or observe) school holidays or other times when traffic conditions are atypical. A night-time visit, undertaken during the hours of darkness, is important in order to understand particular safety concerns at night (e.g. visibility of road markings, readability of the road).
- Need to allow the Assessment Team to take the perspective of all prospective road users (drivers, pedal cyclists, pedestrians etc.).
- Must be undertaken safely. The safety of members of the Assessment Team, other road users and construction or other personnel must not be compromised by the site visit.

Site visits for larger or more complex roads will often need to take place over several days and careful planning will therefore be necessary.

All members of the Assessment Team should attend all site visits together. Other interested parties (e.g. Police, local stakeholders, and managing organisation) may also be in attendance, either for part or all of the visit. It may be necessary to involve different parties at different times and so planning is essential.

*Site Review Principles*

The Assessment Team should bear in mind the key principles for achieving a safe road environment when undertaking the site visit so that they are able to associate with potential problems. These issues are described in Figure 10.

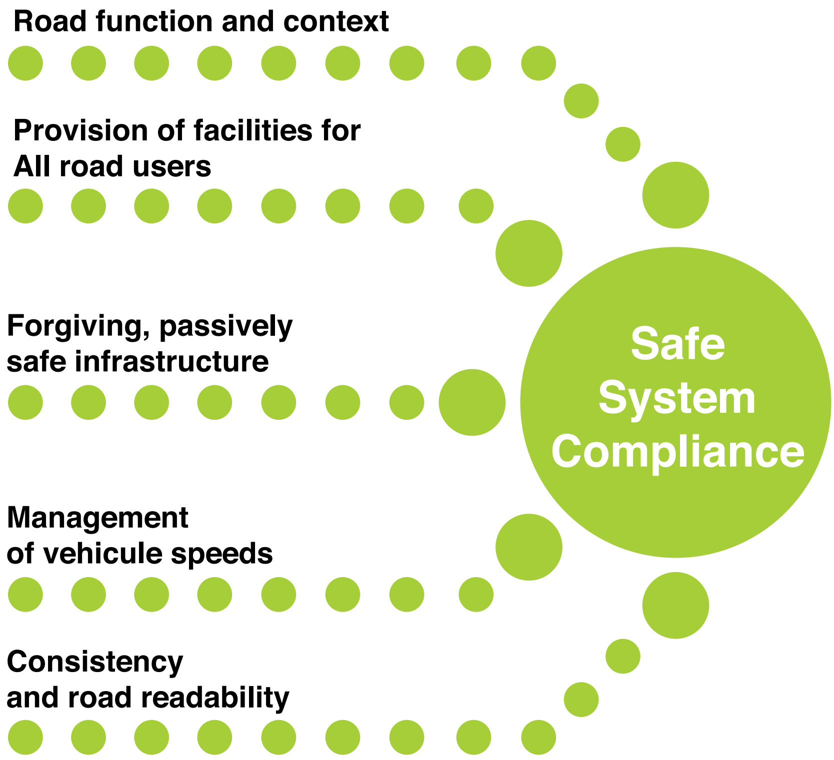



**Figure 10: High level issues for consideration**

Members of the RS Assessment team should consider the following:

- Road function and context:
  - Is the type of road/scheme appropriate for the proposed function of the road?
  - Is the type of road/scheme right for the proposed traffic flow and modal split?
  - Would safety be improved by re-locating or re-aligning the road/scheme?
  - Have controls been put in place to manage or reduce the likelihood of adjacent road-side or ribbon development?
  - Has access been designed to control turning movements in an appropriate way for the type of road/scheme?
  - Is the road/scheme character and scale consistent with the adjacent route and network?
  - Does the road/scheme accommodate anticipated future development or existing traffic generators?

- Provision of facilities for ALL road users:
  - Are there likely to be pedestrians, carts, animals, pedal cyclists or motorcyclists using this road? Have they been provided for?
  - Are there facilities for public transport (e.g. bus stops/laybys/pedestrian crossing points)?
  - Are there rest stops provided?
  - Is there provision for special road users (e.g. mobility or visually impaired, older or younger road users etc.)?
  - Are facilities provided for journeys to schools?

- Forgiving, passively safe infrastructure:
  - Would the main crash types be survivable on this road at expected speeds?
  - Would the road environment minimise injuries for all crash types?

- Management of vehicle speeds:
  - Is the speed limit appropriate for the function of the road?
  - Are drivers likely to obey the speed limit?
  - What is the impression given to drivers about what the speed limit is (without seeing a speed limit sign)? Can this be improved to enhance compliance?

- Consistency and road readability:
  - Are there any surprises for road users?
  - Is the driver guided, warned and informed about the road ahead?
  - Is there consistency in the design throughout the scheme and with nearby roads?
  - Does the scheme control the passage of the driver through conflict points and other difficult sections?

Additional guidance on the aspects that need to be considered through the site visit is given in Appendix C - Prompts.

The expert inspection of the site should also be guided and informed by general principles and consideration of the crashes that typically occur on that type of road. For example, if the road is a complex urban site with high numbers of pedestrians and other VRUs then it would be reasonable for the Assessment Team to be particularly interested in risk features which relate to pedestrian safety. Conversely, if the road is remote, high-speed and characterised by long straight lengths linked by bends then it would be reasonable to be particularly interested in risk features which relate to overtaking or loss of control crashes.

However, every site is different and local conditions can interact and create risks that are not always immediately apparent. An experienced Assessor will be familiar with situations where, for example, bends are correctly designed and signed but, because of local factors, they do not look as acute as they actually are. The expertise which Assessors utilise involves the site-specific assessment of risks based on a consideration of the interaction of unique local characteristics of a location including vehicle mix, speeds, driver behaviour, road alignment, sufficiency of signs, etc.

*Different Viewpoints*

The location that is being assessed should be visited during daylight and also during the hours of darkness. The team should also experience the use of the site from other road users' perspectives. This is likely to involve walking the route and crossing roads; it may also involve riding or driving other types of vehicle through the site. It is almost always necessary to also inspect the site on foot and to observe traffic conditions and road user behaviour from the road-side.

However, some sites are relatively inaccessible and, without precautions such as road closures (which may be impracticable) these sites can only be inspected safely from within a vehicle which is moving at the prevailing traffic speed.

*Recording Findings*

Video cameras, or digital cameras and voice recorders, enable images of the site to be recorded along with a spoken commentary of issues. This is extremely useful when later collating the Assessment Team's observations and the images can also form a very informative part of the Assessment Report.

It is recommended that a full video of the site/road is recorded and that many photographs are taken during the site visit. These are important in order to provide:

- A reminder of key issues when undertaking the assessment and when writing the Assessment Report
- A record of conditions during the site visit

Taking more videos and photographs in a systematic manner will help when reviewing them later. Always start a video sequence speaking to the camera and naming the site, identifying the personnel involved, stating the date and time and by specifying direction of travel. It can also be helpful to provide a video commentary.

Photographs should be taken in a systematic manner so as to assist with subsequently identifying features and locations. For example, ensure that landmarks are included and always progress around an intersection in a clockwise direction. It may also be helpful to photograph a written card which describes the location prior to taking a sequence of photographs.

Copies of plans should also be used to record any specific features seen during the visit for later reference.

The plans and other relevant information need to be reviewed again after completion of the site visit in order to complement the site findings and to enable earlier road safety observations to be confirmed or revised.

*Community Intelligence and Consultation*

When a site visit is undertaken it can be very useful to consult with local interest groups and the wider community. This has a number of advantages:

- Intelligence can be gathered on the crashes that have occurred and any concerns the community has
- The transport and safety needs of the local community can be taken into account when developing a treatment plan
- The local community can be educated on safe use of the road

*5.3.1.6 Undertake the Assessment*

The assessment itself is the detailed review of all information collected through the review process.

The Assessment Team should remember to:

- Consider the needs of all road users (including pedestrians - especially children, pedal cyclists, and motor-cyclists)
- Be thorough and comprehensive
- Be realistic and practical
- Restrict their consideration to road safety issues
- Consider likely traffic flows, mixes and road user behaviours
- Consider the interactions of highways' features

*Use of Prompts*

Two sets of prompts have been developed for use during the assessment:

- The first set are high level road safety issues concerning the function and context of the road, who is expected to use the road and what their risks are.
- The second set of prompts provides a high level list of physical road elements that should be looked at in the site visit.

These can be found in Appendix C.

The prompts present different questions regarding the safety of all users but they are not exhaustive and should not be relied upon as the definitive extent of what needs to be examined. The prompts developed for this manual are an Aide Memoire only to ensure all items are considered by the Assessment Team. The Assessment should not be undertaken as a 'tick list' exercise.

*Conflict Studies (Optional)*

RS Assessments will often involve a specific location, such as for example an intersection, rather than a route or a larger road network. Where site specific data are limited, a conflict study involving observing, recording and evaluating 'near misses' can provide an alternative source of information about risks and likely crash patterns at sites.

The conflict study process assumes that 'near miss' conflicts are likely to be similar in nature to the smaller number of more severe crashes and that, as such, a conflict study can be used as a proxy for crash data. A conflict or encounter often involves a road user (a pedestrian, a pedal cyclist or the driver of a motorised vehicle) taking some form of evasive action. One definition of a conflict (from Ross Silcock, 1998) is: two traffic participants maintain such a course and speed that a sudden evasive manoeuvre of one of the two participants is required to avoid a crash.

Walker, Winnett, Martin and Kennedy (2005) used a similar definition of a conflict and split interactions between pedestrians and vehicles into three increasingly severe categories: encounters, conflicts and crashes. The frequency of encounters and conflicts from the Ross Silcock research was quoted and, from a total of 32,000 pedestrians observed, 5% were involved in an encounter and 0.3% were involved in a conflict. These studies can therefore add substantially to the understanding of crashes without requiring the retrospective analysis of an actual crash.

Conflict studies can be undertaken by making, and recording, observations from the road-side or by observing interactions on video. It should be noted that whilst the most common conflicts are often similar to the most common manoeuvres, this is not always the case. In some instances, movements which are less common can be disproportionately over-represented in conflicts.

Therefore, as well as identifying information about conflicts, it is also necessary to record some indicative traffic counts so as to help to understand the rate of risk exposure associated with any particular conflict.

The assessment of conflicts involves an element of subjective judgement and it is therefore important to ensure that suitably skilled personnel undertake the analysis and that it is undertaken in a consistent manner. In particular, if sites are to be compared, or ranked, on the basis of conflict studies then it is important that these studies should have been carried out by the same person.

**Table 6: Conflict classifications**

| Classification | Description | Example |
|---|---|---|
| 1 | Encounter, Precautionary action | Pedestrian stopping in carriageway to allow vehicle to pass |
| 2 | Controlled action | Pedestrian deviates from route or vehicle undertakes controlled braking |
| 3 | Near miss | Rapid deceleration, lane change or stopping |
| 4 | Very near miss | Emergency braking or violent swerve |
| 5 | Crash | Contact between two parties |

It is recommended that five classifications of conflict severity are used (Table 6).

As well as identifying the manoeuvres and the types of traffic involved in a conflict it is also necessary to consider the severities of conflicts along with the rate of exposure to risk. The study will therefore include representative traffic counts and a categorisation of each observed conflict.

Conflicts can be recorded on site using very simple sketches. These sketches record the manoeuvres and the road user types involved in each conflict, along with the frequency and the severity.

| | |
|---|---|
| Site : | Rift Valley Avenue (east of Sahara Grove) |
| Date of conflict study : | 2nd July 2014 |
| Conflict study undertaken by : | A N Assessor |

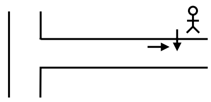
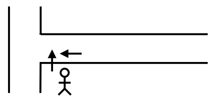
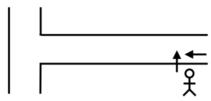
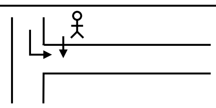
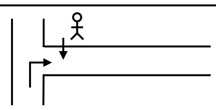
| | Conflict Severity | | | | |
|---|---|---|---|---|---|
| **Sketch of conflict** | **1** | **2** | **3** | **4** | **5** |
|  | III | III | I | | |
|  | IIII | II | | | |
|  | III | III | | | |
|  | ~~IIII~~ III | III | II | | |
|  | ~~IIII~~ | II | II | | |

**Figure 11:** **Example of a conflict study sheet for pedestrian movements**

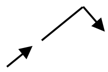
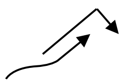
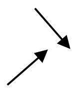
| Site : | Junction of queen's Road and King's Drive | | | | |
|---|---|---|---|---|---|
| Date of conflict study : | 2nd July 2014 | | | | |
| Conflict study undertaken by : | A N Assessor | | | | |
| | **Conflict Severity** | | | | |
| **Sketch of conflict** | **1** | **2** | **3** | **4** | **5** |
|  | ~~IIII~~ | IIII | | I | |
|  | | | II | | |
|  | ~~IIII~~ II | II | III | I | |
|  | ~~IIII~~ I | IIII | II | II | |

**Figure 12: Example of a conflict study sheet for an intersection**

*Use of Risk Assessment Matrices to Semi-Quantitatively Assess Risk*

Crashes are rare, random, multifactor occurrences and attempting to predict where the next one is going to occur is impossible. Therefore whilst it is possible to identify the nature and scale of a hazard, it is only possible to identify where a crash will occur if it is associated with an identified non-random pattern where the risk can be reduced through assessment of that pattern.

The frequency with which crashes will occur is equally difficult to predict with any precision. Nevertheless, the assessment process identifies those elements of the road environment that are hazardous to road users and it also provides an indication of the potential for a crash occurring. As such, the level of risk (i.e. the combination of likelihood and severity) can be determined.

This risk assessment process can be undertaken in a systematic manner using a risk matrix in order to produce semi qualitative risk 'values' which can enable a comparison to be made between the risks associated with different hazards at a particular site or, indeed, at different sites.

A hazard is an aspect of the road environment or the operation of the road which has the potential to cause harm. Risk is the likelihood of harm occurring. An assessment of risk will therefore involve a subjective evaluation of the likely severity and likely frequency of incidents that have been identified. This evaluation for an existing location can be assisted by conflict analysis and study of crash history.

It must therefore be recognised that although the technique can be used to produce a 'ranking', the raw information that is fed into the process is still subjective. As such, comparisons are only reasonable if the subjective assessment is made in a consistent manner (most likely by using the same Assessment Team).

The risk level is determined from Table 7.

**Table 7: Risk level**

| | Frequency/ likelihood of crash occurring | | | |
|---|---|---|---|---|
| **Severity** | **Frequent** | **Probable** | **Occasional** | **Remote** |
| Catastrophic | Very high | High | High | Medium |
| Critical | High | High | Medium | Medium |
| Marginal | High | Medium | Medium | Low |
| Negligible | Medium | Medium | Low | Low |

The subjective assessment as to the likelihood of a crash occurring (i.e. how often the hazard will cause or contribute to a crash) is determined using Table 8.

**Table 8: Crash likelihood**

| Frequency of occurrence | Equivalent crash frequency |
|---|---|
| Frequent | More than once per year |
| Probable | Once every 1 to 3 years |
| Occasional | Once every 3 to 10 years |
| Remote | Less than once in 10 years |

The severity of a hazard is determined from a subjective assessment of the most likely outcome in the event that the hazard causes or contributes to a crash.

Clearly, any type of crash could potentially result in a fatality and it is therefore important to consider the most typical or plausible outcome rather than the worst possible outcome (because the worst possible outcome would always be catastrophic).

Table 9 can be used for assessing the hazard severity

**Table 9: Hazard severity**

| Severity of outcome | Equivalent crash outcome |
|---|---|
| Catastrophic | Results in at least one fatality (fatal) |
| Critical | Results in at least one serious casualty (serious) |
| Marginal | Results in at least one slight casualty (slight) |
| Negligible | Damage-only crash |

It is notable that the process does have some resilience to assessments being made on the basis of more, or less, serious crashes rather than the typical or most likely outcome.

For example, a risk might be assessed as: Probable x Marginal = Medium Risk. If, instead, the Assessor tended to be consider the likelihood of a more serious crash occurring then the assessment might be Occasional x Critical = Medium Risk. That is, because a worse outcome is likely to occur less often, the same level of risk is assessed for this particular hazard.

*5.3.1.7 Recommend Measures*

Each problem identified in the assessment will have one (or more) possible solutions that could reduce both the risk and hazard. For each segment of road, countermeasure options are 'tested' for their potential to reduce deaths and injuries. For example, a section of road that has poor pedestrian provision and high pedestrian activity might be a candidate for a footpath or pedestrian crossing facility. Similarly, where there are numerous roadside obstacles in combination with surprising or poor quality bends, clearing roadside obstacles or installing a vehicle restraint system may be considered.

A list of potential treatments relevant to different crashes is given in Appendix A. It provides high-level, indicative, guidance as to the type of safety improvement measures which might be appropriate in certain circumstances.

The Safe System approach involves recognising that people are fallible and that, because mistakes do happen, it is necessary to engineer the road system in such a way that the consequences of a mistake are of low severity. This could involve, for example, providing a suitable form of vehicle restraint system to prevent an errant vehicle from leaving the road and striking a fixed object (such as a tree or lighting column).

A safety improvement could also involve reducing speeds so as to reduce the kinetic energy associated with a crash and, thereby, reducing the severity. This type of measure is also likely to reduce the likelihood of the loss of control occurring in the first place and, also, increase the likelihood of the crash being avoided if a loss of control does occur.

*5.3.1.8 Write the Assessment Report*

The Assessment Report provides a concise written record to identify safety problems and actions that need to be taken to improve safety. The report provides the formal documentation on which decisions about corrective action will be based.

A formal Assessment Report should be completed for all assessments that are undertaken. Copies of this should be retained by both the Assessment Team and the head of the relevant Road Authority so as to form a verifiable audit trail.

For all RS Assessment Reports, the same layout will be used:

- A brief background description
  - Assessment Team Members as well as the names and affiliations of other contributors to the assessment
  - Details of who was present at the site visit/s, when it was undertaken and what the conditions were on the day of the visit (weather, traffic, etc.)
  - The findings of any crash data analyses/RSIs undertaken that prompted the RS Assessment

- Issues and Recommendations (note some organisations prefer this to be tabulated to allow responses to be added):
  - An A3 or A4 location map marked up with references relating to the issues identified
  - Each specific road safety problem identified separately, supported with reasoning, stating:
    - The location of the problem
    - The nature of the problem
    - The type of crash that is likely to occur (or has already occurred) as a result of the issue
    - Where available, illustrative photograph(s)
    - Where appropriate (and/or required) details of any conflict study findings
    - The assessed risk level (obtained by use of risk matrices and as described in Section 5.3.1.6)

  - Recommendations for action to mitigate or remove the issue

- A list of the documents considered for the assessment
- Analysis of any operational data available along with issues identified during observations of traffic using the site.

A sample report is included in Appendix D.

*5.3.1.9 Feedback*

On completion of the Assessment Report the RSI Manager and RS Assessor will give feedback to the RSI Team and recommendations will be taken forward into the development of a Treatment Plan as described in Section 5.4. This feedback will include a review of the types of features identified and whether any additional hazards have been identified through the detailed assessment that could be identified using RSI in the future. This will enable the RSI Team to improve the performance of their duties.

## 5.4 Development of a Treatment Plan

Treatment plans are a prioritised list of countermeasures that are estimated to offer cost effective improvements to reduce risk.

The Assessment Team will need to take the findings and recommended treatments from the RS Assessment and develop a treatment plan that can be implemented over a defined period of time. Before undertaking RSIs and subsequent RS Assessments it is necessary to ensure that a budget is in place to implement recommended treatments.

It will rarely be possible to implement all possible treatments and so it will be necessary for the Assessment Team to prioritise a programme of treatments. One way of doing this will be through Economic Appraisal (Section 5.4.1) to ensure that the best impact is achieved for the investment.

It should be noted that there will be some recommendations that can be put into a dedicated schedule of safety improvements. Others may require immediate action. Further treatments may be more suited to incorporation into maintenance activities at little, or no, additional cost.

Typically, minor modifications to improving the road environment through signing and lining can be implemented fairly easily, whilst even modest changes such as implementing guardrail or vehicle restraint systems need a specific budget allocation. More major interventions such as junction widening, control or pedestrian provision may even require additional design before appropriate measures can be fully implemented. However, the scale of work and potential benefit needs to be assessed in order to determine a list of priority schemes to fit any budget allocation.

### 5.4.1 Economic Appraisal

Economic Appraisal (EA) should be performed for all proposed treatments and is a means of prioritising a treatment programme.

Economic Appraisal is the formal estimation of the potential benefits of implementing a specific measure or scheme, usually in terms of the expected longer-term financial return on the initial investment, versus the costs. EA is a key method to help engineers make decisions on which schemes should be implemented when budgets are constrained since it provides a reasonably objective measure of expected performance that can be compared between schemes. It will therefore help staff make decisions on which measures should be implemented.

There are several techniques that can be used, from the more complex full Cost Benefit Analysis (CBA) which requires an extensive set of supporting information and parameters, to more straightforward techniques that include First Year Rate of Returns (FYRR) and Cost Effectiveness (CE). If there are limited crash data available and no accepted crash costing values in a country then it may be necessary to rely on CE calculations. It should be noted that EA is a rule of thumb method which should be done as well as practically possible and the results of EA are seldom used as the sole justification for making a decision on whether to fund a scheme.

For all of the methods, it is necessary to estimate the number of relevant crashes and estimate the potential effectiveness of treatments. These are described in the sections that follow.

*5.4.1.1 Estimating Crashes*

Normally EA is applied on treatment plans developed as a result of reactive approaches such as blackspot analysis and treatment where the number of crashes and casualties is known. When EA is used to assess and prioritise treatments as a result of proactive approaches in the absence of detailed crash data, crash numbers on a stretch of road first need to be estimated. In many HICs Accident Prediction Models are applied, however these still require very good crash data for proper calibration and their transferability to different countries and situations is difficult to justify.

It should be noted that this is another reason why it is extremely important to improve the quality and accuracy of crash data (see Existing Roads – Reactive Approaches manual Section 4). Without crash data any economic appraisal can only be a very basic estimate. If crash data are available, this will much improve the accuracy of the EA.

The first step is to calculate the average number of crashes per kilometre across the road network. If this can also be done by crash type this would be a significant advantage (e.g. number of pedestrian/cyclist, head-on, run-off and intersection crashes per km). For intersection crashes, if the number of intersections is known then this could provide an average number of crashes per intersection.

Since traffic flow is considered to be the most important predictor of crash numbers (this is the major factor used in Accident Prediction Modelling), any information on traffic flows (whether this is actual traffic flows or a considered estimate) can be useful in providing a very crude estimate of the number of fatal and/or serious crashes expected on a section.

If traffic flows need to be estimated then it is suggested that these are banded into low, medium and high based on engineering judgement and knowledge of the road network. For low volume roads, it is suggested that the average crash rate per km could be divided by 2, for high volume roads the same figure could be multiplied by 2.

So for example

- The average number of fatal, serious or slight injury run-off road crashes per kilometre per year across the network is 1.75
- The section in question is 3km in length and is considered to have a high traffic volume (if precise traffic volumes are known then a more sophisticated method can be adopted)
- Then it would be anticipated that 1.75 (run off crashes per km) * 3 (3 kms length) * 2 (factor of two to reflect high traffic volume) = 10.5 fatal, serious or slight run-off crashes would occur on the road section.

If required, the number of crashes can then be multiplied by a factor to estimate the number of casualties (since, on average, more than one casualty will be involved in each crash). This factor can be derived from dividing the number of causalities by the number of crashes nationally. If there are 11,000 fatal, serious or slight crashes every year and 15,500 fatal, serious or slight casualties, the factor would be 1.41 (15,500/11,000). So on the 3km stretch, 14.8 fatal, serious or slight casualties would be expected.

If it has been possible to estimate the number of crashes resulting from a particular crash type (e.g. pedestrian crashes or run-off crashes) then these can be used to get a feel for the number of crashes that might be eliminated by targeted treatments designed to solve particular crash type issues. The effectiveness of treatments can then be used to determine how many crashes or casualties might be saved.

*5.4.1.2 Effectiveness of Treatments*

Countries which have been performing road safety management and evaluation for many years may have gathered evidence on the effectiveness of treatments. In this case it is beneficial to use local evidence concerning the likely effectiveness of a treatment. However, the availability of such information in Africa is likely to be somewhat limited. Instead it is necessary to use information about the effectiveness of treatments from other regions of the world and apply road safety engineering judgement and experience when considering the likely impact in the African context.

One significant benefit to improving the quality and analysis of crash data is that it will become possible to evaluate the impact of treatments in the African context. Building a regional resource containing evidence on the impact of treatments should be considered a priority. Sharing such results will allow a significant evidence base to be built relatively quickly. Section 6.2 provides guidance on simple approaches to evaluation that can be used to start to build an evidence base.

There are several international sources on the likely effectiveness of treatments. The first source that can be consulted is the iRAP Road Safety Toolkit (toolkit.irap.org). The iRAP Toolkit compiles best practice information on road safety treatments from across the world. In the toolkit there is information about the effectiveness of a treatment, relative cost, implementation issues and references to sources that provide more detail. Some information within the iRAP Toolkit is contained in Appendix A.

A further source that can be consulted is 'The Handbook of Road Safety Measures' (second edition) (Elvik, Vaa, Hoye, and Sorensen, 2009). This source compiles similar information in greater detail.

In the example used in the estimating crashes section, 10.5 fatal, serious or slight crashes are expected on a 3km section in a given year. If installing a VRS has an effectiveness of 40-60% in reducing run-off crashes (see iRAP toolkit), then a conservative estimate is that 40% of the 10.5 crashes would be saved per year = 4.2.

*5.4.1.3 Economic Appraisal Methods*

*Full Cost Benefit Analysis*

Full Cost Benefit Analysis (CBA) is an extremely demanding task to perform properly. It requires all significant monetised costs and benefits to be assessed typically over a scheme's lifetime. It should include annual maintenance costs, all environmental and social impacts; all costs need to be moved into a single base year value and GDP growth across the assessment period needs to be taken into account. It is an in-depth process that can require significant effort and so is not be suited to smaller schemes.

To do full CBA, the following information is generally required:

- To calculate costs:
  - Treatment implementation cost
  - Approximate annual maintenance costs
  - Treatment lifespan
- To calculate benefits
  - Treatment effectiveness
  - Treatment lifespan
  - Value of a life, serious injury, slight injury and damage only crash
- Standard official inflator factors/GDP growth factors/Discount rates.

These items are then used to calculate a Net Present Value (NPV).

ROSPA (1995) suggests that in some cases it may be advisable to carry out an evaluation which expresses the difference between costs and benefits that may accrue over several years (e.g. if the installation covers more than one year and there are known to be inevitable new maintenance costs in future years. The accrual needs to be against a common year price base.

In the NPV approach there is a need to take account of money having a changing value over time because of the opportunity to earn interest or the cost of paying interest on borrowed capital.

The major factors determining present value are the timing of the expenditure and the discount (interest rate). The higher the discount rate, the lower the present value of expenditure at a specified time in the future. If the discount rate for highways is 6% then $1 of value this year, if it accrues next year would be valued at 6% less (i.e. 94 cents and the following year 88 cents etc.).

The overall economic effectiveness of a scheme is indicated by the NPV, which is obtained by subtracting the Present Value of Costs (PVC, which must also be discounted if spread over more than one year) from the Present Value of Benefits (PVB).

*First Year Rate of Returns*

First Year Rate of Returns (FYRR) is commonly used for appraising low cost schemes. In this method crash costings are required along with estimated treatment costs and crash savings.

The simplest FYRR will be estimated as the number of crashes in the 12 months before installation minus the predicted number of crashes in the 12 months after installation multiplied by the average cost of a crash. This is then divided by the total scheme costs and then multiplied by 100 to give a percentage.

The formula is:

$$100 * \left( \frac{((\text{crashes in year before} - \text{crashes in year after}) * \text{average cost per crash})}{\text{Total cost of the scheme}} \right)$$

An example of a treatment plan ranked according to a FYRR EA is provided at the end of Appendix D.

*Cost Effectiveness*

The simplest method for carrying out EA is called 'Cost Effectiveness' (CE). In CE the cost that needs to be expended for each crash saved in alternative and competing schemes is estimated to help with the prioritisation of investments.

Care must be taken when assessing the likely effectiveness of treatments since these are unlikely to be additive. In some cases, calculations have been seen where the estimated effectiveness of several treatments is greater than 100%. This is clearly not possible. Road safety engineering judgement needs to be applied in combining the likely effectiveness of treatments.

The main parameters required are:

- The number of crashes per year
- The estimated effectiveness of each scheme as an expected reduction in crashes after implementation
- The total estimated cost of the proposed schemes

To calculate the CE for each section the total scheme cost is divided by the number of crashes saved per year in the after period. It is important to use the number of 'relevant' crashes in the calculation – i.e. those which will be impacted by a measure. For example, if there are 10 crashes per year assumed in a section being assessed, 3 of which occurred in day time and 7 at night time. If the proposed measure is to put in street lighting, this measure cannot be expected to reduce the 3 daytime crashes, so the relevant number of crashes is 7 rather than the total.

Using the same example as described earlier in the estimating crashes and effectiveness of treatments sections, the following calculation can be performed.

- Number of relevant crashes per year .................... 10.5
- Expected reduction or measure effectiveness.................... 40%
- Expected saved crashes per year .................... 4.2
- Cost of measure.................... $40,000
- Cost Effectiveness is.................... $9,524 (40,000/4.2)

This gives a value which represents the cost required to save a single crash for each proposed scheme. The potential schemes can be ranked by the calculated CEs in descending order and those schemes with the smallest values should be implemented preferentially.

This method does not require crash cost estimates, although estimates of the effectiveness of treatments are required. Disadvantages include that the approach does not take into account crash severity. Clearly this does require an estimate of the number of crashes, and in some countries this can be difficult to achieve.

An example of a treatment plan ranked according to a CE EA is provided at the end of Appendix D.

### 5.4.2 Implementing a Treatment Plan

Once a treatment plan has been devised and prioritised, implementation should follow. Where there are major changes to a site, section or road, these should be subjected to Road Safety Audit (see New Roads and Schemes – Road Safety Audit Manual.

**All road safety treatments should be subjected to Monitoring and Evaluation (see Section 6 of this manual) as an integral part of implementation**

# 6. Monitoring and Evaluation

Monitoring and evaluating the impact of treatments is critical to refining and improving the treatment of high-risk locations or sections over time. Building an evidence base on the effectiveness of treatments under different conditions in the African context is particularly important. Ideally such evidence will be shared among similar countries through a road safety observatory or through collaborative initiatives.

Reliable crash data are required for formal evaluation.

## 6.1 Monitoring

Monitoring is the operational checking that a scheme is performing as expected. This may involve site visits to physically monitor the site to ensure road users understand the change and also the review and analysis of crash data.

Crash occurrences should be reviewed after six weeks, a year and three years. Statistical methods can be applied after one and three years of data have accumulated, though statistical significance would rarely be reached using just one year of 'after' data

## 6.2 Evaluation

Evaluation is a formal process to check the impact of a treatment/combination of treatments on crash and casualty numbers. It is used by practitioners to understand what has worked, and what has not. It is a vital part of effective road safety management because intelligence on the impact of treatments under different conditions is important if limited resources are to be spent in the most effective manner possible.

Evaluation is rarely done, and if it is done it is often not done as well as it could be. Simply comparing the number of crashes in a time period before and after treatment can be very misleading due to random statistical fluctuations and 'regression to the mean'.

Empirical Bayes method is often recommended for undertaking before and after studies (see OECD, 2012) though it is rarely used because of its complexity.

The three most commonly used statistical approaches to structure before/after testing are the 'Naïve', the 'Yoked Site/Comparator' and the 'Unpaired Site/Comparator' methods. All of these require crash data. These are summarised as follows:

- The naive before/after method is largely discredited because it fails to take into account any external potentially confounding issues. The crashes before the treatment are compared simply with the crashes in the after period. The results from this method are likely to be very inaccurate since no account of any longer-term trends is taken.
- For the yoked site/comparator method, treated sites are paired (individually) with similar but untreated sites for the analysis. Thus the number of crashes in the after period needs to be reduced signifi-

cantly when compared with any reductions observed at the comparator. This method takes account of some confounding effects, though it does not take account of regression to the mean [2]. It is technically difficult to identify suitable untreated comparator sites since often all sites with a particular problem will be treated in a programme.

- In the unpaired site/comparator method, the analysis is similar to the yoked design; however the comparator does not need to be similar to the site in its features. It does however need to be significantly larger than the site with many more crashes in it. It is much easier to identify the required comparators for this method.

(adapted from ITE, 2009).

Generally the chi-squared (X2) test has been used to assess whether the after crashes have changed significantly. This is a very easy test to perform which does not require any assumptions to be made about the underlying statistical distribution of the data.

These tests have all been widely used for road safety analyses and are still being taught to engineers on road safety courses around the world. None of them address regression to the mean but the site/comparator approaches do take some account of other potentially confounding issues.

Given the balance between performance, rigour and ease, the unpaired site comparator method is clearly the best methodology to use. This method is commonly used with the chi-squared statistical test.

Further guidance can be found in the example evaluation calculations found in Appendix E.

2 The regression-to-the-mean effect is the statistical phenomenon that roads with a high number of crashes in a particular period are likely to have fewer during the following period, even if no measures are taken; this is just because of random fluctuations in crash numbers.

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# Glossary

**Access:** Drive-ways, small private roads or car parks that intersect with a public road.

**Area Analysis:** Reactive analysis technique that aims to determine crash themes within geographic areas, and determine the main crash causes for high risk areas.

**Assessment Brief:** Information about the scope and details of an RS Assessment.

**Blackspot Analysis:** Reactive analysis technique that aims to identify high risk locations across the road network. Sometimes known as hazardous locations, hotspots or clusters.

**Client:** The organisation or person that commissions the Audit, Assessment or Inspection. The Client organisation typically either owns or manages the road.

**Continuing Professional Development (CPD):** Attendance of courses, lectures, workshops and any other training opportunities that will serve to ensure knowledge is current.

**Crash:** A rare, random, multifactor event in which one or more road users fails to cope with their environment, and collide with each other or an object. This includes crashes resulting in casualties or those that are damage-only.

**Crash Data:** Information about a crash normally collected by the Police and recorded in a systematic manner.

**Crossfall:** The surface of a road or footpath sloping to one side only.

**Damage-Only Crash:** A crash where there are no injured or killed casualties.

**Delineation:** Road lining treatments and other measures to indicate the path of traffic lanes. Can include marker posts and reflective road studs etc.

**Divided Road:** Road with two carriageways, divided by a built median or VRS.

**Duplication:** Building of a second carriageway to create a divided road.

**Dynamic Risk Assessment:** A continuous process of identifying risk, assessing, and coming up with a way to reduce or eliminate such risk.

**Errant Vehicle:** A vehicle that strays or deviates from its regular or proper course.

**Fatal Crash:** A crash where at least one person died as a result. Ideally the medical progress of seriously injured persons is followed for up to 30 days, however, in many countries only deaths at the scene are considered.

**Forward Visibility:** The clear distance that can be seen ahead.

**Gateway Treatment:** A combination of treatments used to highlight a transition (change in road or speed limit). These are normally used on the approach to urban areas or villages.

**Global Positioning System (GPS):** A space-based satellite navigation system that provides location and time information in all weather conditions, anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites.

**Grade Separation:** A free-flowing junction where turning movements are completed at different levels.

**Hazard:** An aspect of the road environment or the operation of the road which has the potential to cause harm. Risk is the likelihood of harm occurring.

**Head-On Crash:** Crash between two vehicles travelling in opposing directions.

**Health and Safety:** Activities or processes that focus on the prevention of death, injury and ill health to those at work, and those affected by work activities.

**Health and Safety Risk Assessment:** The process of assessing health and safety risks and assigning measures to mitigate against the risks.

**Horizontal Realignment:** Change in road direction/path in a horizontal plane. Usually straightening to reduce the severity of bends.

**Inspection Brief:** Information about the scope and details of an RSI.

**Inspection Form:** Standardised form for the recording of road feature information.

**International Road Assessment Programme (iRAP):** A charitable organisation with a mission to reduce the number of high risk roads in the world. iRAP can also be used to refer to the road inspection technique developed by the charity.

**Intersection Crash:** Crash that occurs at an intersection/junction.

**Kerb:** Stone or concrete edging to a pavement or a raised path.

**Kinetic Energy:** The energy an object possesses due to its motion.

**Lane Change Crash:** Crash occurring when a vehicle changes lane and strikes another.

**Latitude and Longitude:** A geographic coordinate system for specifying a specific location on the surface of the earth.

**Maintenance Inspection:** A routine, scheduled inspection of a road concerned with identifying defects which require repair, such as potholes or damaged signs.

**Manoeuvring Crash:** Crash that occurs when a vehicle is entering or leaving the carriageway, making turns (other than at intersections) or parking.

**Median:** The median is the area of the road that divides opposing traffic. It may be painted, planted, raised or contain a VRS.

**Merge Diverge Intersection:** T-junction where vehicles where vehicles can only leave or join adjacent traffic stream. Crossing movements are prohibited.

**Nearside:** Side of the road nearest to the verge or footpath. The outer edge.

**Offside:** Side of the road nearest to the centreline or median.

**Pedestrian Refuge Island:** A kerbed area in the middle of the roadway designed to protect pedestrians when crossing more than one lane. It also simplifies crossing movements for pedestrians.

**Personal Protective Equipment (PPE):** Workwear such as hard hats, steel toe-cap boots or reflective clothing which is provided to safety assessors, auditors, and inspectors or others who attend a road site.

**Proactive Approaches:** Techniques that use 'known relationships' between road characteristics and crashes to identify and treat priorities across the road network.

**Reactive Approaches:** Techniques that use crash history data and other intelligence to identify and treat priorities across the road network.

**Retro-Reflectivity:** Optical phenomenon in which reflected rays of light are preferentially returned in certain directions. If you shine a light on retro-reflective materials they will appear to shine or glow in the dark.

**Right-Angle Crash:** Crash between two vehicles where one is struck at right angles by the other.

**Road Authority:** The authority ultimately responsible for the operation and maintenance of the road. The Road Authority is often also the Client.

**Road Safety Assessment (RS Assessment):** An intensive expert assessment of the safety of an existing road.

**RS Assessment Prompts:** An aide memoire for use in Road Safety Assessment to ensure that the main road safety issues have been considered and that each physical element of the road has been considered.

**Road Safety Assessor:** Individual that undertakes RS Assessment.

**Road Safety Audit (RSA):** A RSA is a formal systematic process for the examination of new road projects or existing roads by an independent and qualified audit team, in order to detect any defects likely to result in a crash or contribute to increased crash severity.

**Road Safety Auditor:** Individual that undertakes Road Safety Audit.

**Road Safety Engineering:** The design and implementation of physical changes to the road network intended to reduce the number and severity of crashes involving road users, drawing on the results of crash investigations.

**Road Safety Inspection (RSI):** The inspection of an existing road with the objective of identifying aspects of the road, or the road environment, which contribute to safety risk and where safety can be improved by modifying the environment.

**Road Safety Inspection (RSI) Manager:** A person that oversees the RSI process.

**Road Safety Inspector:** A person who undertakes a routine survey-type safety inspection and who gathers data which is used to identify risk factors.

**Road Users:** All persons located within the road reserve irrespective of the purpose of their trip or mode of transport. They include the visually and mobility impaired (i.e. wheel chair users).

**Route/Corridor Analysis:** A reactive analysis technique that aims to identify high risk sections across the road network.

**Run-Off Crash:** A crash involving an errant vehicle that leaves the carriageway.

**Safe System:** The Safe System aims to develop a road transport system that is able to accommodate human error and takes into consideration the vulnerability of the human body.

**Severe/Serious Crash:** A crash in which one or more person is seriously injured, but where no-one dies. A serious injury is where a casualty is hospitalised overnight or suffers life threatening injuries.

**Shoulder:** Area beyond the running lane that is also surfaced. A shoulder can be unsealed (no carriageway surfacing) or sealed.

**Side-Swipe Crash:** A side impact between two vehicles at less than 90 degrees.

**Sight Distance:** See forward visibility.

**Skid Resistance:** The ‘slippiness’ of a road due to the surface texture.

**Slight Crash:** A crash in which one or more person is slightly injured, but where no-one is seriously injured or dies. A slight injury is where a casualty suffers bruising or bleeding and only minor medical assistance is required for treatment.

**T-Intersection:** An intersection or junction where one road intersects with another at right angles.

**Temporary Traffic Management:** The arrangement of temporary sign, markings and other devices to guide all road users safely through road works, whilst also ensuring the protection of works personnel.

**Traffic Calming:** Vertical, horizontal or psychological features installed on a road to control vehicle speeds.

**Traffic Flow Data:** Numerical information on traffic movements.

**Treatment Programme:** A programme of safety improvement works that are undertaken in response to a safety assessment.

**Turning Pocket:** Non-continuous traffic lane on the approach to an intersection/junction providing space for traffic turning across the intersection out of the path of through traffic.

**Two-Wheeled Users:** Pedal cyclists or motorcyclists.

**Vehicle Restraint System (VRS):** Safety barrier (or crash barrier) designed to contain a vehicle if struck.
**Vertical Realignment:** Change in road direction/path in a vertical plane. Usually flattening the road to remove dips and humps.

**Vulnerable Road User (VRU):** Someone with little or no external protection, or has reduced task capabilities, or reduced stamina/physical capabilities. They include pedestrians (including people with visual or mobility impairments, young children, older people), pedal cyclists, and wheelchair users. They may also include motorcyclists.

**Vulnerable Road User (VRU) Crash:** Crash involving one or more VRUs (normally pedestrians and pedal cyclists only).

**X-Intersection:** An intersection or junction where two roads cross.

# Appendix A : Typical Road Safety Solutions

This section of the manual is intended to provide guidance as to the types of engineering measures which might be effective as safety improvements in different circumstances and in response to different types of collision. They should be applied with great care as their appropriateness is dependent upon particular local circumstances.

**Engineers should consider carefully the local conditions under which any of these potential measures will operate before applying a particular solution.**

Table 10 provides information about each treatment [3] Note that although a treatment may have a positive impact on one crash type, there may be negative consequences for other crash types and road users. For instance, the duplication of carriageways to reduce head on crashes can result in an increase in pedestrian risk and potentially higher speed lane change crashes.

**Table 10 : Treatment information**

| Treatment | Cost | Benefits | Implementation Issues |
|---|---|---|---|
| **Additional Lane**  | High | Reduced risk of overtaking crashes.<br><br>Improved traffic flow. | The start and end points of additional lanes must be designed carefully. For example, sight distance must be suitable for the speed of traffic.<br><br>Signs telling drivers when an overtaking lane is ahead will reduce the likelihood of them overtaking in less safe areas.<br><br>Overtaking lanes should not be installed at sites which include significant intersections or many access points.<br><br>Vehicles travelling in the opposite direction to the overtaking lane must be prevented or discouraged from also using this lane.<br><br>Physical barriers may be required. |

3 The material is based on the information provided in the iRAP Road Safety Toolkit (http://toolkit.irap.org/) with the permission of iRAP

| Treatment | Cost | Benefits | Implementation Issues |
|---|---|---|---|
| **Central Hatching**<br> | Low | Fewer head-on and overtaking crashes.<br><br>Can provide refuge for turning vehicles away from through traffic lanes.<br><br>Some reduction in speeds. Possible (though limited) protection for pedestrians. | If rumble strips, or other raised pavement devices are also used, the risk to motorcycles and pedestrians (trip hazard) must be considered.<br><br>Can be used for opportunist overtaking opportunities increasing risk of collisions.<br><br>Maintenance of markings. |
| **Central Turning Lane**<br> | Low | Improved traffic flow.<br><br>Some reduction in speeds. | To be used only in areas with a high concentration of intersections/accesses.<br><br>Two way turning lanes should not be used at intersections.<br><br>Appropriate pedestrian protection should be used in areas with pedestrian activity.<br><br>Two way turning lanes can encourage inappropriate development along the road, so they are best used as a solution for existing roads where more advanced access controls are not possible.<br><br>Priority/usage should be clearly marked to avoid head-on crashes. |
| **Delineation** (includes lining, signing, marker posts etc.)<br> | Low | Road markings are very cost effective. Delineation improvements have been shown to reduce head-on road crashes. | In many countries line-marking is ignored (and physical barriers to crossing the centre line are needed).<br><br>Poorly designed or located delineators can add to crash risk.<br><br>Too many signs can confuse drivers. |

| Treatment | Cost | Benefits | Implementation Issues |
|---|---|---|---|
| | Low | Helps drivers to maintain a safe and consistent lateral vehicle position within the lane.<br><br>Reduction in night-time and low-visibility crashes. | Road studs require a good quality road surface.<br><br>Delineation needs to be consistent throughout an entire country.<br><br>The retro-reflectivity of lines and signs is an important consideration for road use at night and in the wet.<br><br>Maintenance of markings. |
| **Duplication** (changing a single carriageway road into a dual carriageway road)  | High | Separation of the opposing traffic flows, and therefore reduced head-on crashes.<br><br>Simpler traffic movements leading to less opportunity for conflict.<br><br>Redirection of turning movements to safer locations.<br>Protection for turning traffic.<br>Reduced traffic congestion. | This treatment is costly, and other lower cost treatments (such as median barrier installation) should also be considered.<br><br>Requires a large amount of land.<br><br>Potential to increase pedestrian and lane change crashes.<br><br>Community acceptance of the medians that restrict turning movements or restrict pedestrian movements may be an issue. |
| **Grade Separation**  | High | Improved traffic flow.<br><br>Simplifies potentially complex movements typical at 'T' and 'X' intersections. | A range of design options should be considered before a grade separated interchange layout is chosen.<br><br>Adding on-ramps and off-ramps to a freeway can increase high speed weaving and merging crashes.<br><br>Interchanges can negatively impact the appearance of an area. |

| Treatment | Cost | Benefits | Implementation Issues |
|---|---|---|---|
| | | Can also include roundabouts for high traffic flows.<br><br>Removes the cost of running at-grade traffic control hardware. | They may separate communities due to their size.<br><br>Difficult for pedestrians unless specific routes are provided.<br><br>Grade separating rail crossings can involve vertical realignment of a long length of rail track (because trains cannot travel on steep grades), which is very costly. |
| **Horizontal Realignment**<br> | High | Better traffic flow.<br><br>Horizontal realignments often include lane widening, shoulder improvement, and delineation treatments. | Road realignment is costly and time consuming because it usually involves rebuilding a section of road.<br><br>Horizontal curve realignments require considerable design and construction effort. These projects may also require the purchase of land. |
| **Inter-Visibility Improvement - Sight Distance**<br><br> | Low to med. | Adequate sight distance provides time for drivers to identify hazards and take action to avoid them.<br><br>Improved sight distances on the approaches to intersections and through curves can reduce crashes at these high-risk locations. | Sight distance improvement can be high cost if crest and/or curve realignments are required or if the line of sight is outside the road reserve requiring land acquisition to remove obstructions such as embankments, buildings etc.<br><br>In some situations such as intersection approaches, excessive forward visibility can lead to high speeds on approach and take attention away from the intersection.<br><br>In very specific cases, adjustments to reduce sight distances can be helpful in reducing approach speeds. Particular care must be exercised when taking this approach. |

| Treatment | Cost | Benefits | Implementation Issues |
|---|---|---|---|
| | | Good forward visibility at pedestrian crossing facilities will give drivers more time to react.<br><br>Rear end collisions can be reduced with improved forward visibility. | At intersections sight lines and visibility splays are often required at larger angles to the user's normal view point (for example, in a motor vehicle the driver may have to look through the side windows).<br><br>Ensure traffic signs and signal heads are not obstructed by vegetation or street furniture. |
| **Lane Widening**<br> | Med. to high | Additional manoeuvring space.<br><br>Space for two wheeled users. | Lane widening can be costly, especially if land must be purchased.<br><br>Making lanes wider than 3.6 metres does little to reduce crashes. A lane that is too wide might be used as two lanes and this can increase sideswipe crashes.<br><br>Because vehicle speeds increase when roads are widened, lanes should be widened only when it is known that the narrow lane width is causing crashes. |
| **Median Crossing Control**<br> | Low to med. | Reduction in intersection crash types.<br><br>Improves local access.<br><br>Provides an additional emergency access point leading to improved emergency service response times. | Additional road space may be required.<br><br>If the median crossing is used to access a side road, then intersection considerations for cross movements (such as visibility and stopping distance) will apply.<br><br>Roadside hazards need to be removed or sufficiently protected.<br><br>Drainage structures and steep slopes within the median can increase risk. The slopes should be as flat as possible. If the slope cannot be made traversable, it should be protected by safety barrier. |

| Treatment | Cost | Benefits | Implementation Issues |
|---|---|---|---|
| **Median Shoulder Sealing**<br> | Med | Wider shoulders provide opportunity for an errant vehicle to be recovered. | Shoulder widening and shoulder sealing can be done at the same time to reduce costs.<br><br>Edge-lining can be improved at the time of upgrading the shoulder (especially when sealing).<br><br>Shoulders should not be too wide or drivers may use them as an additional lane.<br><br>Sealing can reduce 'edge drop' (where there is a difference between the height of the road surface and the height of the shoulder). Edge drop can make it harder for vehicles which have left the road to get back onto the road. |
| **Median Vehicle Restraint System** (VRS) (Safety Barrier)<br> | Med. to high | Reduced incidence of head-on crashes.<br><br>Can help to prevent dangerous overtaking manoeuvres.<br><br>Can relocate turning movements to safer locations. | Median barriers can restrict traffic flow if a vehicle breaks down, and can block access for emergency vehicles.<br><br>Pedestrians are often reluctant to make detours and may attempt to cross median.<br><br>In some regions the materials used in median barriers may be at risk of being stolen.<br><br>The ends of median barriers must be well designed and installed.<br><br>Clearly visible signs and enforcement are needed to ensure that drivers do not drive on the wrong side of the median. Not all barrier types will adequately restrain all vehicle types.<br><br>Barriers may be a hazard to motorcyclists. |
| **One-Way System**<br> | Med. | Reduces head on collisions.<br><br>Improves traffic flow. | Because speeds can increase on one-way networks, traffic calming measures may be required (especially if the lanes are wide).<br><br>Before a network is made one-way, traffic circulation in the area surroun |

| Treatment | Cost | Benefits | Implementation Issues |
|---|---|---|---|
| | | | ding the network must be considered.<br><br>Converting a network to one-way can be costly as it may involve rebuilding traffic signals, repainting line-marking and replacing and adding signage. |
| **Parking Control**<br> | Low to Med. | Converting angle parking to parallel parking provides extra road space.<br><br>Banning parking lessens the potential for sideswipe or rear-end crashes. | Parking at the side of a road means pedestrian activity is inevitable. Therefore speed limits should not exceed 50km/h where parking is provided.<br><br>Converting angle parking to parallel parking requires replacement of line marking. Changes to parking signs and kerbs may also be necessary.<br><br>The community and business owners often object to the removal of parking in commercial centres.<br><br>Parked cars can obscure crossing pedestrians, particularly children. |
| **Pedestrian Crossing - Unsignalised**<br><br> | Low | A clearly defined crossing point where pedestrians are 'expected' to cross.<br><br>Disruption to traffic flow is comparatively low.<br><br>Reduced pedestrian crashes if installed at appropriate locations, and if pedestrian | Un-signalised crossings – Not suitable where traffic volumes or speeds are high.<br><br>Signalised crossings – Compliance with signals must be good if significant casualty reductions are to be achieved.<br><br>Pedestrians will only use crossings located at, or very near, to where they want to cross. Pedestrian fencing can be used to encourage use of pedestrian crossings.<br><br>Consider incorporating a pedestrian refuge island.<br><br>Through-traffic must be able to see pedestrian crossing points in time to stop. Advance warning signs should be used if visibility is poor. Other high visibi |

| Treatment | Cost | Benefits | Implementation Issues |
|---|---|---|---|
| | | priority is enforced. | lity devices (such as flashing lights) may also be used. |
| **Pedestrian Crossing - Signalised**<br> | Med. | A clearly defined crossing point where pedestrians are 'expected' to cross.<br><br>Reduced pedestrian crashes if installed at appropriate locations, and if pedestrian priority is enforced. | Parking should be removed/prohibited from near pedestrian crossings to provide adequate sight distance.<br><br>Crossing will only be effective if other road users give way to pedestrians. Education and enforcement may be necessary to ensure pedestrians have priority. |
| **Pedestrian Fencing**<br><br> | Low | Helps to guide pedestrians to formal crossing points. Can help to prevent unwanted pedestrian crossing movements.<br><br>Physically prevents pedestrian access to the carriageway. Can help to prevent motorists from parking on the footpath.<br><br>Provides useful guidance for visually impaired pedestrians. | It is important that pedestrian fencing does not obstruct the drivers' view of pedestrians on the footpath, or those about to cross the road.<br><br>The fence height, placement and construction material should be selected to minimise any potential sight obstruction between vehicles and pedestrians about to cross the road.<br><br>Consideration should be given to the design of the fencing to ensure that the risk to errant vehicles is limited upon impact.<br><br>When used at staged or staggered crossings on pedestrian refuges, fences should be aligned so that pedestrians walk along the refuge in the opposite direction to the flow of traffic they are about to cross, and face oncoming traffic as they are about to leave the median. |

| Treatment | Cost | Benefits | Implementation Issues |
|---|---|---|---|
| **Pedestrian Over-Bridge/underpass**<br> | High | Traffic flow improve-ments. | Pedestrians will only use crossing facilities located at, or very near, to where they want to cross the road. This is particularly the case for over-bridges since steps are normally in-volved. Pedestrian fencing can be used to en-courage pedestrians to use crossing facilities.<br><br>Cyclists may also be able to use the faci-lities - ramps would be required which need more land space.<br><br>Personal security at underpasses should be considered. |
| **Pedestrian Refuge Island**<br> | Low to med. | Separating traffic moving in opposite directions to reduce head-on and overtaking crashes.<br><br>May slow vehicular traffic by narrowing the lanes.<br><br>Ensures pe-destrians need only cross one lane of traffic at a time. | Pedestrian refuge islands must be clearly visible to traffic during both day and night.<br><br>Refuge islands should be placed where there is a demand from pedestrians to cross.<br><br>Where cyclists are present, refuge islands must not narrow the lanes too much.<br><br>Turning movements from driveways and intersections must be considered in planning the location of pedestrian refuges. |
| | | | |

| Treatment | Cost | Benefits | Implementation Issues |
|---|---|---|---|
| **Regulate Roadside Activity**<br> | Low to med. | Removal of commercial activity or relocation of bus stops at the side of the road may remove the need for drivers to take last minute evasive action to avoid these.<br><br>Reduction in VRU crashes. | Roads should be designed to allow for changes in land-use over time.<br><br>Building regulations should specify the limits beyond which buildings must not extend.<br><br>Illegal development can only be controlled if there are alternative sites for commercial activity.<br><br>Where activities near the road are permitted, countermeasures may be required to maintain safety and they should be restricted to one side of the road. |
| **Restrict /Combine Direct Accesses**<br> | Med. to high | Reduces the number of potential conflict points.<br><br>Reduces traffic friction and improves flow on the main road.<br><br>Improved traffic management at upgraded access points. | In most situations, it would be difficult to justify and fund construction of a service road on its own merits due to high cost. This type of project is generally undertaken as part of a major road duplication project.<br><br>Minor intersection closures can often be achieved in cooperation with the local road authority, especially when safety at these intersections has been a subject of repeated complaint. |
| **Roadside Hazard Protection** (Vehicle Restraint Systems – Roadside Safety Barriers)<br> | Med. | If properly designed, installed and maintained, barriers should reduce the severity of crashes involving 'out of control' vehicles. | VRS should only be built if the existing hazard cannot be removed (see Roadside Safety - Hazard Removal).<br><br>The terminals or end treatments of VRS can be dangerous if not properly designed, constructed and maintained.<br><br>VRS should be located to minimize high impact angles and should also allow space for vehicles to pull off the traffic lane. |

| Treatment | Cost | Benefits | Implementation Issues |
|---|---|---|---|
| | | Provides protection for substantial structures. | Roadside barriers can be a hazard to motorcyclists.<br><br>Ensure appropriate clearance behind safety barrier is considered particularly for flexible and semi-rigid barriers.<br><br>Although concrete barriers do not deflect, allowance must be made for any hazards taller than the barrier to be offset far enough from the face of the barrier so that during impact vehicles (particularly tall ones) do not lean over the barrier and strike the hazard. |
| **Roadside Hazard Removal**<br><br> | Low to med. | Reduced road furniture repair costs associated with crash damage.<br><br>Improved recovery potential for vehicles.<br><br>Improved survivability of run-off road crashes. | The width of the safety zone required depends on traffic speeds.<br><br>After roadside hazards are removed, the roadside should be left in a safe condition. Large stumps and deep holes are hazards that may remain after removal of a tree.<br><br>Replacement of removed trees with more appropriate plants should be considered, otherwise re-growth or soil erosion may affect the site.<br><br>It is not always possible to remove roadside hazards, particularly in urban areas where space is limited. Reducing vehicle speeds is an alternative solution. |
| **Roundabout**<br> | Med. to high | Minimal delays at lower traffic volumes.<br><br>Little maintenance required.<br><br>Crash severity is usually lower than at | Solid structures should not be located on the central island.<br><br>High painted kerbs around the island can reduce the risk of it being run into.<br><br>Poor visibility on the approach to roundabouts, or high entry speeds, can lead to crashes. |

| Treatment | Cost | Benefits | Implementation Issues |
|---|---|---|---|
|  | | cross road intersections or T-junctions due to angle of crash impacts and lower speeds due to deflection on approaches. | Facilities to help pedestrians cross the arms of the intersection should be provided in most urban locations.<br><br>Roundabouts can be difficult for large vehicles, particularly buses, to use.<br><br>Designers should be conscious of the risk that roundabouts can be present for cyclists and other slow vehicles, such as animal drawn vehicles.<br><br>Care must be taken in the design of roundabouts to ensure adequate deflection upon approach to reduce vehicle speeds. |
| **Rumble Strips**<br> | Low | Can be parallel or transverse.<br><br>Warning to motorists approaching the centreline.<br><br>Improved visibility of centre lines.<br><br>Raised awareness on the approach to other hazards or devices i.e. road humps. | Gaps in the rumble strips may be needed in some areas to allow water to drain from the road surface.<br><br>The noise made by rumble strips can be difficult for drivers of larger vehicles to hear.<br><br>Consideration must be given to those living near to the road as rumble strips can generate noise.<br><br>Rumble strips can be a hazard to motorcyclists. |
| **School Zones**<br> | Low to med. | School zones and crossing supervisors can reduce pedestrian risk.<br><br>School zones aim to reduce vehicle speeds. | Traffic signs and road markings must make it clear to motorists that they have entered a school zone.<br><br>Consider incorporating flashing beacons to complement the school zone signs and markings.<br><br>Through-traffic must be able to see |

| Treatment | Cost | Benefits | Implementation Issues |
|---|---|---|---|
| | | School crossing supervisors can help to control.<br><br>pedestrian crossing movements and provide a safe place to cross. | pedestrian crossing points in time to stop for them.<br><br>Advanced warning signs should be located on approaches with adequate forward visibility.<br><br>Parking provision should be carefully considered within school zones with adequate sight distances at pedestrian crossings. |
| **Segregated Diverge Nearside - Signalised**<br> | Low to med. | Reduced crashes between turning vehicles and oncoming through-traffic.<br><br>Reduced severity of crashes throughout the intersection. | Adding diverge signals reduces intersection capacity.<br><br>It may be necessary to lengthen diverge lanes to fit longer traffic queues.<br><br>Other signal changes can be used to improve intersection capacity when signalised turns are implemented. |
| **Segregated Diverge Nearside - Unsignalised**<br> | Low to med | Reduced loss of control while turning crashes.<br><br>Improved traffic flow.<br><br>Increased intersection capacity. | Painted diverge lanes must be clearly delineated and have good sight distance.<br><br>Diverge lanes should be long enough to allow a vehicle time to stop within it (clear of through-traffic).<br><br>If a diverge lane is too long, through drivers may enter the lane by mistake.<br><br>Signs at the start of the diverge lane may help prevent this.<br><br>Installing diverge lanes can increase the width of the intersection and cause problems for pedestrians trying to cross.<br><br>One solution is to provide a pedestrian refuge island between lanes. |

| Treatment | Cost | Benefits | Implementation Issues |
|---|---|---|---|
| **Segregated Facilities - Pedestrians**  | Low to med. | Improves facilities for pedestrians (improves accessibility).<br><br>May help to increase walking as a mode of transport (environmental benefits and reduced traffic congestion).<br><br>Walking can improve health and fitness. | A routine maintenance programme is needed to ensure that footpaths are kept clean and level, free from defects and to prevent vegetation from causing an obstruction.<br><br>Signage should be used to warn drivers of pedestrians if the road shoulder is commonly used as an informal footpath.<br><br>Street traders, public utility apparatus and street furniture should not be allowed to obstruct the footpath. |
| **Segregated Facilities - Pedal/ Motor-Cycles**   | Low to med. | Increased use of pedal and motor cycles (reduced road congestion).<br><br>Associated health and environmental benefits that come with increased pedal cycle use. | On-road cycle lanes are cheaper than off-road paths if shoulder sealing is not required. Though this does still lead to some interaction with motorised traffic.<br><br>Traffic calming treatments or narrow road sections such as bridges can force pedal and motor cycles out into traffic, resulting in conflicts.<br><br>Parked vehicles may also force pedal and motor cycles out into main traffic, and so parking enforcement is very important for the success of on-road lanes.<br><br>Surface quality must be high or it will pose a safety risk.<br><br>Cycle lanes should be maintained to ensure that it is preferable to use the facilities rather than the shoulder or roadway. |

| Treatment | Cost | Benefits | Implementation Issues |
|---|---|---|---|
| | | | Maintenance includes repairs to the pavement surface and vegetation clearance.<br><br>Adequate sight distance must be provided around bends and at path intersections. This also aids personal security.<br><br>Cycle paths should be clear of obstructions and service covers. This includes keeping others such as vendors and adjacent land owners from encroaching on the path. Where an obstruction is necessary, it should be made obvious, and lines should be used to guide cyclists safely past.<br><br>Adequate crossing facilities need to be provided. |
| **Service Road**<br><br> | High | Can reduce the number of conflict points (intersections) along a route.<br><br>Can be used by local traffic and vulnerable road users as an alternative to the (often higher speeds and higher volume) main road.<br><br>Safer loading/ unloading of commercial vehicles. | Service roads require large amounts of space. Where space is limited, a service road may fit behind the properties.<br><br>Parking and other potential visual obstructions should be carefully controlled where service lanes re-join the main road. |

| Treatment | Cost | Benefits | Implementation Issues |
|---|---|---|---|
| **Shoulder Sealing**<br> | Med. | Wide shoulders allow vehicles to pull off the road in emergency situations.<br><br>Sealed shoulders can provide a cycling space and can be marked as cycle lanes.<br><br>Provide structural support to the road pavement.<br><br>Sealing can reduce 'edge drop'. Edge drop can make it harder for vehicles to get back onto the road. | Shoulder widening and shoulder sealing can be done at the same time to reduce costs.<br><br>Edge-lining can be improved at the time of upgrading the shoulder (especially when sealing).<br><br>Shoulders should not be too wide or drivers may use them as an additional lane. Controls may be necessary to prevent informal businesses from using shoulders. |
| **Side Slope Improvement**<br> | Med. | This will reduce the likelihood of rollover in a run-off road/ loss of control crash and may also reduce the severity of these types of crashes.<br><br>Flatter side slopes are generally less likely to erode. | Side slopes should be free of hazards and objects that may cause vehicle snagging.<br><br>Maximum traversable gradient is 1:3. On downward slopes, a clear run-out area may also be required at the base of the slope.<br><br>The provision of traversable side slopes may require the removal of native flora, which can result in erosion, sedimentation of waterways and removal of animal habitats. |

| Treatment | Cost | Benefits | Implementation Issues |
|---|---|---|---|
| | | The cost of providing a traversable slope may be less than the cost of stabilising and maintaining steep slopes. | The provision of traversable side slopes may have property impacts and require extensive land acquisition.<br><br>In areas where the side slope transitions from an upward slope to a downward slope (and vice versa), the rate of change in gradient of the crossfall should be gradual to ensure that the side slope can be traversed. |
| **Signalisation** (Intersections)<br> | Low to med | Can increase intersection capacity.<br><br>Can reduce certain types of crashes (especially right-angle crashes).<br><br>Can improve pedestrian and cyclist safety. | Signalising an intersection may have no safety benefit where compliance is poor and can reduce the capacity of an intersection.<br><br>Drivers need to be educated so they understand the meaning of the signals. Signals used at intersections with low traffic flows and fixed timings are likely to be disobeyed.<br><br>Well-designed traffic signals will usually reduce total crashes but will sometimes increase specific (low severity) crash types (e.g. rear-end crashes).<br><br>Traffic signals should not be used in high speed locations.<br><br>In urban areas it can be difficult to ensure that traffic signals have sufficient visibility.<br><br>Before installing traffic signals, information on traffic volumes, pedestrian volumes, intersection approach speeds and previous crashes at the site should be considered.<br><br>Traffic signals need continuous power.<br><br>Traffic signals and vehicle detection equipment are prone to malfunction so good maintenance is required. |

| Treatment | Cost | Benefits | Implementation Issues |
|---|---|---|---|
| **Signing**<br> | Low | Signs help drivers to adjust their behaviour to deal with approaching hazards or decision points.<br><br>If reflective, they can help reduce night-time/poor visibility crashes. | Poorly designed or located signs can add to crash risk.<br><br>The message they convey needs to be clear and unambiguous<br>Too many signs can confuse drivers.<br><br>The retro-reflectivity of signs is an important consideration for road use at night and in the wet.<br><br>Maintenance of signs in rural and isolated areas can be problematic. Signs may be stolen in some areas. |
| **Skid Resistance**<br> | Low to med. | Improved safety for roads where many crashes happen in wet weather.<br><br>Resurfacing provides an opportunity to fix other road surface problems, such as crossfall and rutting.<br><br>Provides the opportunity for adding or replacing road surface delineation such as painted markings or reflective road studs. | Side slopes should be free of hazards and objects that may cause vehicle snagging.<br><br>Maximum traversable gradient is 1:3. On downward slopes, a clear run-out area may also be required at the base of the slope.<br><br>The provision of traversable side slopes may require the removal of native flora, which can result in erosion, sedimentation of waterways and removal of animal habitats.<br><br>Skid resistance improvements gained by retexturing and resurfacing will lessen over time, especially on roads with lots of heavy vehicle traffic and in tropical climates. As such, regular monitoring of skid resistance is important.<br><br>The skid resistance of the entire road surface (right up to the edge) should be maintained for the safety of pedal cycles and other slow-moving vehicles. |

| Treatment | Cost | Benefits | Implementation Issues |
|---|---|---|---|
| | | Can extend life of pavement surface.<br><br>Retexturing has environmental benefits (lower cost and energy) over some traditional hot mix asphalt resurfacing.<br><br>Often quick and repeatable treatments with low traffic disruption.<br><br>In most cases roads can be driven on immediately after application. | Warning signs should not be considered a solution to the problem of poor skid resistance. Warning signs can be used temporarily, until other solutions are carried out.<br><br>Existing road surface must be sound, therefore pre-patching and repairs may be necessary prior to application.<br><br>These treatments will not typically add any strength to the road pavement. |
| **Speed Management**<br><br><br> | Med. | Reductions in travel speeds save lives and prevent injuries.<br><br>Lower speeds can reduce the severity of all crashes.<br><br>Reduced speeds will also reduce the likelihood | Reduced speed limits need to be signed clearly and repeater signs used to remind road users of the speed limit.<br><br>Road engineering treatments should ideally accompany reduced speed limits in order to encourage compliance.<br><br>Enforcement may be necessary to achieve compliance.  Speed limits should appear credible so that drivers will adhere to them.<br><br>Where there is a significant drop in speed limit (e.g. on approach to a village/urban |

| Treatment | Cost | Benefits | Implementation Issues |
|---|---|---|---|
|  | | of crashes occurring.<br><br>The wider benefits of reducing speeds include improved fuel consumption, lower green-house gas emissions and less traffic noise. | area), gateway treatments are recommended (these use a combination of treatments including prominent signs, road markings, pinch-points, coloured surfacing to make the change in road type clear).<br><br>Vertical traffic calming measures (e.g. speed humps, bumps and tables) should only be used in low speed environments. Horizontal traffic calming measures (e.g. chicanes and pinch-points) may offer significant benefits.<br><br>Speed humps and other devices need to be well designed to provide maximum safety benefits and located appropriately.<br><br>Traffic calming devices can impede emergency vehicles and cause discomfort for bus passengers.<br>Some traffic calming devices are hazardous to motorcyclists.<br><br>Community support and consultation is recommended before speed limits are changed or traffic calming installed. |
| **Street Lighting**<br> | Med | Street lighting helps to reduce night-time crashes by improving visibility.<br><br>Can reduce pedestrian crashes by approximately 50%.<br><br>Can help to aid navigation. | The provision of street lighting poles can introduce hazards to the roadside.<br><br>Frangible poles should be considered particularly in areas where there is low pedestrian activity. Alternatively, the poles can be protected by roadside safety barrier.<br><br>It is important to achieve the correct spacing of lamp columns to prevent uneven lighting levels along a route.<br><br>The provision of street lighting requires an electricity supply and is associated with ongoing power costs. Solar panels |

| Treatment | Cost | Benefits | Implementation Issues |
|---|---|---|---|
| | | Street lighting helps people to feel safe and can help to reduce crime.<br><br>Route lighting can help to reduce glare from vehicle headlights. | may be considered as an alternative power supply.<br><br>Adequate clearance must be provided to overhead lines.<br><br>Low pressure sodium lamps may be used to reduce light pollution particularly in urban areas. |
| **Turing Pockets Offside - Signalised**<br> | Low to med. | Reduced crashes between tur-ning vehicles and oncoming through-traffic.<br><br>Reduced severity of crashes throu-ghout the intersection. | Adding turn signals reduces intersection capacity.<br><br>It may be necessary to lengthen turn lanes to fit longer traffic queues.<br><br>Other signal changes can be used to improve intersection capacity when signalised turns are implemented. |
| **Turing Pockets Offside - Un-signalised**<br> | Low to med. | Reduced loss of control while turning crashes.<br><br>Improved traffic flow.<br><br>Increased intersection capacity. | Painted turn lanes must be clearly delineated and have good sight dis-tance.<br><br>Turn lanes should be long enough to allow a vehicle time to stop within it (clear of through-traffic).<br><br>If a turn lane is too long, through drivers may enter the lane by mistake.<br><br>Signs at the start of the turning lane may help prevent this.<br><br>Installing turn lanes can increase the width of the intersection and cause problems for pedestrians trying to cross. One solution is to provide a pedestrian refuge island in the median. |

| Treatment | Cost | Benefits | Implementation Issues |
|---|---|---|---|
| **Vertical Realignment**  | High | Reduced risk of vehicle equipment failure (steep grades).<br><br>More uniform traffic flow. | Vertical curve realignments require a lot of design and construction effort, and a lot of time and money. It is much better to design the road well before it is built than to rebuild it.<br><br>Horizontal and vertical alignments should be considered together. Poor combinations of vertical and horizontal alignment can confuse drivers and lead to dangerous situations. |

# Appendix B : RSI Inspection Form and Filled Sample

## B.1 Road Safety Inspection Form Record Sheet

Inspection route.......................................................................................................................................
Inspection section ......................................................................................................................................
Start point ..................................................................................................................................................
End point....................................................................................................................................................
Date ..........................................................................................................................................................
Commencement time ................................................................................................................................
Finish time .................................................................................................................................................
RSI Team Leader........................................................................................................................................
RSI Team Member .....................................................................................................................................

**General prevailing conditions**

***Section type (urban, rural, semi-urban)***

Tick one

| | |
|---|---|
| Urban | ❏ |
| Rural | ❏ |
| Semi-urban | ❏ |

***Road type (single, divided, expressway/motorway)***

Tick one

| | |
|---|---|
| Single | ❏ |
| Divided (non-expressway) | ❏ |
| Expressway / motorway | ❏ |

***Type of development***

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| Pedestrian area (e.g. school, or shopping area) | ❏ | ❏ | |
| Residential | ❏ | ❏ | |
| Commercial | ❏ | ❏ | |
| Adjacent service road | ❏ | ❏ | |
| Undeveloped | ❏ | ❏ | |

If you ticked pedestrian area (as a majority or exception) please describe the nature of the high pedestrian use area (school, shopping, etc.) and its location. Note any important observations such as distance from road, parking provision, pattern of use etc. (e.g. dropping off/picking up habits of parents at a school, high number of taxis dropping off people at shopping area).

.......................................................................................................................................................
.......................................................................................................................................................
.......................................................................................................................................................

***Number of forward lanes***

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| 1 | ❑ | ❑ | |
| 2 | ❑ | ❑ | |
| 3 | ❑ | ❑ | |
| More than 3 | ❑ | ❑ | |

***Lane width***

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| 3m | ❑ | ❑ | |
| 3.3m | ❑ | ❑ | |
| 3.65m | ❑ | ❑ | |
| Other (please specify) | ❑ | ❑ | |

***Environment***

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| Open feel (undeveloped or development more than 20m from edge of road) | ❑ | ❑ | |
| Closed feel (buildings or trees within 20m of the side of the road) | ❑ | ❑ | |

**Transitions**

***Transitions - speed limit changes***

No speed limit changes ❑

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| Speed limit changes with no clear signing | ❏ | ❏ | |
| Clear speed limit signing only | ❏ | ❏ | |
| Clear speed limit signing and gateway treatment | ❏ | ❏ | |
| Clear speed limit signing, gateway treatment and additional engineering treatments to reduce vehicle speeds | ❏ | ❏ | |

**<u>Speed limits</u>**

***Speed limit (km/h)***

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| 30 | ❏ | ❏ | |
| 40 | ❏ | ❏ | |
| 50 | ❏ | ❏ | |
| 60 | ❏ | ❏ | |
| 70 | ❏ | ❏ | |
| 80 | ❏ | ❏ | |
| 90 | ❏ | ❏ | |
| 100 | ❏ | ❏ | |
| 110 | ❏ | ❏ | |
| 120 | ❏ | ❏ | |
| Unknown | ❏ | ❏ | |
| Other (please specify) | ❏ | ❏ | |

***Speed limit compliance***

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| Poor compliance with speed limit | ❏ | ❏ | |
| Good compliance with speed limit | ❏ | ❏ | |

***Low speed limits (50km/h or below) - road engineering treatments***

| | |
|---|---|
| Speed limit higher than 50km/h | ❏ |

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| No traffic calming (horizontal or vertical) | ❑ | ❑ | |
| Poor quality traffic calming | ❑ | ❑ | |
| Good quality traffic calming | ❑ | ❑ | |

**Signing and road readability**

***Signing and road markings***

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| Poor signing and markings | ❑ | ❑ | |
| Good signing and markings | ❑ | ❑ | |

***Readability of the section***

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| Road characteristics inconsistent and not easily understood by road users | ❑ | ❑ | |
| Road characteristics consistent and easily understood/read by road users | ❑ | ❑ | |

***Forward visibility***

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| 0-70m (low visibility) | ❑ | ❑ | |
| 70-150m | ❑ | ❑ | |
| 150-225m | ❑ | ❑ | |
| 225-300m | ❑ | ❑ | |
| 300m + (high visibility) | ❑ | ❑ | |

**Bends/curves**

***Bend type***

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| Section mostly straight with no bends | ❏ | ❏ | |
| Bends are slight | ❏ | ❏ | |
| Bends are tight | ❏ | ❏ | |

***Bend quality***

| | |
|---|---|
| No bends | ❏ |
| Bends all good quality | ❏ |
| Tick all that apply | ❏ |

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| Bends are inconsistent along section | ❏ | ❏ | |
| Bends are difficult to drive at prevailing traffic speeds | ❏ | ❏ | |
| Poor advance warning/signing | ❏ | ❏ | |
| Presence of bend hidden | ❏ | ❏ | |

**Road sides**

***Safe zone (area at side of road that is clear of obstacles, slopes and cuttings)***

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| None | ❏ | ❏ | |
| Safe zone 0-4m | ❏ | ❏ | |
| Safe zone 4-10m | ❏ | ❏ | |
| Safe zone 10m+ | ❏ | ❏ | |

***Vehicle restraint systems (VRS - safety barriers)***

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| No VRS | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| Poor quality VRS | ❏ | ❏ | |
| High quality VRS | ❏ | ❏ | |

***Slope***

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| 1:3 or more (steep) | ❏ | ❏ | |
| 1:3 to 1:5 (slight) | ❏ | ❏ | |
| 1:5 or less (flat) | ❏ | ❏ | |

**<u>Intersections and accesses</u>**

***Intersection type***

No intersections ❏

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| At-grade non signalised, no right of way markings | ❏ | ❏ | |
| At-grade non signalised intersection, right of way markings | ❏ | ❏ | |
| At grade signalized intersection | ❏ | ❏ | |
| Roundabout | ❏ | ❏ | |
| Merge diverge | ❏ | ❏ | |
| Grade separated | ❏ | ❏ | |
| Other (please specify) | ❏ | ❏ | |

***Turning pockets***

No at-grade intersections ❏

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| Turning pockets provided to assist traffic turning across opposing flow | ❏ | ❏ | |
| No turning pockets provided | ❏ | ❏ | |

***Intersection density***

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| No intersections | ❏ | ❏ | |
| Low (spaced more than 5km apart) | ❏ | ❏ | |
| Medium (spaced 1-5km apart) | ❏ | ❏ | |
| High (spaced less than 1km apart) | ❏ | ❏ | |

***Legibility/visibility*** *(for users crossing the road or turning across the intersection)*

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| Good legibility of the presence of the intersection and priorities | ❏ | ❏ | |
| Poor legibility of the presence of the intersection and priorities | ❏ | ❏ | |

***Legibility/visibility*** *(for users of the secondary road)*

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| Good legibility of the presence of the intersection and priorities | ❏ | ❏ | |
| Poor legibility of the presence of the intersection and priorities | ❏ | ❏ | |

***Access density***

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| No accesses | ❏ | ❏ | |
| Low (spaced more than 1000m apart) | ❏ | ❏ | |
| Medium (spaced 100m-1000m apart) | ❏ | ❏ | |
| High (spaced less than 100m apart) | ❏ | ❏ | |

**Vulnerable Road Users (VRU)**

***Pedestrian - presence***

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| None | ❏ | ❏ | |
| Low (less than 50 in busiest hour) | ❏ | ❏ | |
| Medium (50-200 in busiest hour) | ❏ | ❏ | |
| High (200+ in busiest hour) | ❏ | ❏ | |

***Pedal cyclist - presence***

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| None | ❏ | ❏ | |
| Low (less than 50 in busiest hour) | ❏ | ❏ | |
| Medium (50-200 in busiest hour) | ❏ | ❏ | |
| High (200+ in busiest hour) | ❏ | ❏ | |

***Motorcyclist - presence***

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| None | ❏ | ❏ | |
| Low (less than 50 in busiest hour) | ❏ | ❏ | |
| Medium (50-200 in busiest hour) | ❏ | ❏ | |
| High (200+ in busiest hour) | ❏ | ❏ | |

***Pedestrian facilities***

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| N/A - No pedestrian demand evident | ❏ | ❏ | |
| Good quality, continuous footpaths and crossings provided where required | ❏ | ❏ | |
| Good quality, continuous footpaths are provided without crossings | ❏ | ❏ | |
| Crossings are provided without footpaths | ❏ | ❏ | |
| No pedestrian facilities provided | ❏ | ❏ | |

***Pedal cyclist facilities***

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| N/A – No pedal cyclist demand evident | ❏ | ❏ | |
| Good quality, continuous cycle lanes provided | ❏ | ❏ | |
| No pedal cyclist facilities provided | ❏ | ❏ | |

***Motorcyclist facilities***

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| N/A - No motorcyclist demand evident | ❏ | ❏ | |
| Good quality, continuous motorcycle lanes provided | ❏ | ❏ | |
| No separate facilities, but adequate space on roadway | ❏ | ❏ | |
| No motorcyclist facilities provided | ❏ | ❏ | |

***Parking***

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| Parking provided on road | ❏ | ❏ | |
| Parking provided off road | ❏ | ❏ | |
| No parking provided - no need | ❏ | ❏ | |
| No parking provided - clear need | ❏ | ❏ | |

**Median**

***Median treatment***

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| Unmarked | ❏ | ❏ | |
| Surface treatment | ❏ | ❏ | |
| Lining | ❏ | ❏ | |
| Separation | ❏ | ❏ | |
| Separation with obstacles | ❏ | ❏ | |
| Median barrier | ❏ | ❏ | |

***Obstacles in median***

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| Obstacles present in median | ❏ | ❏ | |
| Obstacle free median | ❏ | ❏ | |

## B.2 Completed Road Safety Inspection Form Record Sheet

| | |
|---|---|
| Inspection route | Spring Road (RN 18) |
| Inspection section | Km 0 – 10 |
| Start point | Junction of Spring Rd & Autumn Lane |
| End point | Junction of Spring Rd and Summer Road |
| Date | 29/04/14 |
| Commencement time | 13 : 00 |
| Finish time | 13 : 45 |
| RSI Team Leader | S. [signature] |
| RSI Team Member | J. [signature] |

**General prevailing conditions**

**Section type (urban, rural, semi-urban)**

Tick one

| | |
|---|---|
| Urban | ☐ |
| Rural | ☑ |
| Semi-urban | ☐ |

**Road type (single, divided, expressway/motorway)**

Tick one

| | |
|---|---|
| Single | ☑ |
| Divided (non- expressway) | ☐ |
| Expressway / motorway | ☐ |

**Type of development**

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| Pedestrian area (e.g. school, or shopping area ) | ☐ | ☑ | |
| Residential | ☐ | ☑ | Local linear village between Km 2.5 & Km 3. |
| Commercial | ☐ | ☑ | |
| Adjacent service road | ☐ | ☐ | |
| Undeveloped | ☑ | ☐ | |

If you ticked pedestrian area (as a majority or exception) please describe the nature of the high pedestrian use area (school, shopping, etc.) and its location. Note any important observations such as distance from road, parking provision, pattern of use etc. (e.g. dropping off/picking up habits of parents at a school, high number of taxis dropping off people at shopping area).

*In the middle of the village local primary school with direct access onto Spring Road. Currently no obvious notification – signing missing!*

**Number of forward lanes**

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| 1 | ☑ | ☐ | |
| 2 | ☐ | ☑ | *Localised turn pocket approaching junction with Summer Road.* |
| 3 | ☐ | ☐ | |
| More than 3 | ☐ | ☐ | |

**Lane width**

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| 3m | ☐ | ☐ | |
| 3.3m | ☑ | ☐ | |
| 3.65m | ☐ | ☑ | *Road widens through linear village!* |
| Other (please specify) | ☐ | ☐ | |

**Environment**

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| Open feel (undeveloped or development more than 20m from edge of road) | ☑ | ☐ | *Even through village properties are set well back and low density. Encroachment of HGV parking/servicing in isolated locations* |
| Closed feel (buildings or trees within 20m of the side of the road) | ☐ | ☐ | |

**Transitions**

**Transitions – speed limit changes**

No speed limit changes ☐

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| Speed limit changes with no clear signing | ☑ | ☐ | Speed limit should reduce through village but no indication |
| Clear speed limit signing only | ☐ | ☐ | |
| Clear speed limit signing and gateway treatment | ☐ | ☐ | |
| Clear speed limit signing, gateway treatment and additional engineering treatments to reduce vehicle speeds | ☐ | ☐ | |

**Speed limits**

**Speed limit (km/h)**

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| 30 | ☐ | ☐ | Legal requirement within village! |
| 40 | ☐ | ☐ | |
| 50 | ☐ | ☑ | |
| 60 | ☐ | ☐ | |
| 70 | ☐ | ☐ | |
| 80 | ☑ | ☐ | |
| 90 | ☐ | ☐ | |
| 100 | ☐ | ☐ | |
| 110 | ☐ | ☐ | |
| 120 | ☐ | ☐ | |
| Unknown | ☐ | ☐ | |
| Other (please specify) | ☐ | ☐ | |

**Speed limit compliance**

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| Poor compliance with speed limit | ☑ | ☐ | |
| Good compliance with speed limit | ☐ | ☐ | |

**Low speed limits (50km/h or below) – road engineering treatments**

| | |
|---|---|
| Speed limit higher than 50km/h | ☐ |

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| No traffic calming (horizontal or vertical) | ☑ | ☐ | |
| Poor quality traffic calming | ☐ | ☑ | Attempt @ road humps @ either end of linear village not been maintained or signed. |
| Good quality traffic calming | ☐ | ☐ | |

**<u>Signing and road readability</u>**

**Signing and road markings**

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| Poor signing and markings | ☑ | ☐ | Lack of maintenance (or even initial provision) No markings evident. |
| Good signing and markings | ☐ | ☐ | |

**Readability of the section**

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| Road characteristics inconsistent and not easily understood by road users | ☐ | ☐ | general lack of compliance with road characteristics. Inappropriate speed and overtaking witnessed. |
| Road characteristics consistent and easily understood/read by road users | ☑ | ☐ | |

**Forward visibility**

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| 0-70m (low visibility) | ☐ | ☐ | Majority of section is either straight or 'sweeping' Tight curves present @ Km 1.5, 3.7 and series between km 7.5 and 9. |
| 70-150m | ☐ | ☑ | |
| 150-225m | ☐ | ☐ | |
| 225-300m | ☑ | ☐ | |
| 300m + (high visibility) | ☐ | ☐ | |

**Bends/curves**

**Bend type**

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| Section mostly straight with no bends | ☐ | ☐ | |
| Bends are slight | ☑ | ☐ | |
| Bends are tight | ☐ | ☐ | |

**Bend quality**

| | |
|---|---|
| No bends | ☐ |
| Bends all good quality | ☐ |

Tick all that apply

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| Bends are inconsistent along section | ☑ | ☐ | |
| Bends are difficult to drive at prevailing traffic speeds | ☐ | ☐ | see comments above regarding forward visibility |
| Poor advance warning/signing | ☐ | ☑ | |
| Presence of bend hidden | ☐ | ☐ | |

**Road sides**

**Safe zone (area at side of road that is clear of obstacles, slopes and cuttings)**

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| None | ☐ | ☐ | Generally acceptable where flat but issues on unprotected embankments! |
| Safe zone 0-4m | ☑ | ☐ | |
| Safe zone 4-10m | ☐ | ☐ | |
| Safe zone 10m+ | ☐ | ☐ | |

**Vehicle restraint systems (VRS – safety barriers)**

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| No VRS | ☑ | | |
| Poor quality VRS | ☐ | ☐ | |
| High quality VRS | ☐ | ☐ | |

**Slope**

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| 1:3 or more (steep) | ☐ | ☑ | elevated section between km. 4.7 – 5.2 is reasonably straight but embankments rise to over 4m in places. |
| 1:3 to 1:5 (slight) | ☐ | ☐ | |
| 1:5 or less (flat) | ☑ | ☐ | |

**Intersections and accesses**

**Intersection type**

No intersections ☑

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| At-grade non signalised, no right of way markings | ☐ | ☐ | |
| At-grade non signalised intersection, right of way markings | ☐ | ☑ | Junctions @ either end of section under consideration with Autumn Lane and Summer Road are the only ones present. |
| At grade signalized intersection | ☐ | ☐ | |
| Roundabout | ☐ | ☐ | |
| Merge diverge | ☐ | ☐ | |
| Grade separated | ☐ | ☐ | |
| Other (please specify) | ☐ | ☐ | |

**Turning pockets**

No at-grade intersections ☐

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| Turning pockets provided to assist traffic turning across opposing flow | ☑ | ☐ | see above. |
| No turning pockets provided | ☐ | ☐ | |

**Intersection density**

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| No intersections | ☑ | ☐ | |
| Low (spaced more than 5km apart) | ☐ | ☐ | |
| Medium (spaced 1-5km apart) | ☐ | ☐ | |
| High (spaced less than 1km apart) | ☐ | ☐ | |

**Legibility/visibility** (for users crossing the road or turning across the intersection)

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| Good legibility of the presence of the intersection and priorities | ☑ | ☐ | |
| Poor legibility of the presence of the intersection and priorities | ☐ | ☐ | |

**Legibility/visibility** (for users of the secondary road)

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| Good legibility of the presence of the intersection and priorities | ☑ | ☐ | |
| Poor legibility of the presence of the intersection and priorities | ☐ | ☐ | |

**Access density**

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| No accesses | ☐ | ☐ | Limited access with the exception of the Linear Village where there is direct frontage access and 3 defined access through the village. |
| Low (spaced more than 1000m apart) | ☑ | ☐ | |
| Medium (spaced 100m-1000m apart) | ☐ | ☑ | |
| High (spaced less than 100m apart) | ☐ | ☐ | |

B

**Vulnerable Road Users (VRU)**

**Pedestrian - presence**

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| None | ☑ | ☐ | |
| Low (less than 50 in busiest hour) | ☐ | ☐ | |
| Medium (50-200 in busiest hour) | ☐ | ☑ | Linear village! |
| High (200+ in busiest hour) | ☐ | ☐ | |

**Pedal cyclist - presence**

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| None | ☐ | ☐ | |
| Low (less than 50 in busiest hour) | ☑ | ☐ | No concentrations of cyclists noted but general low flows throughout length. |
| Medium (50-200 in busiest hour) | ☐ | ☐ | |
| High (200+ in busiest hour) | ☐ | ☐ | |

**Motorcyclist - presence**

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| None | ☑ | ☐ | Even in the village no M/C usage was evident. |
| Low (less than 50 in busiest hour) | ☐ | ☐ | |
| Medium (50-200 in busiest hour) | ☐ | ☐ | |
| High (200+ in busiest hour) | ☐ | ☐ | |

**Pedestrian facilities**

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| N/A – No pedestrian demand evident | ☑ | ☐ | |
| Good quality, continuous footpaths and crossings provided where required | ☐ | ☐ | |
| Good quality, continuous footpaths are provided without crossings | ☐ | ☐ | |
| Crossings are provided without footpaths | ☐ | ☐ | No specific provision even through village. |
| No pedestrian facilities provided | ☐ | ☑ | |

**Pedal cyclist facilities**

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| N/A – No pedal cyclist demand evident | ☐ | ☐ | |
| Good quality, continuous cycle lanes provided | ☐ | ☐ | as above. |
| No pedal cyclist facilities provided | ☑ | ☐ | |

**Motorcyclist facilities**

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| N/A – No motorcyclist demand evident | ☑ | ☐ | |
| Good quality, continuous motorcycle lanes provided | ☐ | ☐ | |
| No separate facilities, but adequate space on roadway | ☐ | ☐ | |
| No motorcyclist facilities provided | ☐ | ☐ | |

B

**Parking**

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| Parking provided on road | ☐ | ☐ | |
| Parking provided off road | ☐ | ☑ | informal hardstanding developing through village otherwise no demand. |
| No parking provided – no need | ☑ | ☐ | |
| No parking provided – clear need | ☐ | ☐ | |

**Median**

**Median treatment**

Tick one option that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| Unmarked | ☑ | ☐ | No road marking present |
| Surface treatment | ☐ | ☐ | |
| Lining | ☐ | ☐ | |
| Separation | ☐ | ☐ | |
| Separation with obstacles | ☐ | ☐ | |
| Median barrier | ☐ | ☐ | |

**Obstacles in median**

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| Obstacles present in median | ☐ | ☐ | no defined median |
| Obstacle free median | ☑ | ☐ | |

# Appendix C : Prompts

Experience has shown that whilst very long checklists can appear to be thorough, the use of such lists is problematic.

- No list can ever be truly comprehensive
  No list can anticipate all of the unique scenarios that might be present at a site and reliance on a detailed list can result in safety risks being undiagnosed (i.e. those which are present at a site but which do not appear in the prompt list).

- Some people can be over reliant on checklists
  There is a risk that checking against a long list of prompts will be used as a substitute for the exercise of expertise and creative assessment.

- Long lists often tend to be very poorly used in practice
  Many people are deterred by lists which seem overwhelming and which include many comments which are not relevant to the road which is being considered.

For these reasons, the following prompts have been designed to be manageable lists of high level pointers which should help guide the RS Assessment Team ensure that all the necessary general issues and aspects of a road are considered.

Two sets of prompts have been developed:

- The first set (C.1) are high level road safety issues
- The second set (C.2) is a high level list of physical road elements that should be examined during the site visit

The prompts are an **Aide Memoire only** to ensure all items are considered by Assessment Teams and they should not be used as 'tick lists'.

## C.1 High Level Prompts - Road Safety Issues

The auditor needs to begin by considering some high-level issues at each stage.

- Road function and context:

  - ❏ Type of scheme and suitability for function of the road (residential/local road, collector, distributor etc.)
  - ❏ Type of scheme and suitability for traffic flow and mix
  - ❏ Character and scale of scheme in relation to adjacent route/network
  - ❏ Impact on traffic flows, speeds and surrounding road network
  - ❏ Linkages with other roads
  - ❏ Consistency with nearby roads
  - ❏ Location of scheme (could safety be improved through re-location/re-alignment?)
  - ❏ Controls for adjacent road-side or ribbon development

- ❏ Control of turning movements
- ❏ Future development of road and adjacent towns/villages etc.
- ❏ Existing traffic generators
- ❏ Construction stages/order

- Provision of facilities for ALL road users:

  - ❏ Mix of road users and vehicle types expected and variation in these:
    - Buses
    - Trams
    - Trucks
    - Agricultural equipment/vehicles
    - Minibuses
    - Maintenance vehicles
    - Emergency services
    - Cars
    - Carts
    - Motorcyclists
    - Pedal Cyclists
    - Pedestrians
    - Animals
    - Special road users (e.g. mobility or visually impaired, older or younger road users etc.)

  - ❏ Facilities for each road user group
  - ❏ Facilities for schools
  - ❏ Rest stops/laybys
  - ❏ Public transport facilities (and suitability for pedestrians)

- Forgiving, passively safe infrastructure:

  - ❏ Survivability of:
    - Head-on crashes
    - Run-off crashes
    - Crashes at intersections (including visibility/sight distances)
    - Crashes involving Vulnerable Road Users (VRU's) i.e. pedestrians, motorcycle riders, pedal cyclists, public transport users and road-side vendors.

- Management of vehicle speeds:

  - ❏ Speed limit appropriate for road function
  - ❏ Speed limit credible/likely to be obeyed (impression of road, general levels of compliance)
  - ❏ Speed limit safe
  - ❏ Temporary speed limits during construction

- Consistency and road readability:
  - ❏ Surprising elements of the road
  - ❏ Consistency of design
  - ❏ Advance warning of hazards
  - ❏ Readability of road
  - ❏ Information/guidance/signing
  - ❏ Control of movements through intersections

## C.2 High Level Prompts - Physical Road Elements to Consider During the Site Inspection

The following list is of physical road elements that should be examined whilst reviewing plans and during the site inspection. Not all items will be relevant at all stages. The list is deliberately non-exhaustive and high level so that it does not limit the RS Assessment Team's considerations.

- Adjacent to the road:
  - ❏ Terrain
  - ❏ Development density/type
  - ❏ Generators of road users/desire lines etc.
  - ❏ Rest areas and laybys
  - ❏ Interfacing roads/similar nearby roads
  - ❏ Distracting advertisements
- Road-side:
  - ❏ Clear zone/ obstacles (trees, signs, lighting columns, culverts etc.)
  - ❏ Vegetation/trees likely to obscure signage or become an obstacle when they grow
  - ❏ Guard rail (adequacy, necessity, safe installation/terminals, safe for different road user groups)
  - ❏ Shoulders/recovery area, cutting slopes
  - ❏ Parking provision (including generation of slow moving vehicles and presence of pedestrians) and loading facilities
  - ❏ Drainage
  - ❏ Buried services
  - ❏ Signing: Clear and understandable for all road users; visible in the day and at night; visible under different weather conditions (e.g. heavy rain, fog, sand storm); no shadows; unobstructed (include consideration of vegetation growth and maintenance); height and size of signs
  - ❏ Fencing for animals and pedestrians
- Median:
  - ❏ Type of median treatment

- ❏ Barrier type if applicable (adequacy, necessity, safe installation/terminals, safe for different road user groups)
- ❏ Width of median and obstacles (trees, signs, lighting columns, culverts etc.)
- ❏ Signing: Clear and understandable for all road users; visible in the day and at night; visible under different weather conditions (e.g. heavy rain, fog, sand storm); no shadows; unobstructed (include consideration of vegetation growth and maintenance); height and size of signs
- ❏ Vegetation/trees likely to obscure signage or become an obstacle when they grow

- Road-way:

  - ❏ Lane widths and number of lanes
  - ❏ Provision for/restriction of overtaking
  - ❏ Road surface: smooth and free of debris/mud/gravel; durability and maintenance; cross fall/super-elevation; anti-skid high friction surfacing where required
  - ❏ Gradient
  - ❏ Horizontal alignment: Consistency of bends, warning signs/treatments, anti-skid high friction surfacing, camber, clear zones/guard rail
  - ❏ Vertical alignment: Dips/humps and visibility
  - ❏ Forward visibility: Sight and stopping distances
  - ❏ Markings: Clear and understandable for all road users; visible in the day and at night; visible under different weather conditions (e.g. heavy rain, fog, sand storm)
  - ❏ Lighting
  - ❏ Transitions
  - ❏ Overhead services (clearances)

- Intersections and accesses:

  - ❏ Intersections:
    - Type of intersection - appropriateness for road type/speed
    - Spacing and frequency
    - Sightlines
    - Readability/clarity for road users
    - Signing and markings
    - Anti-skid high friction surfacing
    - Provision for VRUs
    - Lighting

  - ❏ Accesses, laybys and rest areas:
    - Appropriateness for road type/speed
    - Spacing and frequency
    - Sightlines
    - Provision for VRUs

- ❏ Roundabouts:
  - Alignment and deflection on approaches
  - Visibility of roundabout and traffic islands
  - Obstacle free zone in central island
  - VRU provision
- ❏ Signalised intersections:
  - Visibility of intersection
  - Visibility of signal lanterns (day/night and sunrise/sunset)
  - Sight lines
  - Stopping distances from back of queue
  - VRU provision
  - Phasing sequences
  - Turning phases
  - Location of signal posts/control boxes (obstacles)

■ Facilities for VRUs:

- ❏ Clear, continuous and unobstructed footpaths and crossing points
- ❏ Desire lines and VRU generators near to the road
- ❏ Prevention of access to unsuitable roads
- ❏ Crossing wait times, crossing times and lengths
- ❏ Reduced vehicle speeds
- ❏ Accessible for those with mobility impairment or prams/pushchairs
- ❏ Visibility

■ Other considerations:

- ❏ Weather (adverse weather conditions that may have an impact on safety e.g. heavy rain, sand, fog etc.)
- ❏ Special events/seasonal attractions
- ❏ Provision for
  - Maintenance and maintenance vehicles
  - Large/heavy vehicles (e.g. swept paths, turning circles, lane widths)
  - Enforcement/emergency services
  - Agricultural/stock movements

■ Temporary traffic management:

- ❏ Clear and unambiguous path for vehicles in daytime and at night
- ❏ Clear and accurate advance signing visible (sign sizes) in daytime and at night
- ❏ Merges signed and good length
- ❏ Clear tapers and temporary markings
- ❏ Clear and safe path for VRUs
- ❏ Work area clearly defined, safety buffers in place
- ❏ Removal/covering of permanent signs/markings

- ❏ Lane widths
- ❏ Barriers separating work area and traffic
- ❏ Road surface clear of mud/grave/debris etc.
- ❏ Temporary speed limit and enforcement
- ❏ Controlled site entrances/exits
- ❏ Flagmen located safely if used
- ❏ Order of phases of construction safe
- ❏ Temporary traffic signals signed and stopping distances

# Appendix D : RS Assessment Report

The report should begin with an introductory statement which must always include the following information:

1. The name and length of road that has been assessed
2. Any relevant background to the assessment
3. The names of the those commissioning and undertaking the assessment
4. A reference to the written instruction (which will have described the scope of the assessment)
5. Information that was available to the assessors (e.g. crash or traffic flow data)
6. The date(s) that the road was visited
7. Confirmation that the road was visited during daylight and also at night
8. The weather conditions at the time of the visit
9. Traffic conditions at the time of the visit (and whether these were typical or affected by seasonal factors etc.)
10. The people who were present during the visit
11. Confirmation that the assessment was undertaken in full compliance with the procedures described in this manual

The introductory statement must then always be followed by a location plan which shows the location and extent of the roads that have been assessed. This can be accompanied by a description of the road.

The plan may also include labels showing the locations of specific problems that have been identified. However, depending upon the scale of the plan and the number of problems, the inclusion of this information can make the plan cluttered and difficult to follow. Therefore, it may be judged preferable to indicate these locations using further, larger scale, plans or, alternatively, these locations might be sufficiently clear from the photo images and location descriptions that are given.

The following pages comprise an example of a RS Assessment Report.

## Summer Street RS Assessment

**Introduction**

This RS Assessment Report relates to approximately 6 miles of Summer Street in the Happy Valley District.

The instruction to undertake this Assessment was received by email from Mr Client on 7th June 2013. It is understood that the Assessment has been triggered by findings from a routine Road Safety Inspection and that no crash data or traffic flow data are available.

The Assessment was undertaken in accordance with the procedure described in the AfDB Existing Roads: Proactive Approaches manual. The site was inspected on various dates between 10th and 19th June 2013 during daylight and also during the hours of darkness.

The Assessment Team comprised Mr A Leader and Mr A Member from the RS Assessment Department. The weather was generally fine during these inspections although conditions during rainfall were also observed.

The Summer Street assessment route follows a broadly west to east alignment and extends from the signalised intersection with Sunny Avenue, approximately 2 miles east of Happy City, to the roundabout intersection with Main Road at the eastern end of the route.

The route is approximately 6 miles long and is a two lane single carriageway which is generally urban at the western end, becoming more rural towards the east. The route is level and generally straight with frequent side road intersections, intermittent street lighting and some bends towards the eastern end. There are some residential and other frontages at the western end of the route with unregulated parking and trading in places. The road surface is paved and there are footways for some of the more urban stretches of the route although there are few formal pedestrian crossing facilities. The road is busy with a mix of motorised traffic, pedal cycles and pedestrians. The road is subject to a 30km/h speed limit in the urban areas.


**Figure 13: Location plan**

**Table 11 : RS Assessment tables**

| Reference | Location | Images | Problems and Recommendations |
|---|---|---|---|
| Summer 1 | At the intersection of Summer Street and Sunny Avenue | <br> | **Problem:** There are no pedestrian facilities at the signals. Pedestrians cross between moving traffic and pedestrian barriers trap them in the road and hinder them from getting to a safe place at the end of the crossing movement.<br><br>Advertising banners distract motorists and block the sightline through the guard railings.<br><br>These factors increase the risk of pedestrian crashes.<br><br>**Recommendation:** Provide designated pedestrian crossing routes which reflect pedestrian desire lines (with breaks in the pedestrian guard railings at these points). Provide pedestrian signals and pedestrian phases in the sign sequencing.<br><br>Remove advertising banners. |
| Summer 2 | Approximately ½ mile east of Sunny Avenue | <br> | **Problem:** There are no pedestrian facilities at the signals. Pedestrians cross between moving traffic and pedestrian barriers trap them in the road and hinder them from getting to a safe place at the end of the crossing movement.<br><br>These factors increase the risk of crashes involving pedestrians.<br><br>**Recommendation:** Provide designated pedestrian crossing routes which reflect pedestrian desire lines (with breaks in the pedestrian guard railings at these points). Provide pedestrian signals and pedestrian phases in the sign sequencing. |

| Reference | Location | Images | Problems and Recommendations |
|---|---|---|---|
| **Summer 3** | Approximately ½ mile east of Sunny Avenue |  | **Problem:** The bus stop is located such that stopped buses will obstruct the sight-line to the traffic signal. Buses will also block the view of pedestrians attempting to cross at the signals. There is therefore an increased risk of crashes associated with unintentional non-compliance with the signals.<br><br>**Recommendation:** The bus stop should be decommissioned and relocated. |
| **Summer 4** | Approximately 1 mile east of Sunny Avenue |  | **Problem:** The bus stop is located between two traffic islands in the middle of trafficked roadway. Pedestrians have to cross busy roads where complex manoeuvring occurs in order to access or leave the bus. This places pedestrians at risk of a crash.<br><br>**Recommendation:** The bus stop should either be relocated or the road-way on the passenger side of the bus should be pedestrianised so that pedestrians do not have to cross trafficked roadway. |
| **Summer 5** | Approximately 2 miles east of Sunny Avenue |  | **Problem:** There are bus stops located on both sides of Summer Street and these generate an appreciable number of pedestrian crossing movements. There are no crossing facilities in this location and the road is busy and relatively complex with a number of busy side roads. There is consequently a risk of pedestrians being injured.<br><br>**Recommendation:** Provide a suitable form of pedestrian crossing complete with a large and wide pedestrian refuge in the centre of the road. |

| Reference | Location | Images | Problems and Recommendations |
|---|---|---|---|
| **Summer 6** | Approximately ½ mile east of Sunny Avenue |  | **Problem:** Considerable amounts of mud are deposited on the road surface by trucks and other traffic using the farmland to the north of Summer Street. This reduces traction, increases the likelihood of loss of control and may lead to run off and head on crashes<br><br>**Recommendation:** Clean the road more frequently and initiate discussions with farm operator and require that they provide and use wheel washing facilities. |
| **Summer 7** | Approximately 3 miles east of Sunny Avenue |   | **Problem:** Two lanes are provided for eastbound traffic so that slower vehicles can be overtaken on the steep hill. However, it is also possible to turn right from the middle (overtaking) lane. Consequently, faster traffic is being encouraged to overtake in a traffic lane where leading vehicles might slow down and stop prior to turning right. As such there is a risk of rear-end shunt crashes.<br><br>**Recommendation:** The right-turn manoeuvre into the side road should be prohibited. Traffic intending to access the side road should be re-directed so that they continue east for quarter of a mile where they can do a U-turn at the roundabout and then return and turn left. The banned movement and the alternative route should be well signed and the layout of the side road should be modified so as to deter the banned manoeuvre. |
| **Summer 8** | Approximately 3½ miles east of Sunny Avenue |  | **Problem:** The white painted steel 'post and rail' fence provided on the nearside affords insufficient crash protection and is, in itself, a road-side hazard.<br><br>**Recommendation:** A suitable form of barrier should be provided for an appropriate length and with an energy absorbing deformable terminal. |

| Reference | Location | Images | Problems and Recommendations |
|---|---|---|---|
| **Summer 9** | Approximately 3½ miles east of Sunny Avenue |  | **Problem:** The photograph shows the view from the side road looking southbound. It is difficult to see Summer Street and it is not clear that southbound traffic needs to stop at this point. There is a risk of vehicles failing to stop and crashing into vehicles on Summer Street.<br><br>**Recommendation:** Signing in advance of the intersection and at the intersection needs to be improved. The use of one or more traffic islands in the centre of the side road (either on the approach or, preferably near the stop line) would also help to increase awareness of the junction. |
| **Summer 10** | Approximately 4 miles east of Sunny Avenue |  | **Problem:** Signage is obscured and insufficient and it is not clear to approaching westbound drivers that the right-turn bend involves giving way to traffic emerging from a side road on the left. There is consequently an increased risk of vehicles failing to give-way or stop at the intersection and of vehicles failing to negotiate the bend.<br><br>**Recommendation:** Provide additional advance warning signage along with road markings to better depict the layout and priorities at the intersection. |
| **Summer 11** | Approximately 4 miles east of Sunny Avenue |  | **Problem:** The severity and extent of the eastbound bend to the left is not sufficiently clear. This increases the likelihood of run off and head-on crashes occurring.<br><br>**Recommendation:** Provide bend warning signage in advance of the bend and provide two chevron 'sharp deviation to the left' signs on the outside of the bend. |

| Reference | Location | Images | Problems and Recommendations |
|---|---|---|---|
| **Summer 12** | Approximately 5 miles east of Sunny Avenue |  | **Problem:** The vehicle restraint system is not tied-in to the bridge parapet and there are a series of concrete bollards placed in front of the barrier. In the event of a crash, a vehicle would collide with the bollards first and this would limit the effectiveness of the vehicle restraint system. The vehicle restraint system would then deflect and channel the vehicle into the end of the parapet wall.<br><br>**Recommendation:** The concrete bollards should be removed and the vehicle restraint system must be tied in to the parapet wall so that it is flush with it both before and during a vehicular impact. |
| **Summer 13** | Approximately 5 miles east of Sunny Avenue |  | **Problem:** A road-side fence has been provided as the road passes over a culvert, it is constructed from concrete posts and steel rails. The fence has been damaged and this is consistent with a vehicle having collided with the end. The fence is an unforgiving structure in any case, but in its current state there is an increased risk of impaling occurring in the event of a further crash.<br><br>**Recommendation:** It is not clear what purpose the fence serves, although it may be intended to deter heavy traffic from mounting the footway at this location. The fence is a significant hazard and it should be removed and, if necessary, replaced with a forgiving structure. The metal fence and the ditch at the back of the footway should be suitably protected with barriers and/or a deformable terminal unit. |

| Reference | Location | Images | Problems and Recommendations |
|---|---|---|---|
| Summer 14 | Approximately 5½ miles east of Sunny Avenue |  | **Problem:** The vehicle restraint system between the pipe and the carriageway presents a 'fishtail' end to oncoming traffic such that there is a risk of impaling. This particular barrier is also discontinuous with a gap that could be penetrated and which provides a second fishtail impaling hazard.<br><br>**Recommendation:** Extend the vehicle restraint system and close the gap. Replace fishtails with an energy absorbing deformable terminal (P4 or similar as shown below).<br> |

The following table summarises the various safety problems which were identified during this assessment and treatments proposed.

**Table 12: Assessed risk levels and treatment summary**

| Recommendation Reference | Recommended Treatment | Assessed Risk Level |
|---|---|---|
| Summer1 | Pedestrian crossings (signalised) | High |
| Summer2 | Pedestrian crossings (signalised) | High |
| Summer3 | Relocate bus stop | High |
| Summer4 | Relocate bus stop | High |
| Summer5 | Pedestrian crossing (refuge) | High |
| Summer6 | Clean roadway and require farmers to wash vehicles | Medium |
| Summer7 | Close right turn and sign alternative route | High |
| Summer8 | Vehicle restraint barrier | Medium |
| Summer9 | Advance signing of intersection and installation of traffic islands | Medium |
| Summer10 | Advance signing of intersection and improved marking | Medium |
| Summer11 | Advanced warning sign for bend and chevron signs | Medium |
| Summer12 | Remove concrete bollards and improve vehicle restraint system installation | Medium |
| Summer13 | Remove fence and install vehicle restraint system | High |
| Summer14 | Extend the vehicle restraint system and close the gap. Replace fishtails with an energy absorbing deformable terminal. | Medium |

Following detailed design and evaluation of collision savings the FYRR has been derived and the following scheme priorities are recommended. (Note other Economic Appraisal methods may also be used (see Section 5.4.1.3 )).

**Table 13: Prioritised FYRR**

| Recommendation | A Treatment Cost (Local engineering knowledge required) | B Average Crash Cost (Based on national figures) | C Relevant Average Crashes/Year (see Section 5.4.1.1) | D Effectiveness Estimate (see Section 5.4.1.2) | E Crash Savings (C*D) | F FYRR (%) ((E*B)/A) | Priority |
|---|---|---|---|---|---|---|---|
| Pedestrian crossings (signalised) | 970,000 | 600,000 | 3.7 | 30% | 1.11 | 69% | 14 |
| Pedestrian crossings (signalised) | 900,000 | 600,000 | 4.4 | 30% | 1.32 | 88% | 13 |
| Relocate bus stop | 250,000 | 600,000 | 5.2 | 20% | 1.04 | 250% | 10 |
| Relocate bus stop | 250,000 | 600,000 | 3.2 | 20% | 0.64 | 154% | 11 |
| Pedestrian crossing (refuge) | 900,000 | 600,000 | 7 | 30% | 2.1 | 140% | 12 |
| Clean roadway and require farmers to wash vehicles | 50,000 | 600,000 | 12 | 15% | 3.6 | 2160% | 1 |
| Close right turn and sign alternative route | 200,000 | 600,000 | 7.3 | 25% | 1.825 | 548% | 8 |
| Vehicle restraint barrier | 200,000 | 600,000 | 3 | 50% | 1.5 | 450% | 9 |
| Advance signing of intersection, traffic islands | 150,000 | 600,000 | 6.3 | 30% | 1.89 | 756% | 6 |
| Advance signing of intersection and improved marking | 80,000 | 600,000 | 4.3 | 20% | 0.86 | 645% | 7 |
| Advanced warning sign for bend and chevron signs | 50,000 | 600,000 | 3.7 | 20% | 0.74 | 888% | 4 |
| Remove bollards and improve VRS installation | 150,000 | 600,000 | 4.5 | 50% | 2.25 | 900% | 3 |
| Remove fence and install VRS | 75,000 | 600,000 | 3.6 | 50% | 1.8 | 1440% | 2 |
| Extend the VRS, close gap, replace fishtails | 75,000 | 600,000 | 2.1 | 50% | 1.05 | 840% | 5 |

Table 14 provides an appraisal of the same treatments using CE.

**Table 14: Prioritised CE**

| Recommendation | A Treatment Cost (Local engineering knowledge required) | B Relevant Average Crashes/Year (see Section 5.4.1.1) | C Effectiveness Estimate (see Section 5.4.1.1) | D Crash Savings (C*D) | E CE (A/D) | Priority |
|---|---|---|---|---|---|---|
| Pedestrian crossings (signalised) | 970,000 | 3.7 | 30% | 1.11 | 873,874 | 14 |
| Pedestrian crossings (signalised) | 900,000 | 4.4 | 30% | 1.32 | 681,818 | 13 |
| Relocate bus stop | 250,000 | 5.2 | 20% | 1.04 | 240,385 | 10 |
| Relocate bus stop | 250,000 | 3.2 | 20% | 0.64 | 390,625 | 11 |
| Pedestrian crossing (refuge) | 900,000 | 7 | 30% | 2.1 | 428,571 | 12 |
| Clean roadway and require farmers to wash vehicles | 50,000 | 12 | 15% | 3.6 | 27,778 | 1 |
| Close right turn and sign alternative route | 200,000 | 7.3 | 25% | 1.825 | 109,589 | 8 |
| Vehicle restraint barrier | 200,000 | 3 | 50% | 1.5 | 133,333 | 9 |
| Advance signing of intersection, traffic islands | 150,000 | 6.3 | 30% | 1.89 | 79,365 | 6 |
| Advance signing of intersection and improved marking | 80,000 | 4.3 | 20% | 0.86 | 93,023 | 7 |
| Advanced warning sign for bend and chevron signs | 50,000 | 3.7 | 20% | 0.74 | 67,568 | 4 |
| Remove bollards and improve VRS installation | 150,000 | 4.5 | 50% | 2.25 | 66,667 | 3 |
| Remove fence and install VRS | 75,000 | 3.6 | 50% | 1.8 | 41,667 | 2 |
| Extend the VRS, close gap, replace fishtails | 75,000 | 2.1 | 50% | 1.05 | 71,429 | 5 |

List of documents and plans considered for assessment:

- x
- y
- z

# Appendix E : Evaluation Example

## E.1 Introduction

Evaluation is a vital part of road safety management. Good monitoring and evaluation provide robust and transparent methods that can demonstrate effectiveness. These methods also provide the information that builds up into the intelligence on what works well and what does not, so the methodology feeds into the process to fine tune treatment choice in the future.

Evaluation is often not done very well. It is common practice to simply compare the number of 'before' crashes with the number of 'after' crashes without applying any statistical techniques or making comparisons with control sites. These approaches are unacceptable, particularly where blackspot analysis based on the use of crash data has been applied. The same crash data can be used to statistically assess performance of measures and schemes in a more robust fashion.

Statistical analysis will give a clearer indication of the robustness of any decreases (or increases) in crashes. Statistical analyses indicate whether any reduction could, in terms of probability levels, have been the result of random variation or factors. If a statistical result is significant at the 5% level ($P<0.05$) then we can be reasonably sure that the change observed was 'real'.

When using an unpaired control method to perform statistical analyses, there are two techniques which have been used widely to 1) obtain the size of the reduction at the site or scheme and 2) to assess the statistical significance of any change in crash occurrence. These are the Tanner K test and the chi-squared (X2) test respectively:

- The Tanner K test provides a way to estimate the size of the change in crash numbers (as a proportion or percentage) in relation to any change at the control site before and after
- The chi-squared test provides an indication of statistical significance

These will be applied to the scheme in Accra which has been outlined in the Reactive Approaches manual. Real measures were implemented at that site to improve safety; however, the data numbers in the after period are simulated since we do not know exactly what was put in place and the timings.

The Tanner K and chi-squared tests both require crash figures in the before and after periods, the easiest approach is to use before and after periods that are equal in length.

The data come from the site and also a large unpaired Control area which is larger (with up to ten times more crashes).

Both methodologies require the crash data totals to be formatted as per Table 15.

**Table 15: Crash totals matrix**

| | Crashes at site | Crashes at Control | Total |
|---|---|---|---|
| Before | a | c | g |
| After | b | d | h |
| Total | e | f | i |

## E.2 Tanner K Test

The Tanner K test formula (in terms of the before after crash number matrix in Table 15) is as follows*:

$$k = \frac{b/a}{d/c}$$

if k < 1 then there has been a decrease in crashes relative to the control
if k = 1 then there has been no change relative to the control
if k > 1 then there has been an increase relative to the control
* if any of the crash figures in any cells are zero, then 0.5 should be used instead of zero.
The result can simply be presented as a percentage difference which is calculated as follows:

$$(k - 1) * 100$$

## E.3 Chi-Squared Test

The chi-squared (X2) test formula (in terms of the before after crash number matrix as set out in Table 15) is as follows:

$$x^2 = \frac{((ab - bc) - \frac{n}{2})^2 n}{efgh}$$

The resulting statistic needs to be compared to values in a standard chi-squared distribution table with degrees of freedom = 1 for x^2 which is being applied to a 2 X 2 matrix of data). Further guidance on completing chi-squared analyses can be found in most statistics books.

## E.4 Worked Example

Figure 14 shows the site location and the larger control by polygons which can be used to capture the number of crashes occurring in the before and after period.

Ideally these polygons are saved in a crash database system so that the tests can be repeated exactly after different time periods.

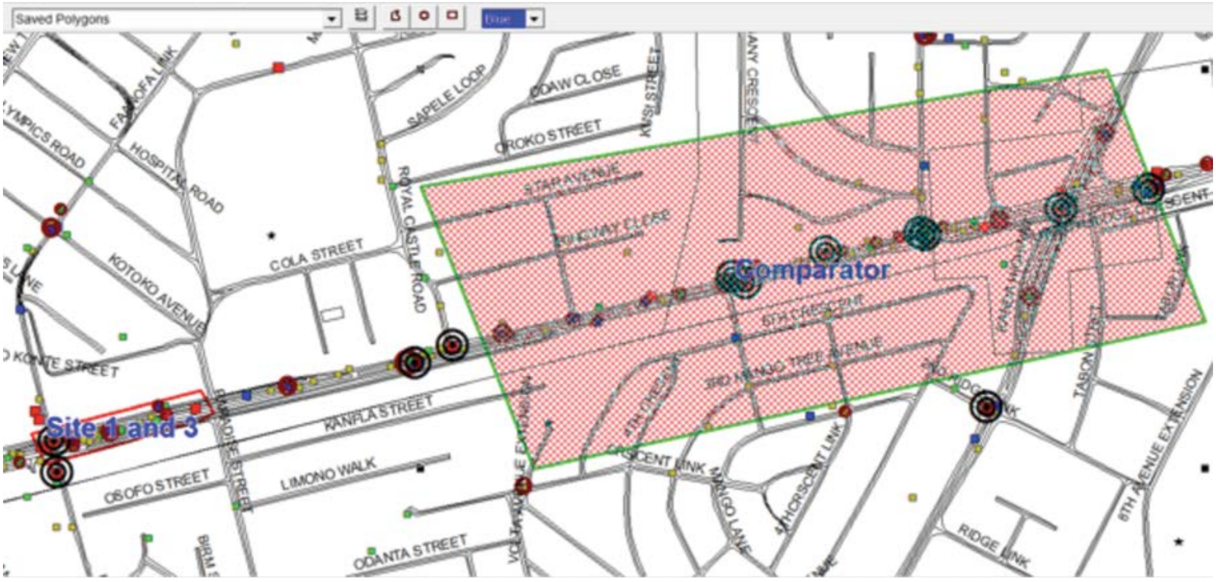


**Figure 14:** **Polygons for the site and control**

Crash data numbers from the site and controls for three years are shown in Table 16.

**Table 16:** **Crash numbers at the treated site in the before and after periods (3 years)**

| Site 1, 3 | Fatal | Hospitalised | Injured | Total |
|---|---|---|---|---|
| 2001 | 1 | 9 | 10 | 20 |
| 2002 | 2 | 9 | 12 | 23 |
| 2003 | 5 | 5 | 1 | 11 |
| 2004 | | Works done | | |
| 2005 | 2 | 1 | 5 | 8 |
| 2006 | 1 | 2 | 6 | 9 |
| 2007 | 0 | 3 | 5 | 8 |

**Table 17:** **Crash numbers at the untreated control site in the before and after periods (3 years)**

| Site 1, 3 | Fatal | Hospitalised | Injured | Total |
|---|---|---|---|---|
| 2001 | 10 | 23 | 22 | 55 |
| 2002 | 15 | 15 | 28 | 58 |
| 2003 | 8 | 20 | 19 | 47 |
| 2004 | | Works done | | |
| 2005 | 10 | 17 | 17 | 21 |
| 2006 | 8 | 16 | 20 | 16 |
| 2007 | 9 | 3 | 25 | 15 |

**Table 18: Total injury crash numbers at site and control in the required matrix (as per Table 15)**

| | Total injury crashes at site | Total injury crashes at control site | Total |
|---|---|---|---|
| Before | 54 | 160 | 214 |
| After | 23 | 125 | 148 |
| Total | 77 | 285 | 367 |

## E.4.1 Worked Example of the Tanner K Test

$$k = \frac{b / a}{d / c} = \frac{(23 / 54)}{(125 / 160)} = 0.55$$

if k < 1 then there has been a decrease in accidents relative to the control
if k = 1 then there has been no change relative to the control
if k > 1 then there has been an increase relative to the control

Therefore as k is less than 1 there has been a **decrease** in accidents relative to the control site.

The percentage change at the site is given by:

$$k = ( k - 1 ) * 100 = ( 0.66 - 1 ) * 100 = - 45 \%$$

## E.4.2 Worked Example of the Chi-Squared Test

$$k = \frac{((( 54 * 125 ) - ( 23 * 160 )) - 362/2 ) 2 * 362}{77 * 285 * 214 * 148}$$

$$= \frac{3021368202}{695042040}$$

$$= 4.347$$

Looking up in the chi-squared tables, the value (4.347) falls between the values (for 1 degree of freedom) which correspond to p=0.05 and p=0.025 (see Table 19).

This means the result is significant at the 5% (p<0.05) level, which is the level accepted to indicate that the result is unlikely to occur by chance.

Results which have a p value of 0.01 or less are described as being highly significant.

**Table 19: Chi-squared values**

| | p value | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **df** | **0.25** | **0.20** | **0.15** | **0.10** | **0.05** | **0.025** | **0.02** | **0.01** | **0.005** | **0.0025** | **0.001** | **0.0005** |
| 1 | 1,32 | 1,64 | 2,07 | 2.71 | 3.84 | 5.02 | 5.41 | 6.63 | 7.88 | 9.14 | 10.83 | 12.12 |
| 2 | 2,77 | 3.22 | 3.79 | 4.61 | 5.99 | 7.38 | 7.82 | 9.21 | 10.60 | 11.98 | 13.82 | 15.20 |
| 3 | 4.11 | 4.64 | 5.32 | 6.25 | 7.81 | 9.35 | 9.84 | 11.34 | 12.84 | 14.32 | 16.27 | 17.73 |
| 4 | 5.39 | 5.59 | 6.74 | 7.78 | 9.49 | 11.14 | 11.67 | 13.23 | 14.86 | 16.42 | 18.47 | 20.00 |

Table from: http://www.unc.edu/~farkouh/usefull/chi.html

Alternatively this can be done in programs such as MS Excel, using the CHISQ.TEST function. This requires that the Expected values are calculated

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