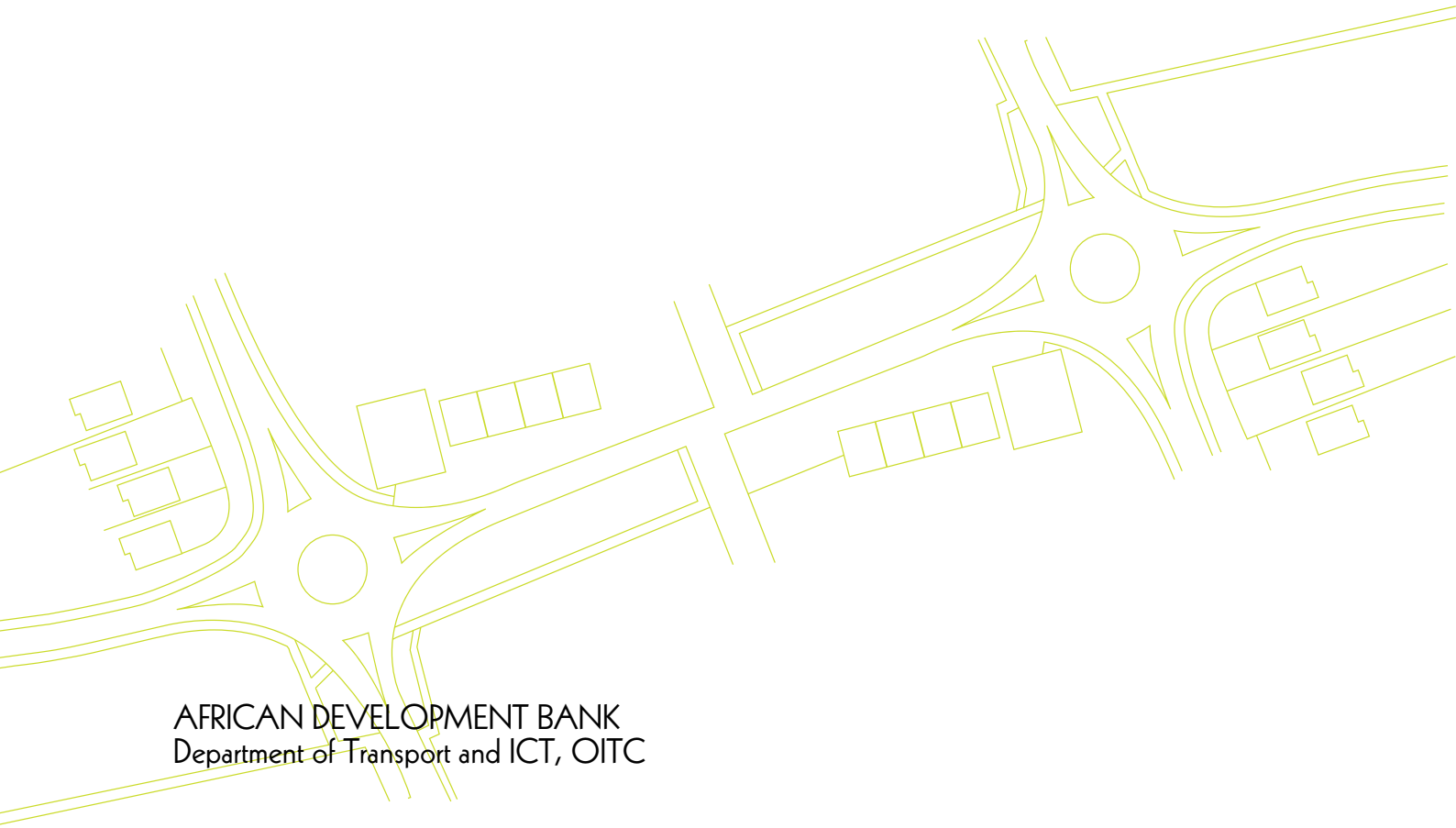
ROAD SAFETY MANUALS FOR AFRICA

New Roads and Schemes: Road Safety Audit

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 “New Roads and Schemes: Road Safety Audit” manual is one in a series of three manuals which will be used by road authorities and road designers and planners to conduct road safety audits for new road projects in order to identify potentially hazardous designs and locations and put remedial measures in place to minimize crashes.

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 audit 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.

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This manual has been developed based on a number of good practice manuals from Africa and elsewhere. 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)

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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.

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1. Introduction to this Manual

This manual is one of a series of three which deal with distinctive, but related, road 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 (RSI) methods
- Existing Roads – Reactive Approaches: This manual provides guidance on reactive methods such as using data to identify hazardous locations, roads and routes and Road Safety Assessment

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 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

RSAs are a valuable tool to review the features or character of a new road or improvement scheme during its development and help identify aspects of the design that may have an adverse impact of the safety of anyone who will use the road after it is completed. The other two manuals describe techniques for application on existing roads.

Other reactive approaches for application on existing roads use data to understand road safety issues. Depending on the quality and details recorded in crash data, several different types of analyses may be undertaken each with a differing level of granularity. These issues are discussed in detail in the other manuals.

These data also provide the basis for understanding the collision factors that can be influenced by particular design features. This manual deals with the application of these known safety features within the design process.

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 the RSA process. It has been developed to provide a consistent framework for

RSA 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 RSA. It is therefore a document that will be repeatedly referred to as organisations develop their own processes. The manual may be used by countries that do not already have a detailed RSA procedure until they have formalised their own.

The manual is set out in the following sections:

- Section 2 details the institutional and managerial steps to be taken to embed RSA
- Section 3 introduces the RSA concept, outlines what RSAs are, why they are necessary, the costs and benefits and how RSA fits into wider road safety management
- Section 4 outlines the RSA stages for application of the technique throughout the life-cycle of a road (through design, construction and opening)
- Section 5 deals with roles, responsibilities and experience of the key parties involved in undertaking either an individual or a group of audits associated with a particular road scheme
- Section 6 details the step by step process involved in undertaking any stage of RSA for any size of scheme
- Section 7 outlines requirements for monitoring
- A series of appendices are provided at the end of the manual to provide: potential design enhancements to address the main crash types; prompts for use while auditing; and a sample RSA report

The manual can be used by anyone involved in the RSA process; experienced practitioners, those considering the introduction of RSA into their organisation or those responsible for the development of RSA procedures for their country.

2. Embedding RSA

The following steps outline a process for ensuring that RSA becomes embedded in the design and construction of new roads and schemes.

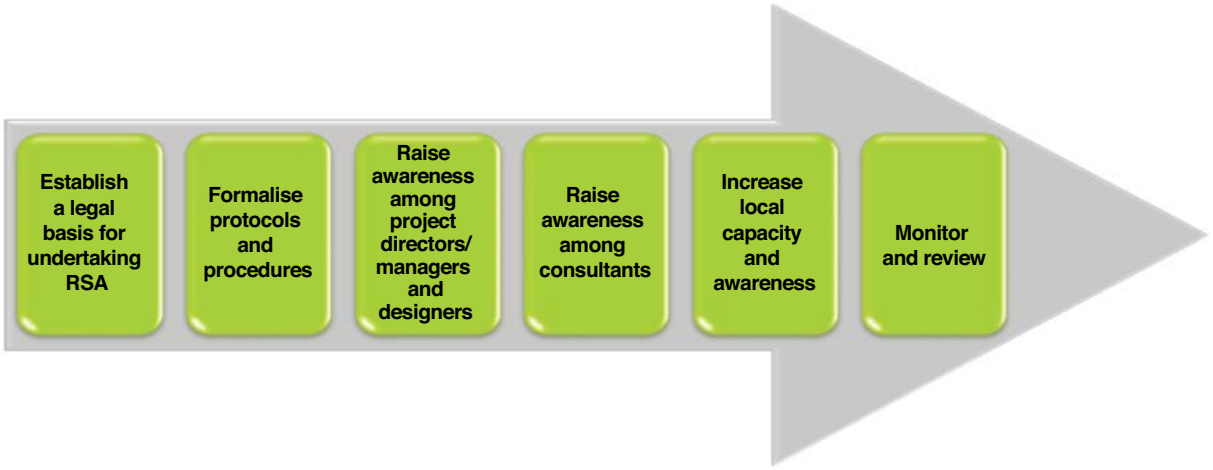

Figure 1: Embedding Road Safety Audit

Step 1: Establish a legal basis for undertaking RSA.

Many countries have a legal requirement for the road authority to ensure that new roads and schemes are subjected to safety reviews. Responsibility should rest with the relevant authority for safety which must be supported at the highest political level (i.e. President/Prime Minister).

Step 2: Written and formal protocol or procedure to be produced by the road organisation for establishment of RSA within the design and construction process. This protocol/procedure can be based on this manual, though it should be adapted for local conditions wherever possible.

This needs to specify:

- The resources needed to undertake RSA. The level of resources will depend on the scale of the safety problem. The RSA team (of at least 2 people) needs to be independent of the design team but managed through the design process. Typically a single stage of RSA for around 50km of new or improved road should take an RSA team no more than 20 person days to complete. This will vary depending in the scale and complexity of the scheme and the size and origin of the team selected. Wherever possible local resources should be developed to deliver RSA.
- Organisational responsibility for managing and delivering the RSA process. This should be devolved to the road authority that is responsible for designing and improving the road network. Although independent resources may be contracted to undertake the RSA, responsibility for organising, managing and agreeing RSA outcomes rests with the road authority.
- The detailed process to be followed as set out in formally approved manuals or guidelines. These documents should specify the approaches to applied across all roads and set out the appropriate scale and response to any issue identified.

- The stages and scheme types that must be subjected to RSA. RSA is a process that is repeated through the project development and implementation process and needs to be programmed within the project lifecycle.
- The process to be followed for those types of schemes and stages that will not be subjected to RSAs. The process needs to identify where it is not cost effective to undertake and audit and how any safety concerns on these schemes will be addressed.
- Feedback of RSA recommendations into the design process and modifications of design elements as necessary. All safety issues identified in the RSA need a formal response and action recorded and approved by the head of the road authority responsible.
- How RSA stages interact with the project development process. These need to be programmed within the lifecycle of the project.

Step 3: Raise awareness among project directors/managers and designers.

Ensure that all project directors/managers/designers reporting to the Client organisation (usually the road agency) are aware of:

- The RSA protocol/procedure. Appropriate training and awareness of the application of RSA should be provided throughout the road authority on a regular basis.
- The details contained in the manual (including how to procure a suitably qualified RSA Team). This can be established as a formal contractual requirement for all new and road rehabilitation projects.
- Implications for the adoption of the protocol/procedure including:
  - Budget of road project/scheme.
  - Time (typically 1month per stage to undertake an audit and report finding).
  - Inclusion of requirement in contractual documents etc.
  - How to ensure that local staff are included in RSA teams (e.g. extra points awarded for local knowledge/expertise).

Step 4: Make sure local consultants are aware of any new requirements and have the contractual requirements to implement the processes.

Step 5: Increase local capacity and awareness.

The road organisation should undertake the following activities:

- Offer RSA training to local practitioners (e.g. engineers/police crash investigators) to fulfil RSA Team requirements:
  - 5 days formal crash investigation or road safety engineering training.
  - Completion of a recognised RSA course of at least 4 days duration.

- Mentoring opportunities for local practitioners to ensure that they gain the experience required to fulfil RSA Team roles.
- Training for designers on road safety engineering in order to adequately interpret the issues and recommendations raised by RSA.

Step 6: Introduction of a formal system for monitoring and reviewing RSA recommendations to identify 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 RSA Concept

The RSA concept was originally developed and introduced in the United Kingdom in the mid to late 1980s. The benefits of RSA were soon recognised around the world and many countries have since established their own similar systems. RSAs can produce significant benefits at low cost if carried out in a formal and coordinated manner at all stages in the planning, design and implementation of a road project. The process requires co-operation, management commitment, skilled auditors, and an on-going training programme.

RSA is a systematic and formal examination of a new road or highway improvement project, in which an independent and qualified team of road safety specialists identifies potential road safety problems from the point of view of all road users. RSA is undertaken at various stages of road design and construction including at feasibility, preliminary design and detailed design stages, and then prior to, and after, road opening. The team provides suggestions on measures to mitigate the problems identified. The RSA process results in a report describing potential safety concerns that should be considered prior to advancing to the next stage of the design process or works.

RSA is a formal procedure for independently assessing and modifying new roads or highway improvement schemes. A RSA systematically identifies safety issues, and provides recommendations for how the design can be improved to remediate against those issues.

3.1 How RSA Fits 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. Conducting RSAs on new or improved roads is a proactive approach essential to ensure that safety is built

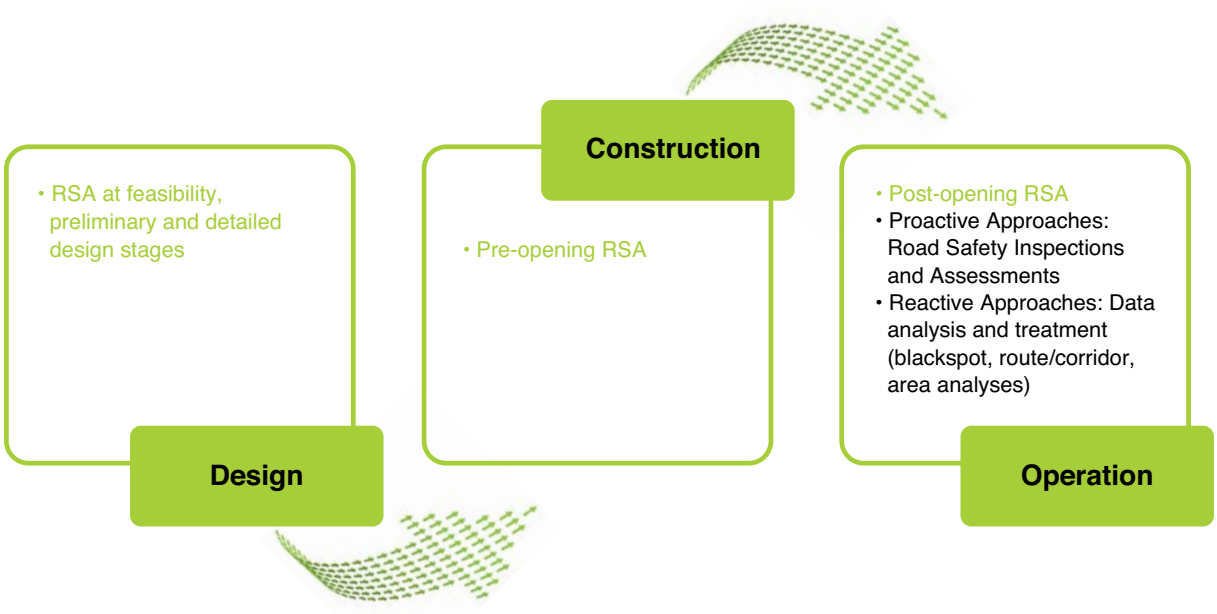

Figure 2: Two stage proactive approach

into new roads. Once a road becomes operational it should be subjected to further proactive and reactive management techniques described in the "Existing Roads – Proactive Approaches Manual" and the "Existing Roads – Reactive Approaches Manual".

3.2 RSA and the Safe System

3.2.1 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.

3.2.2 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.

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

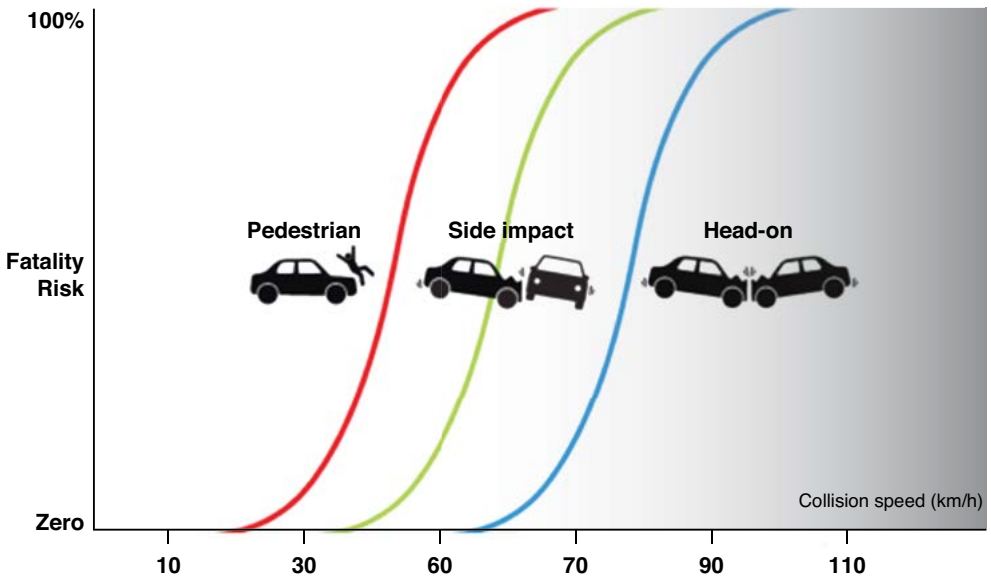

Figure 3: Crash types and indicative fatality risk at speeds (source: Wramborg, 2005, p14)

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.

3.2.3 Applying Safe System Principles to RSA

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 Road Safety Audit:

- 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

During an RSA, the Audit Team must be aware of the Safe System principles, the importance of speed and the mechanisms underlying typical crash types. The prompts that are provided in Appendix B provide a guide on some Safe System concepts that the RSA Team should keep in mind during the RSA.

3.3 An Introduction to RSAs

Objective: The objective of a RSA is to identify potential safety problems so that, where possible, the design/works can be changed to eliminate or reduce them – ideally before the scheme is built and operational.

How: An experienced RSA Team examines a new road project or highway improvement project at different stages of development to detect defects or features that may contribute to casualty crashes or to the severity of such crashes. It relies on a basic understanding of the typical crashes that are likely to occur on such roads either through historic crash data or through experience.

The RSA should check adequate attention has been given to the safety needs of all the regular users of the road, especially the vulnerable ones, i.e., the pedestrians, motorcycle riders, pedal cyclists, passengers waiting for transport, and road-side vendors - anyone not contained within a motorised vehicle.

Auditors need to check that the design takes account of the realities of the operating environment, including poor road user discipline, the difficulty of law enforcement, the lack of access control and the high proportion of vulnerable road users.

Who: The RSA is carried out by trained and experienced auditors who are road safety specialists independent of the scheme designers. These specialists can be in-house safety experts of the Client or design organisation or external specialist consultants.

Highway designers have sometimes been used as RSA Team Members and this can lead to the RSA being conducted as though it were a design check. Whilst auditors must have an understanding of the design process, it is much more important that they have knowledge and experience of typical crash situations in the environment in which the road will operate.

When: RSA can be applied to all kinds of road projects – new road construction, scheme development or the rehabilitation of existing roads. It can be applied to small and large projects and used on rural as well as urban roads. It can be applied to specific operating and maintenance activities on existing roads as well as for systematic assessment or road safety aspects on existing roads and road networks.

What it is not:

- A check of compliance with road design standards, rather it is a check of safety (note: these are not the same, as a road that complies with design standards can still be unsafe)
- A procedure focused on the needs of motorised vehicles, rather it should be focused on the needs of all road users
- A critique of the competence of highway designers, rather an opportunity for complementary specialists to review safety aspects of the design (diplomacy and respect between RSA parties is essential)

In Summary

RSAs:

- Help achieve the objectives of a Safe System by providing a safer road network
- Reduce the risk of crashes (with specific attention given to the most severe) that may result from design deficiencies in a proposed road project
- Minimise the need for rework and physical remedial works caused by road safety deficiencies at the various stages of project development, including construction
- Reduce the whole-of-life costs of the project
- Improve the awareness of, and contribute to, improvements in safe design practices

3.4 Why are RSAs Necessary

Building new roads, or undertaking highway improvement programmes, can have a negative impact on road safety. Often there is a conflict between the need for increased capacity and speed and the safety of road users. As roads are 'improved' to allow greater capacity and/or higher speeds, the safety of road users can become compromised.

Even though road agencies employ professional highway designers and insist on the use of good design standards there are a number of reasons why RSA is still necessary. These include:

- Compliance with standards does not guarantee safety. Although conformity with standards and guidance is helpful for safety, there will be many situations that are not covered by the standards and sometimes a number of individual elements, all designed to standard, may, when combined, be unsafe
- Standards for new roads are developed from highly-motorised countries where road user mix, behaviour and vehicle performance can be substantially different from the environment in which it is being constructed
- Road users may not conform to the behaviour expected by the designers/design standards
- Safety can be unduly compromised in the trade-off between conflicting requirements: It can be difficult for highway designers to produce a design that meets all the project objectives
- Lack of knowledge of crash causation: Highway designers may not have an understanding of road safety issues

3.5 Costs and Benefits of RSAs

Costs

There is often a concern that RSA will increase the cost of a project, though this is rarely the case. In particular, adoption of RSA at the early phases of road design means that the design can be adjusted with minimal cost implications. Moreover, many recommendations involve small adjustments to the signing, marking and layout of the road; these have minimal cost implications at early stages.

RSA costs include:

- Cost of personnel to undertake the RSA (typically 2-3 weeks of work for 2-3 Auditors – note larger schemes will require much larger time inputs)
- Cost of personnel to accommodate the recommendations into designs
- Cost of any construction arising from recommendations that would not otherwise have been undertaken

There may be occasions when the RSA recommendations save costs by suggesting the removal of unnecessary design components.

In addition to material costs, inclusion of RSA may result in additional lapsed time within a project: firstly to undertake the RSA and then to accommodate the recommendations.

The cost of an RSA and the consequent cost of changing a design are significantly less than the cost of remedial treatments after works have been constructed, or the social cost of road crashes (for a whole country these are estimated to be 1-3% of GDP).

It is easier to change design plans than to make changes after the road is constructed. However it is still worth undertaking Post-Construction RSAs since the cost of remedial work is often less than the cost of crashes that might result.

Benefits

Research in developed countries suggests that the benefit to cost ratio of undertaking RSA can be around 20:1 and the measures that are recommended can have a benefit to cost ratio of up to 250:1.

Experience worldwide has shown that RSAs are both effective and cost beneficial, achieving significant savings in crash numbers at relatively low cost and with minimal project delay.

Australian and New Zealand experiences suggest that although RSA can add up to a maximum of 4% to the cost of road projects, the benefits are:

- Savings in the time and cost by changing project details at the planning and design stage rather than the more expensive option of removing or changing road infrastructure once installed
- Reductions in the number of crashes and the consequent savings in road crash-related costs
- Reductions in possible litigation costs (ADB, 2003)

It has been suggested (from a limited British study) that one-third of future crashes at road improvements could be prevented by RSA.

The UK Highways Agency (Wells 1999, as cited in OECD, 2008) compared the cost of implementing recommendations made by a design stage audit to making changes after the project was constructed, they found an average saving per scheme of £11,373 (just under $20,000 US). Schelling (1995, as cited in

OECD, 2008) found that investments in measures recommended by RSA of 13 projects had an overall first year rate of return of 146%. A similar study undertaken in Jordan found that corrective measures implemented as a result of design stage audits had a first year rate of return of 120% (Al-Masaeid, 1998, as cited in OECD, 2008). A study by Austroads (Macaulay and McInerney, 2002) found that for nine design stage audits, recommendations had a benefit to cost ratio of 3:1 to 242:1, with most of the recommendations being low in cost to implement. For existing road assessments, recommendations had a benefit to cost ratio of 2.4:1 to 84:1.

It may even be possible that there is little or no additional cost. The experience in one of the earliest RSA applications and safety checking on a project in the Republic of Korea (ADB, 2003) demonstrated that minor modifications in design to incorporate safety improvements could, at some locations, actually reduce the cost of the proposed scheme.

When RSA is undertaken over a longer period of time with the same Client, the average number of safety issues per audit declines over time. This is because designers anticipate the safety issues, learn from the RSA process, and include safety features from the start. Another benefit of RSA is therefore that it contributes to a 'safety by design' culture within organisations.

In general, the available evidence suggests that the costs of changes introduced as a result of the RSA are significantly outweighed by the benefits.

4. RSA Stages

RSA can, and ideally should, be conducted at every stage in the life-cycle of a road scheme; from feasibility stage, through the design stages, during construction, and before and after the road is opened.

RSA was originally developed to be carried out on road project designs so that changes could be made before the road was built. RSA is now also practiced on roads during construction, before and after they open.

A RSA conducted early in the life-cycle of a road has the greatest opportunity to improve the safety of the road and reduce the severity and occurrence of crashes. As the design develops further towards implementation, the opportunity to influence crash prevention positively becomes more difficult and costly, and the implementation of remedial measures more time consuming.

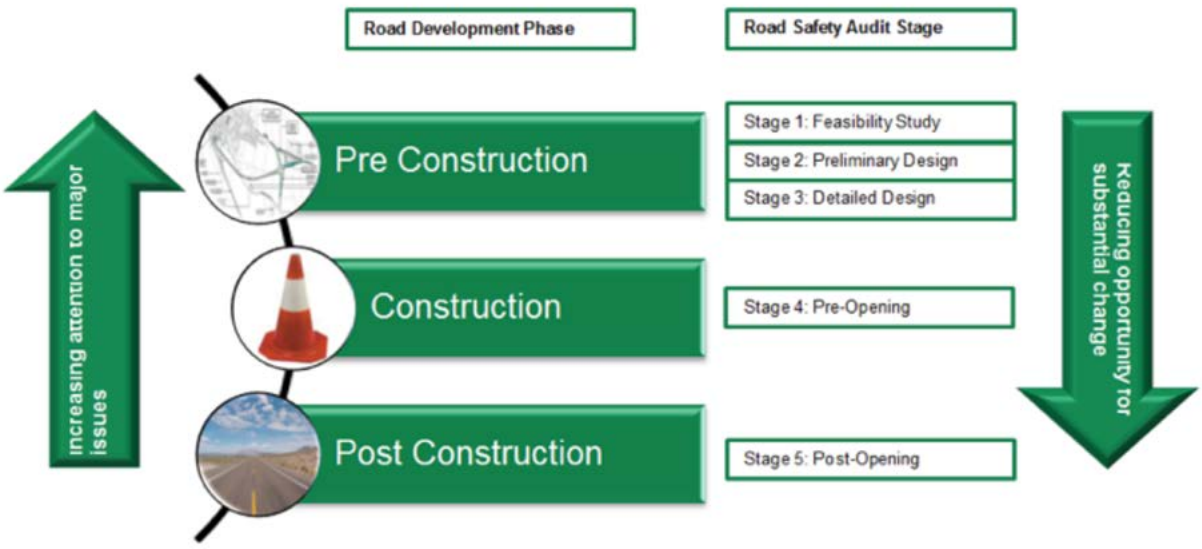

Figure 4: RSA stages

RSAs are appropriate for all kinds of road construction, including rehabilitation and upgrading, as well as a 'new-build'. They can also help in assessing the safety of:

- Arrangements for traffic control and signing at road-works
- Traffic management schemes
- Major road-side building development (e.g. shopping malls, car parks, leisure centres, etc.)
- Existing roads (see also Road Safety Assessments in the Reactive Approaches for Existing Roads Manual)

The earlier a road scheme is audited, within the design and development process, the better

For all types of road construction projects there are five opportunities when an RSA can be undertaken:

1. Feasibility Study Audit
2. Preliminary Design Audit
3. Detailed Design Audit
4. Pre-Opening Audit
5. Post-Opening Audit

One project can have up to five separate RSA stages that cover three basic phases of the project cycle.

- Pre-construction:
  - Stage 1: Feasibility Study Audit during initial planning and early design
  - Stage 2: Preliminary Design Audit during draft design
  - Stage 3: Detailed Design Audit once designs are fully developed

- Construction:
  - Stage 4: Pre-Opening Audit immediately before the road or scheme is opened

- Post Construction:
  - Stage 5: Post-Opening Audit within one year after the road or scheme has been opened

Depending on the size and scope of the project, some stages may be merged (e.g. combining Stage 2 and Stage 3 RSAs). A five-stage audit is only undertaken for long term major projects.

One audit from the pre- and post- construction phases must be undertaken as a minimum requirement on all schemes.
At all stages of audit the needs of all road users must be considered.

Table 1: Critical stages of audit depending on scale and location of scheme

Scheme Type	Audit Stage				
	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
Major Scheme National Road	x	x	x	x	x
Major Scheme Regional Road		x	x	x	x
Major Scheme Local Road		x	x	x	
Minor Scheme National Road		x	x		
Minor Scheme Regional Road		x	x		
Minor Scheme Local Road		x	x		

Small road improvement projects usually do not have preliminary design and detailed design phases and may not have significant construction periods requiring RSA. They do however, still need to be subjected to an RSA pre and post construction.

For larger, more complex projects, it may be necessary to have more than one Construction Phase Audit. International practice is to involve RSA increasing in the construction process to monitor the safety performance of different stages – particularly the work process and temporary traffic management arrangements.

It is however, essential that an RSA is undertaken on all completed schemes prior to opening to public use.

4.1 Stage 1: Feasibility Study

Audits at this stage can influence fundamental issues such as design standards (including design speed and possible speed limits), cross-sections, route choice, impact on the surrounding road network, and the number, location and type of intersections. If issues are not identified at this stage it can be very difficult and often impossible to correct the resulting problems at a later stage in the design or construction process.

Feasibility Study RSAs will be undertaken with minimal design information and need to consider the overall concept and function of the scheme, together with its relationship with the surrounding environment.

At this stage, it is not just the movement along the proposed scheme that is important, but its impact on existing movement patterns and centres of traffic generation. Careful consideration should be paid to the existing patterns of movement that may cross the proposed scheme particularly for pedestrians and even animals, particularly in rural areas. Where facilities and generators/attractors can be widely separated, movement patterns can be diverse and whilst individual volumes may not be high, the impact of even relatively small diversions or closures can have a disproportionately large impact on the local population.

An important aspect of the RSA at this stage is to understand these wider contextual issues and ensure that they are given appropriate consideration within the scope of the scheme extents. Even if the proposed scheme does not appear to directly affect adjacent land uses and communities, existing cross routes of all scales and sizes need to be identified and the scheme impact investigated.

Particular attention should be given to the potential severance of communities and their local movement patterns. Also the possible attraction of additional uses and development along the scheme could be relevant to the audit considerations.

Feasibility Study RSAs sometimes have to deal with phased construction – for example, it may be proposed that the road is designed as a dual carriageway but is built initially as a single carriageway. Auditors should be aware that this often involves design compromises that adversely impact upon safety. Interim designs need more attention, not less. Future developments around the road that may influence the road function or operational circumstances should also be considered. These can typically include such things as uncontrolled road-side trading.

4.2 Stage 2: Preliminary Design

The preliminary or draft design will determine the standards, the cross-section, the alignment, and the layout of intersections. The Preliminary Design RSA will check all of these elements, but will also look at wider issues, such as:

- The specific needs of all likely road users
- Access to adjacent property
- Safe accommodation of local traffic movements
- Adequate and safe connections to the existing road network

4.3 Stage 3: Detailed Design

A Detailed Design RSA occurs on completion of the detailed road design but before construction contract documents are prepared and land acquisition fixed.

It is a chance to check all of the proposed details, such as signs and markings, safety barrier provision, road-side obstacles, visibility conditions at intersections, non-motorised user facilities and connections to existing roads. Checks are also undertaken on the interaction of the detailed elements – for example, checking that the lighting columns are behind the safety barrier not in front, or that surface pedestrian crossing facilities are in a location where vehicle speeds can be controlled.

Attention to detail at this stage can help reduce the cost and nuisance of last-minute changes during construction. However, it is often difficult to get sufficiently detailed information because many minor decisions are left for the supervising engineer during the construction phase or because all detailed plans are not provided together (e.g. lighting or safety barriers not present when plans are being delivered to the RSA Team).

4.4 Stage 4: Pre-Opening

A Pre-Opening RSA takes place immediately before the road or scheme is opened to traffic, and involves a detailed inspection of the road, all of the signs, and other road furniture. The objective is to identify any hazardous features that were not apparent at previous stages and check that all of the design details have been correctly implemented. It must include examination of the completed scheme both in daylight and in darkness to assess any specific issues that may occur at night (often this will concern how the road is perceived by drivers when it is dark).

It is good practice to have a local traffic police officer take part in the site inspection at this stage of audit, as they are likely to have a good understanding of how the local people will cope with the new road. They can also be asked to arrange for an increased police presence in the first few days after opening, particularly if any specific issues are identified.

4.5 Stage 5: Post-Opening

A Post-Opening RSA is completed after the road has been open for about a year and prior to the end of the maintenance period. This will show how the road is actually being used, and, if there are any problems, they will most likely be apparent already. It may be possible to make minor changes before the contractor fully demobilises. A Post-Opening Audit is conducted primarily around a

detailed site visit of all elements and the interaction of how vehicles and non-motorised users are coping with the revised/improved facilities. Any unexpected conflicts or behaviours need to be noted. It can be helpful to undertake informal conflict studies. This type of study is considered in more detail in the Existing Roads: Proactive Approaches manual that is a companion document to this manual.

4.6 Other Types of Audit

4.6.1 Safety Review of Existing Roads

RSA techniques can also be applied to existing roads. This is known as Road Safety Assessment and is covered in the Existing Roads: Proactive Approaches manual. They can be especially useful when planning major maintenance or rehabilitation projects or in response to known road safety issues either through crash data analyses or through local (police or community) intelligence.

4.6.2 Traffic Management Schemes

It is advisable to undertake RSAs of major traffic management schemes. For example, when the existing circulation patterns are altered by means of one-way systems, road closures, parking restrictions, traffic calming etc. there is still the potential for crashes. RSAs of traffic management schemes should focus on:

- Potential problems with one-way systems especially at connections with two-way streets
- Whether there is adequate signing – for both drivers and pedestrians
- Potential problems caused by increased speeds on one-way streets
- Potential adverse impact of vertical and horizontal traffic calming features, revised intersection configurations and road features

4.6.3 Building Development

Large building and land use developments usually generate considerable vehicular and pedestrian traffic, so they have a major impact on the surrounding road network. The layout of the site, and the design of the car parks, access roads, footways, etc., is critical for the safety of visitors and the passing traffic on the surrounding network. RSAs of building developments will typically focus on:

- The vehicular and pedestrian access
- The safe provision of public transport services
- The safety impact of any congestion caused by the vehicles entering or leaving the development
- The generation of pedestrian movements across surrounding roads
- The adequacy of the parking provision (to avoid parking overflow onto surrounding roads)
- Speeds within the site and at access points
- Pedestrian - vehicle conflicts within the site and at access points

4.6.4 Temporary Traffic Management Audit

Temporary arrangements for traffic implemented during the construction period tend to result in a high number of crashes. The reasons for this include:

- Drivers not seeing or understanding the temporary arrangements, especially at night
- Drivers and pedestrians not adjusting their behaviour to suit the changed conditions
- Confusion over the route to take to avoid the construction area – conflicting messages
- Poor or non-existent traffic control (signs, barriers, warning etc.)
- Little or no provision for pedestrians and other VRUs
- Narrow traffic lanes and other hazards
- Inadequate protection for workers

Many authorities are making efforts to promote greater safety at road-works which will often be covered in general manuals for the design and operation of roads and bridges. Although these standards and specifications will be helpful, they are no guarantee of safety. Standards cannot cover all possible situations, and road contractors may have difficulty interpreting them. Consequently there are benefits in subjecting major construction sites to RSA when they include restrictions or changes to the road network. This applies to major maintenance works as well as rehabilitation and new-build.

The focus of Construction RSAs should be:

- Advance warning and clarity of the route for drivers
- Clear guidance by means of signs and other devices
- Provision of unobstructed routes for pedestrians and pedal cyclists
- Speed control
- Clear and efficient traffic control
- Protection of workers
- Safe access and egress for construction vehicles

As a number of different temporary traffic layouts may be needed during the construction process it is important that each change in planned layout is subjected to a separate RSA.

5. Team and Personnel Requirements

The section that follows outlines:

- Key roles and remit of different RSA stakeholders
- RSA Team Composition, Qualifications and Experience

Though the implementation of RSA may vary from country to country, the preferred requirements for all parties involved in the RSA process are described in the following sections.

5.1 Key Roles and Remit

RSAs involve three parties with defined roles - the Client, the Project Team, and the RSA Team.

RSA is a formal process: comments and decisions made by the various parties are documented in reports or meeting minutes. In practice, the parties maintain dialogue during the process to avoid or minimize misunderstandings. Managing the relationship between the different parties involved is critical to the success of RSA.

It is vital that the RSA team is independent of the design process and only involved in undertaking and report the audit findings. As such it is the Client who provides instruction and scope of the work to be undertaken and decides whether or not to implement the audit recommendation.

5.1.1 Client (Road Authority or Commissioning Organisation)

The Client is the organisation that commissions the design, pays for and owns the road project – usually the Road Authority. They are the logical entity to retain RSA information throughout the life-cycle of the road. They are responsible for having a RSA carried out and will:

- Initially define the scope of the RSA to be undertaken
- Review the qualifications and experience of the RSA Team
- Decide on the issues and advise (in writing) the other two parties as to the final decision for each issue, often following a detailed technical review; where the designer and RSA Team disagree, the Client will be the final arbiter on the safety aspects of the scheme

Clients may rely on a technical Project Team to prepare the detailed specification or Terms of Reference for the RSA, but they have the ultimate responsibility for deciding the appointment of the team and the response to the RSA findings. They therefore need to be made aware of the safety implications of their decisions by the technical design team and need to have clear recommendations and reasons provided through the audit findings to assist them in making safe decisions.

5.1.2 Project Team (Designer/Contractor)

The Project Team is the party responsible for the project planning/design; and ultimately the construction, and may cover several different organisations though the life of the project

If a project is designed within a Road Authority, the 'Project Team' may be the Planning Division, Survey and Design Division, Road Maintenance Division, or the Regional Engineer. If the project is designed outside the Road Authority the Project Team might be a consultant or even a contractor (in the case of very small or design and build projects).

The Project Team may prepare the audit brief for the Client, assess the appropriateness of the RSA Team proposed, and review the technical aspects of the RSA finding before forwarding recommendations to the Client for the final approval.

The Project Team will:

- Be the main point of contact for the RSA Team during the audit to provide scheme information, relevant contacts, and key construction dates for programming each audit stage
- Be responsible for reviewing the RSA Team's comments and ensuring that the Client is advised of the consequences of any audit recommendations and identifying any design/audit disagreements
- Provide technical support and advice to the Client

5.1.3 RSA Team

The RSA Team comprises two or more road safety specialists that critically review all project materials in terms of best road safety practice and identifies and describes all project related road safety concerns from the perspective of all road users. The RSA Team does not participate in the planning or design of the project nor do they weigh economic considerations higher than safety considerations.

The RSA Team needs to be comprised of independent specialists engaged specifically for the scheme with a clear brief and terms of reference put in place by the Client organisation. In this way the RSA Team will be taking a fresh look at the project without the distraction of having been involved in the design.

5.1.4 Relationship Management

Keeping lines of communication open between the Client, the Project Team and the RSA Team is essential for a successful RSA.

It is important throughout the RSA process that the Client and particularly the Project Team is encouraged to maintain contact with the RSA team, where appropriate. This liaison can take a number of forms:

- Direct contact to clarify the scheme brief, to discuss issues on plans or to request further information
- Meeting designers/Client on site as and when required
- Undertaking Interim Audits or providing Safety Advice when requested
- Attending post-audit meetings to clarify issues raised in RSA Reports

It is important, however, that this liaison does not compromise the independence of the RSA Team. Road Safety Auditors should not remove or change RSA problems and recommendations from reports unless liaison with the Client has revealed that the RSA comment was based on the Road Safety Auditor being misinformed. In this scenario it may be appropriate to amend the report.

RSA involves one set of specialist professionals checking the safety implications that result from the design produced by another set of professionals. This calls for diplomacy and mutual respect. The RSA Team must try and understand the background to design decisions and avoid being 'over-critical' of issues that are not substantive.

Highway designers should keep an open mind and accept that the RSA Team may be able to improve the safety of the design for the benefit of every road user. The RSA process brings specialist advice into the design process – it is not a test of the competence of the highway designers.

5.1.5 RSA Team Continuity

It is preferable that the same RSA Team undertake all the audit stages of a particular project wherever possible. This is advantageous from a point of view of economy and consistency of approach. Any changes to the RSA Team or its individual members will be subject to approval by the Client.

5.2 RSA Team Composition and Experience

5.2.1 Capacity and Availability of Experienced Personnel

Many countries where this manual will be used have a limited number of appropriately qualified or experienced Road Safety Auditors and need to rely on external specialists. 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 RSA 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, though the Team Leader experience and qualifications presented in this manual are relatively stringent, essential and desirable experience and qualifications are included for the other roles such that this is a possibility.

It remains the prerogative of the Client to accept the nomination of an RSA Team Leader and other Team Members based on an overview of the nominee's experience and skills as provided in Curriculum Vitae (CV). The CV should demonstrate the essential qualifications and experience as outlined below and any relevant specialist experience. A Continuing Professional Development (CPD) record should demonstrate active learning opportunities in road safety, crash investigation and/or road safety engineering.

5.2.2 RSA Team Composition

RSA Teams must include two or more people. One Team Leader and one Team Member are essential at all RSA Stages.

At least one member of the team needs an engineering qualification.

One person alone will not identify all safety issues; therefore it is considered essential that a RSA Team is 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 provide a different perspective.

One of the team should be designated as the RSA Team Leader. Other members of the RSA Team can have varying degrees of knowledge and experience of RSA and differing specialisms and, as such, bring a fresh perspective to aspects of the scheme and their comments should not be discounted.

Successful Road Safety Auditors need to be able to read scheme plans and visualise what the scheme will look like from the point of view of different road user groups. They must be able to take on the perspective of each type of road user and imagine how they would be able to cope with the scheme. Asking themselves questions such as, how easy will it be for the motorist to make the right turn at an intersection? Where would a pedestrian want to cross the road?

If the members of the RSA Team have different areas of expertise, particularly in non-engineering areas, this can enhance the quality of the audit as it is important to consider the scheme from the point of view of all road users. Non-engineering examination can sometimes reveal unexpected aspects overlooked by those who are more familiar with the design process. Every RSA can serve as a training exercise for novice auditors, and be an opportunity for all members of the RSA Team to gain more experience.

Having at least one member of the RSA Team (Leader, Member, Observer or Specialist Advisor) with good local knowledge should be considered essential so that how the scheme is likely to be used by the local population is taken into account along with the wider context of the scheme. It may be appropriate to invite a local engineer from the Client organisation to become an Observer to fulfil this important role. The need for such a Member or Observer to be independent from the actual design process or from the line management pertaining to that project, must still be emphasised. This will also serve to enhance capacity within the Client organisation.

The specialist skills and size of the RSA Team depend upon the type and size of the scheme and complexity of the project and the RSA Stage.

Audits at the different stages of project implementation can call for different skills in the RSA Team as detailed in the following paragraphs.

5.2.2.1 Stage 1: Feasibility Study

Essential:

- A RSA Team Leader who is very experienced (as per the requirements of Section 5.2.3.1) and can identify broad and subtle road safety issues. Familiarity with road designs/standards is necessary and the Team Leader needs to be able to visualise the layout in three dimensions.
- A RSA Team Member who meets the essential experience and qualification requirements as per Section 5.2.3.2.
- One member of the RSA Team (Leader, Member, Observer or Specialist Advisor) must have local experience in order to provide local context and appreciation of how the scheme fits into the wider road network/understanding of road user behaviour.

As required (if not covered by the RSA Team Leader/Team Member/Observer):

- If there are unusual aspects to the proposed project, Specialist Advisors can be included.

5.2.2.2 Stage 2: Preliminary Design

Essential:

- A RSA Team Leader who meets the essential experience and qualification requirements as per Section 5.2.3.1.
- A RSA Team Member who meets the essential experience and qualification requirements as per Section 5.2.3.2.
- One member of the RSA Team (Leader, Member, Observer or Specialist Advisor) must have local experience in order to provide local context and appreciation of how the scheme fits into the wider road network/understanding of road user behaviour.

As required (if not covered by the RSA Team Leader/Team Member/Observer):

- Specialist Advisor in traffic behaviour.
- If there are unusual aspects to the proposed project, Specialist Advisors can be included.

5.2.2.3 Stage 3: Detailed Design

Essential:

- A RSA Team Leader who meets the essential experience and qualification requirements as per Section 5.2.3.1.
- A RSA Team Member who meets the essential experience and qualification requirements as per Section 5.2.3.2.
- One member of the RSA Team (Leader, Member, Observer or Specialist Advisor) must have local experience in order to provide local context and appreciation of how the scheme fits into the wider road network/understanding of road user behaviour.

As required (if not covered by the RSA Team Leader/Team Member/Observer):

- Specialist Advisor in traffic behaviour.
- Specialist Advisors to deal with details 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 fields or a representative of the road user group (e.g. elderly, pedal cyclist, public transport operator or pedestrian).

5.2.2.4 Stage 4: Pre-Opening

Essential:

- A RSA Team Leader who meets the essential experience and qualification requirements as per Section 5.2.3.1.
- A RSA Team Member who meets the essential experience and qualification requirements as per Section 5.2.3.2.
- One member of the RSA Team (Leader, Member, Observer or Specialist Advisor) must have local experience in order to provide local context and appreciation of how the scheme fits into the wider road network/understanding of road user behaviour.
- Specialist Advisors:
  - Traffic Officer (local knowledge of traffic patterns and road user behaviour).
  - Maintenance agent representative.
  - Community representative.

(Note Specialist Advisors may be accompanied by the RSA Team Leader at a separate time from the rest of the RSA Team to avoid distraction from the technical audit).

As required (if not covered by the RSA Team Leader/Team Member/Observer):

- Specialist Advisor in traffic behaviour.
- 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 fields or a representative of the road user group (e.g. elderly, pedal cyclist, public transport operator or pedestrian).

5.2.2.5 Stage 5: Post-Opening

Essential:

- A RSA Team Leader who meets the essential experience and qualification requirements as per Section 5.2.3.1.
- A RSA Team Member who meets the essential experience and qualification requirements as per Section 5.2.3.2.

- One member of the RSA Team (Leader, Member, Observer or Specialist Advisor) must have local experience in order to provide local context and appreciation of how the scheme fits into the wider road network/understanding of road user behaviour.
- Specialist Advisors:
  - Traffic Officer (local knowledge of traffic patterns and road user behaviour.
  - Maintenance agent representative.
  - Community representative.

(Note Specialist Advisors may be accompanied by the RSA Team Leader at a separate time from the rest of the RSA Team to avoid distraction from the technical audit).

As required (if not covered by the RSA Team Leader/Team Member/Observer):

- Specialist Advisor in traffic behaviour.
- 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 fields or a representative of the road user group (e.g. elderly, pedal cyclist, public transport operator or pedestrian).

5.2.3 Training and Experience of the RSA Team

Road Safety Auditing is a skilled job and 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 RSA depends to a very great extent on the skills, abilities and experience of the RSA Team. Selecting the right team for a particular project is essential. Competence in RSA comes through hands-on experience. Training is helpful at the start but is only a base upon which experience needs to be built.

RSAs are best undertaken by road safety or traffic specialists who have had experience of undertaking crash investigation. Highway engineers with no safety experience do not make good Road Safety Auditors as they tend to view RSA as a check of compliance against design standards and do not have an appreciation of road safety issues. Specialists who have a background in behavioural sciences and experience in road safety can also bring useful skills and perspective to the audit process, but they also need an appreciation of the engineering aspects to develop appropriate audit recommendations. At least one member of the RSA Team needs an engineering qualification.

5.2.3.1 RSA Team Leader

The RSA Team Leader has overall responsibility for carrying out the RSA, managing the RSA 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 OR 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 Completion of a recognised RSA course of at least 4 days duration	-
Experience	5 years' experience in a relevant road safety, design, construction or traffic engineering field 3 years' experience of crash investigation Experience working in the country/region	10 years' experience in a relevant road safety, design, construction or traffic engineering field 5 years' experience of crash investigation
RSA Experience	Must have undertaken at least 5 RSAs of representative stages within the last 2 years as a RSA Team Leader or Member For those with more than 10 years' experience of crash investigation or RSA, must have undertaken: ■ 10 RSAs within the last 10 years as a Team Leader or Member AND ■ 1 RSA within the last year as a Team Leader or Member	-
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 local or international RSA organisation

5.2.3.2 RSA Team Member

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

Table 3: Team member experience and qualifications

	Essential	Desirable
Qualification	University degree OR 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 Completion of a recognised RSA course of at least 4 days duration	-
Experience	2 years' experience in a relevant road safety, design, construction or traffic engineering field 1 years' experience of crash investigation Must have undertaken at least 3 representative	3 years' experience in a relevant road safety, design, construction or traffic engineering field 2 years' experience of crash investigation Experience working in the country/region
RSA Experience	RSAs within the last 2 years as a RSA Team Leader, Member or Observer OR For those with more than 10 years' experience of crash investigation or RSA, must have undertaken: ■ 10 RSAs within the last 10 years as a Team Leader, Member or Observer AND ■ 1 RSA within the last year as a Team Leader, Member or Observer	-
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 local or international RSA organisation

5.2.3.3 Observer

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

Table 4: Observer experience and qualifications

Essential
Experience: 1 year experience of crash investigation or road safety OR Completion of a recognised RSA course of at least 4 days duration

5.2.4 Specialist Advisor

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

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

The Client and the RSA 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 appointment of Specialist Advisors to advise the audit team. Appointment of Specialist Advisors is subject to the approval of the Client who would separately instruct them on their role. A Specialist Advisor is not a member of the RSA Team but advises the team on matters relating to their specialism. They should be named in the Audit Report.

6. The RSA Process

Before beginning a RSA, there are some important considerations:

- The team undertaking the RSA should be qualified as per the requirements in Section 5.2.3
- The process needs to be repeated for every Audit Stage as per Section 4
- The whole process should be applied for all schemes regardless of scheme type or size, though the complexity will differ

A Project Safety File should be kept and maintained by the Client (this is sometimes a construction Health and Safety requirement) that will contain the following for all RSA stages:

- Any background information such as crash data, traffic flow data, plans, related projects, earlier RSA reports and other relevant local knowledge
- RSA report
- RSA final record

6.1 Contracts and Planning

RSA is an integral part of the design and construction process and needs to be planned accordingly and appropriate contracts need to be put in place.

At the beginning of any new road scheme, or any scheme for the improvement or modification of the road network, the Client must consider and plan for RSA. As is discussed in Section 3.4, the effective use of RSA does provide substantial life and cost savings to a road project. It is far easier and cheaper to modify plans during the design and implementation stages than it is to rework elements once constructed. Budgetary provision for undertaking a RSA and for addressing RSA recommendations needs to be identified and reserved at an early stage.

The complete RSA process needs to be specified and detailed within any contact documents. The Client should plan for the management of RSA throughout the entirety of the scheme development including post road opening. The Client is also responsible for specifying the level and timing of audit involvement required on any scheme in accordance with the process outlined in Section 6.2.

Issues that should be considered include:

- What Stages of RSA need to be undertaken (depending on scheme size and complexity)?
- Which Design/Contracting organisations will be involved? This will depend on the RSA Stage. The following organisations are collectively known as the ‘Project Team’:
  - Design Consultants
  - Contractor
  - Maintenance Organisation
  - Temporary Traffic Management Consultants

Note: Although members of the Project team might contribute information or help facilitate road safety auditing, the RSA team must always comprise different people to, and be independent of, the Project Team.

Written records of information and reports developed during the audit process need to be retained within the Client organisation with copies passed on to subsequent RSA teams to provide continuity and traceability of audit findings and recommendations.

6.2 Steps for Each Stage

This Section provides guidance on the step-by-step process for completing a RSA. The process is shown in Figure 5.

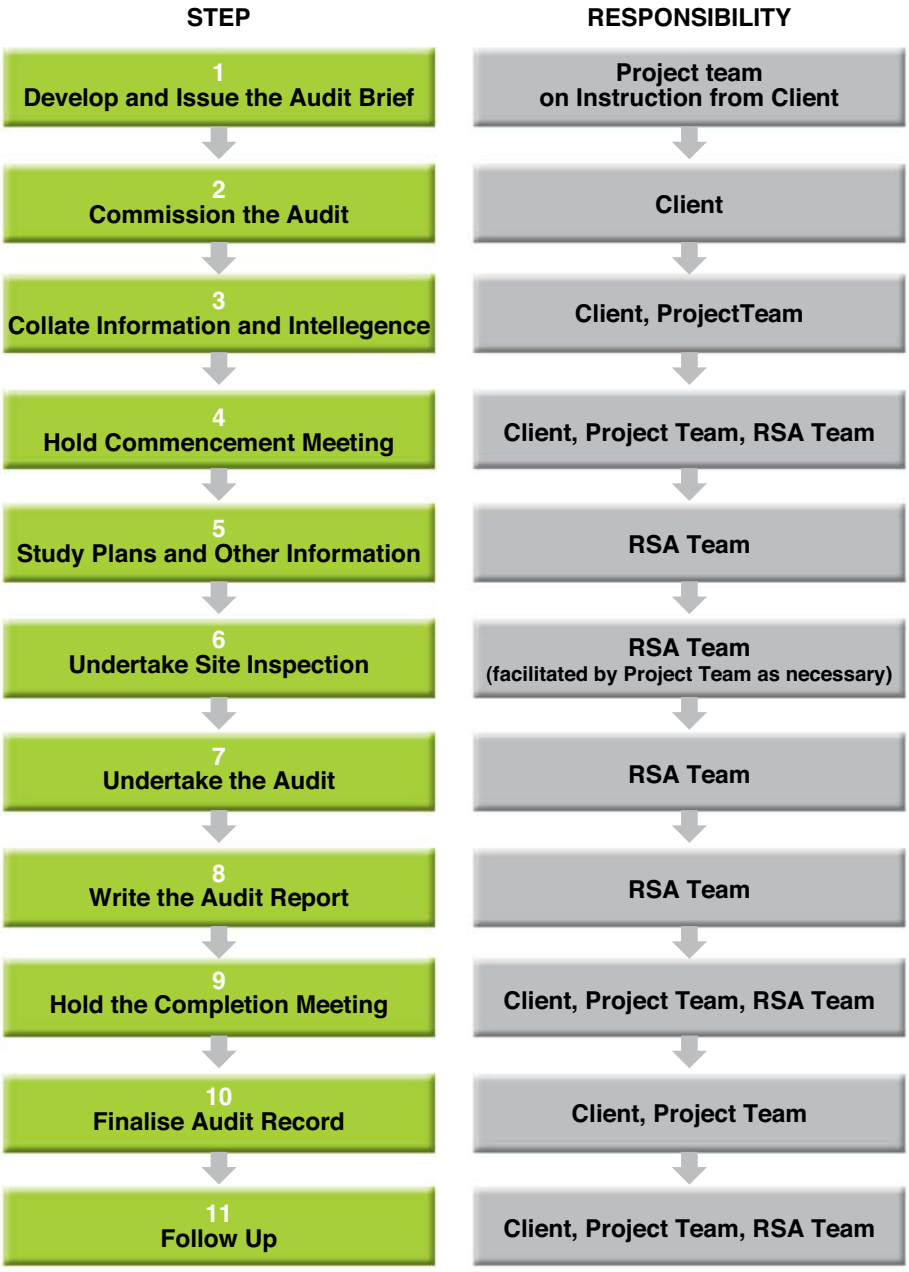

Figure 5: RSA process flow chart

5.2.1 Develop and Issue the Audit Brief

The Audit Brief is critical to ensuring the effective management and delivery of a RSA. The Audit Brief provides the basis on which to engage an appropriately qualified and experienced RSA Team in accordance with the requirements specified in Section 5.1.3.

It is the responsibility of the Client organisation to approve the brief, but often it is developed by the Project Team.

Ideally, an Audit Brief should be developed for the first Audit Stage undertaken and should cover all stages throughout the life of the project. When later audit stages are commissioned, the Audit Brief should be reviewed and updated as necessary prior to being re-issued.

A RSA Team is often engaged through some form of competitive tendering process and should be independent of the Client and Project Team. They will not have knowledge of the scheme they are being asked to consider. Therefore in order for the RSA Team to provide a realistic estimate of the time and resources needed for the audit, it is important that they are given as much information as possible in the initial brief. A clear and accurate proposal will only be received in response to a clear and comprehensive Audit Brief.

If the RSA Team is in-house, independence needs to be maintained and the Audit Brief is still required.

The brief needs to include:

i. Project title
ii. Summary description of the scheme to be audited – its nature, scale and duration
iii. Audit stages to be undertaken
iv. Any RSA or other manuals or guidelines to be adhered to. This will include a specification of the required RSA methodology and reporting system along with details of necessary meetings and site inspections.
v. Background to the scheme
    a. Description of the purpose and key elements of the scheme (i.e. pedestrian improvement; route widening)
    b. Overall layout and location plan (minimum scale 1:1250)
    c. Continuity with adjacent network and land uses
    d. Type and level of information to be made available (it is unrealistic to make all information available until the RSA Team is appointed)

vi. Timescales for the Audit:
    a. Likely timings for each Audit Stage
    b. Timescales for notification and mobilisation of RSA Team (typically 2-3 weeks)
    c. Timescales for completion of Audit Reports
    d. Timescales for the completion meeting and follow-up

6.2.2 Commission the Audit

This step will depend on whether there is an independent in-house RSA team within the Client organisation or not:

- If there is an independent in-house RSA team in the Client organisation then the commissioning of the audit can be a simple memo attached to the Audit Brief (see Section 6.2.1.
- If there is no independent in-house RSA team, a structured and more formal procurement process is needed. This needs to be planned in a similar way as the contract for the design and supervision of the works. Special care should be given to ensure that the procured RSA team has adequate experience and qualifications (see Section 5.1.3) and experience in auditing the type of scheme.

In commissioning an audit, the following issues need to be considered:

- Scale and complexity of the works
- The RSA stage that is to be undertaken

The Client should provide the Project Team (Designer or Contractor depending on the Audit Stage) with information about the instruction of the RSA Team.

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

6.2.3 Collate Information and Intelligence

Following appointment of the RSA Team and formal instruction to commence, the Client, through the Project Team, needs to provide all the relevant information to the RSA Team as specified in the Audit Brief. The level of detail required by the RSA Team will vary depending on the Audit Stage.

The RSA Team can only audit the scheme on the basis of the information they have been provided. It is essential that all relevant documents are provided to the RSA Team prior to them undertaking the audit.

The following detailed information and intelligence should be provided to the RSA Team:

i. Confirmation of the title of the project and scope of the audit
ii. Reporting requirements
iii. A full set of plans appropriate for the stage of audit being undertaken (minimum scale 1:500):
    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 for the RSA Team to mark up any issues
v. Copy of any previous Audit Reports and Project Team Responses
vi. A copy of the design standards adopted
vii. Any departures from standards, approved and planned
viii. Traffic flows, composition (including intelligence on pedestrian/pedal cyclist road usage)
ix. Historical speed data
x. Key traffic generators and attractors
xi. Intersection control information (traffic signal timing is appropriate)
xii. Key contacts with Client, Project Team and Police (and possibly local community groups)
xiii. Available historical crash data
xiv. Any other pertinent local knowledge or information

6.2.4 Hold Commencement Meeting

The most effective way for the RSA Team to acquaint themselves with the background and information available for a scheme is to review the project plans and other information at a formal Commencement Meeting.

This meeting provides the opportunity to discuss the project's purpose, particular issues and any problems which have been encountered during the planning, design or construction stages. The opportunity should also be taken for the RSA Team to become fully acquainted with the stated objectives of the scheme and to raise any queries relating to the brief and information that has been provided.

In order to gain best value from the discussion, the RSA Team should review the Audit Brief and any supplied information prior to the Commencement Meeting taking place. In this way they are fully prepared for a detailed discussion on the scheme itself.

The meeting is also a good time to confirm the process and distinguish between the tasks and responsibilities of the RSA Team and those of the Project Team. The protocol for delivery of the Audit Reports should also be discussed at this meeting.

6.2.5 Study the Plans and Other Information

The aim of this step is to identify issues for:

- Further clarification from the Client or Project Team
- Further investigation during the Site Inspection

After appointment, the RSA Team should review the plans and other information provided by the Client in detail. It is important to review all documentation received and to ensure that there is sufficient time to do

so. Some of the information may be discounted since it is not relevant to road safety, though this should be documented in the RSA Report.

The review of the information should consider the impact of the scheme on all types of road users (including pedestrians and pedal cyclists).

The initial review might generate a number of queries that need to be resolved by the RSA Team and which may involve the request for more detailed information or clarification of details already received. This can best be achieved by direct contact with the Project Team once the initial review of the documentation has been undertaken.

The review of plans and other information also enables the RSA Team to record first impressions and list possible issues to be considered during the Site Inspection. Auditors should keep in mind the key principles described in Figure 6 throughout the audit.

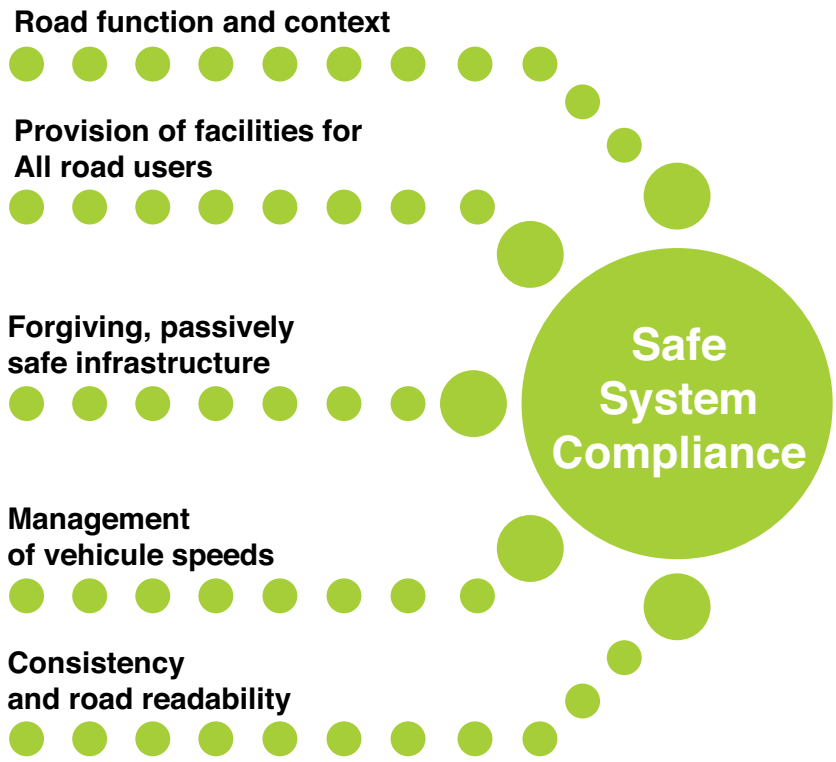

Figure 6: High level issues for consideration

Members of the RSA team should consider the following:

- Road function and context:
  - Is the type of scheme appropriate for the proposed function of the road?
  - Is the type of scheme right for the proposed traffic flow and modal split?

- ❏ Would safety be improved by re-locating or re-aligning the 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 scheme?
- ❏ Is the scheme character and scale consistent with the adjacent route and network?
- ❏ Does the 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?

6.2.6 Undertake Site Inspection

In order for a clear understanding of the project to be gained, it is important that the RSA Team carry out a Site Inspection.

It is just as important to visit a site at an early stage of scheme development, as it is when the road is being built or is due to be opened. This is in order for the RSA Team to understand the context of any plans and

the scheme within the existing road network. It will also allow the RSA Team to see how the current facilities are used and the level of traffic etc.

More detail will be available at later stages and it is more likely that specific hazards will be identifiable during those site visits.

Site Inspections:

- Should be undertaken at different times of the day and at night-time. Site Inspections 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 school holidays or other times when traffic conditions are atypical. A night-time inspection, 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 RSA Team to take the perspective of all prospective road users (drivers, pedal cyclists, pedestrians etc.).
- Must be undertaken safely. The safety of members of RSA Team, other road users and construction or other personnel must not be compromised by the Site Inspection.

Site Inspections for major schemes will often need to take place over several days and careful planning will therefore be necessary.

All members of the RSA Team should attend all Site Inspections together. Other interested parties (e.g. Police) may also be in attendance.

It is recommended that a full video of the whole route inspected is recorded and that many site photographs are taken during the Site Inspection. These are important in order to provide:

- The RSA Team with a reminder of key issues when undertaking the audit/writing the Audit Report
- Illustrations of issues to the Project Team
- A record to the Client
- A record of conditions on-site during the site inspection

Taking videos and photographs in a systematic manner will help when reviewing them later. A video sequence should be started by 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 inspection for later reference.

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

Safety

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

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

Site inspections need to be carefully planned as various people will need to stop at several locations where safety hazards will be present. A full risk assessment and safe plan of action needs to be prepared prior to undertaking the site visit to assess all potential hazards to the Audit Team and other road users and to develop a methodology for minimising risks.

Assess to the roads, means of travel and potential stopping places must be carefully considered together with use of appropriate high visibility clothing and markings for vehicles.

6.2.7 Undertake the Audit

The Audit itself is the detailed review of all information collected through the review process and Site Inspection to determine the safety issues that would be experienced by all users of the completed scheme. Reviews of the information should be done individually and in a team-setting. Individual auditing allows an in-depth consideration of different aspects of the design while discussing with the wider team can lead to the identification of new safety issues and better ways to mitigate or eliminate safety concerns. The Team Leader is responsible for bringing these views together and achieving consensus.

Where no consensus is achieved or specific issues are unclear, additional input can be provided by a specialist advisor.

Auditors should remember to:

- Consider the needs of all road users (including pedestrians (especially children), pedal cyclists, and motorcyclists) in all weathers and lighting conditions
- Be thorough and comprehensive
- Be realistic and practical
- Restrict their consideration to road safety issues
- Consider the implications of any advised departures from normally applicable design standards (whilst also remembering that compliance elsewhere does not necessarily guarantee the safety of a road)
- Consider likely traffic flows, mixes and road user behaviours
- Consider the interactions of highways' features

Use of Prompts

In this manual two sets of prompts have been developed for use at each stage of audit.

- 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. These can be found in Appendix B.1.
- The second set of prompts provides a high level list of physical road elements that should be looked at in the Site Inspection. These can be found in Appendix B.2.

The prompts present different questions regarding the safety of all users for different stages of a project's development 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 RSA Team. A RSA should not be undertaken as a 'tick list' exercise.

6.2.8 Write the Audit Report

A formal Audit Report should be completed for all Audit Stages undertaken.

The main purpose of the Audit Report is to succinctly report on aspects of the project that involve hazards and make recommendations about actions to remove or reduce those hazards. The recommendations should indicate the nature or direction of a solution, rather than precise details. Responsibility for incorporating the recommendations into design solutions will rest with the Client and Project Team.

For reports at all stages of RSA, the same layout will be used:

- A brief background description
  - Identification of the Audit Stage
  - RSA Team Members as well as the names and affiliation of other contributors to the audit
  - 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.)

- 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 as a result of the issue
    - Where available, illustrative photograph(s)
  - Recommendations for action to mitigate or remove the issue

- A statement, signed and dated by the RSA Team Leader
- A list of the documents and plans considered for the audit
- Post-Opening Audits will have been undertaken on roads that have been open to use by the public for a number of months (typically 12 months). As such, the report should also include consideration and analysis of operational data (including crash data) along with issues identified during observations of traffic using the site.

Where previous RSA reports have been produced for the scheme these should be reviewed before identifying new issues and any outstanding items should be re-stated along with a reason why the RSA Team believes that the issue has not been resolved.

The report should be written in an objective and professional manner and not be judgemental of the professional or technical knowledge of the Project Team. Words such as 'unsafe'; sub-standard'; 'unacceptable' and 'deficient' should be avoided.

Any recommended treatment should be appropriate and viable for that particular stage of the audit and proportionate to the scale of the identified problem. Recommendations worded as "to consider...", "to study....", "to monitor...", "to investigate possible treatments and implement the most appropriate...", etc. need to be avoided.

Similarly when describing the problems themselves, they should not seek to identify the solution or seek to encourage the Client to take a particular course of action. A phrase such as 'there is a sharp tree lined bend with no road restraint system' should be rephrased to 'the bend at xxkm is estimated as having a radius of 'yy' m. For the anticipated design speed it will encourage run off crashes'. A sample report is included in Appendix C.

The report only considers road safety implications. It is the Client's responsibility to take these safety concerns and incorporate them with all the other scheme parameters to decide on the most appropriate course of action following consideration of the report recommendations.

On completion, the Audit Report is submitted to the Client who will send a copy to the Project Team for technical consideration of any recommendations. Once these have been reviewed there is the opportunity for all parties to meet to discuss the findings.

Crashes are rare, random, multifactor occurrences and attempting to predict where the next one is going to occur is impossible. What the audit process does is identify those elements of the road environment which present the greatest hazard to road users. Therefore whilst it is possible to identify the nature and scale of the hazard it is very difficult to identify when a crash will occur. The frequency with which crashes will occur is equally difficult to predict. Therefore trying to rank the risk of individual problems is inappropriate. A number of international authorities do propose risk ranking methods but these are very subjective and dependent upon large amounts of crash investigation to deliver any certainty. It is therefore recommended that, unless specifically required by the Client, no comparative ranking of risk of individual problems should ordinarily be made through the audit reporting process.

6.2.9 Hold the Completion Meeting

Once the Project Team's report has been received, the Client will request the RSA Team Leader to attend the Completion Meeting together with the Project Team. The purpose of the Completion Meeting is to enable the Client to obtain further information or clarification about the audit findings and to explore with the Project Team what corrective action can be taken.

It is important that the RSA Team and Project Team understand that the Client alone will make the decision on what action is to be taken (or not) to correct the safety problems identified by the audit. These decisions should be based on the consideration of all the relevant scheme criteria (i.e. cost, complexity, crash saving, road user benefit, etc.). There is no need to reach agreement between all three parties. The Client will decide on the corrective action either at the meeting or afterwards. In some circumstances the Client may wish to consult other parties before making a final decision.

6.2.10 Finalise Audit Record

The Audit Record documents the responses of the Client (possibly informed by the Project Team) to the RSA report issues and recommendations. The Audit Record should comprise a written response to each individual audit finding or recommendation. It should state what actions are being taken in response to each recommendation and, if this differs from the recommended action, then the reasons for this decision should be clearly stated.

The Audit Record should be signed by a representative of the Client. This response document forms the conclusion of the audit process.

In preparing responses for the Audit Record, careful consideration should be given to each recommendation. Although Audit recommendations are not mandatory, it must be considered that in the event of a crash, the Audit Record (including the reasons for not following Audit recommendations) may be sought by representatives of an injured person.

It is therefore essential that if it is not possible to adopt a recommendation then a reason should be given. Consideration may be given to another way of partly addressing the issue, or the implementation of a staged solution over time and, if this is the case, then this should be detailed in the Audit Record. Upon preparing the Audit Record responses, the Client or Project Team may wish to instruct an independent assessor for assistance to determine how to respond to Audit findings.

Each issue or recommendation in the Audit Report can be responded to by:

- Accepting it completely and:
  - Designing a solution to overcome or reduce the problem in line with the audit findings or recommendation
  - Providing an alternative solution that fully addresses the issue

- Accepting it in part or in principle but, due to other constraints, implementing changes which go only part of the way to resolving the safety problem
- Not accepting the finding or recommendation

If the recommendation is accepted completely, the proposed action (for example, by whom and when) should be recorded.

Where the recommendation is accepted in part or not at all, the reasons must be set out in writing. If the finding is accepted but the recommendation is rejected this must be reflected in the response.

The Client must sign a statement in the Final Audit Record that commits them to follow up the decisions recorded in the Audit Record.

The Project Team should also sign a statement to the effect that they accept the Client's decisions and will amend the design accordingly.

Copies of the Final Audit Record should be sent to the RSA Team Leader for information and to the Project Team for action. The original approved report needs to be stored centrally for future reference.

6.2.11 Follow Up

It is essential that any changes to the design which are agreed by the Client as a result of the RSA process are implemented. The Client will instruct the Project Team to make the necessary amendments to the design and it is important that these instructions are clearly recorded in order to avoid confusion and in order to demonstrate, if necessary, that best practice has been followed.

In the event of the Client not fully agreeing to the recommendations of the RSA Team, the Client may ask for a final or supplementary road safety report or reports to be written prior to receiving the RSA Report from the next Stage.

Completed audit reports should be stored centrally so that these can be reviewed periodically.

7. Monitoring

All completed audit reports should be stored centrally and the findings summarised and reviewed on a regular basis. Where common problems are repeated over a number of audits there may be a case for additional training of designers, or modification to design standards to take account of particular local requirements. Audit is not a static process, but an ever changing one as experience in design and safety issues, and changes in road user behaviour in a particular environment develop. Consequently the findings from RSA reports can have a positive influence on future designs and through an on-going process of communication with design teams the overall design of new schemes can be enhanced and efficiency in delivery improved.

There is no clear evidence base concerning the effectiveness of road safety engineering treatments in Africa. Therefore it is necessary to monitor any recommendations resulting from RSA to determine the impact of a treatment or treatment plan under different circumstances. The monitoring process should consider:

- Is the resultant design being used by the public in the manner that was anticipated / intended?
- Have any crashes occurred that the recommendation was intended to mitigate or minimise?
- Have any other crashes occurred as a result of the implemented solution?

The findings from all RSA reports should be stored or registered centrally so that they can be periodically reviewed (e.g. every 3 years). The review is undertaken to detect instances where similar problems are repeatedly detected and treated in a similar manner. In these instances, it may be appropriate to revise the design standards or included in the training of designers.

In addition, the final outcomes of any RSA reports should be referred to a road safety team for inclusion in a programme of Road Safety Assessments so that the performance of the proposed improvements can be monitored and evaluated in specific local conditions. This will ensure the effectiveness of treatments is quantified, and that the value of RSAs is better understood.

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Glossary

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

Audit Brief: The instructions to the audit team defining the scope and details of the road project to be audited, including sufficient information for the audit to be undertaken.

Audit Record: A written response to the Audit Report which is signed by the Client and which records actions that are to be taken in response to each and every safety observation identified in the Audit report.

Audit Report: This provides a concise written record to the Client of identified safety problems and of actions that need to be taken to improve safety. The report provides the formal documentation on which decisions about corrective action will be based.

Audit Team: A team that works together on all aspects of the audit, independent of the design team and approved for a particular audit by the Client.

Audit Team Leader: A person with the appropriate training, skills and experience who is approved for a particular audit by the Client. The Audit Team Leader has overall responsibility for carrying out the audit, managing the audit team and certifying the report.

Audit Team Member: A member of the audit team with the appropriate training, skills and experience who is approved for a particular audit by the Client, and who reports to the Audit Team Leader.

Audit Team Observer: A person with the appropriate training, skills and experience accompanying the audit team to observe and gain experience of the audit procedure.

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

Clear Zone: Lateral roadside area free from any obstacles that could cause harm.

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.

Crash Investigation: The collection and examination of historical crash data over a period of time in order to identify patterns, common trends and factors which may have contributed to the crashes.

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

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

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

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.

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.

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

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.

Maintenance Agent: The authority responsible for maintaining the completed road project. This is typically a term contractor employed on behalf of the road authority to undertake this function.

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.

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. Ribbon Development: Development that occurs along roads between settlements.

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

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

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

Road Furniture: A collective term for objects and equipment installed on streets and roads for a variety of purposes. The term includes items such as safety barriers, phone boxes, lighting columns, signs, waste receptacles etc.

Road Projects: All works that involve construction of new road or permanent change to the existing road layout or features. This includes changes to road layout, kerbs, signs and markings, lighting, signalling, drainage, landscaping and installation of road-side equipment. A road project may involve construction of a major or minor road, major or minor rehabilitation/retrofit, a major or minor development, or traffic calming.

Road Safety Assessment: An intensive expert assessment of the safety of a road environment and the way in which road users interact with and use it. This process involves site inspection(s) and is undertaken in reaction to intelligence.

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

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 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.

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.

Specialist Advisor: A person approved by the Client, to provide specialist independent advice to the audit or assessment team should the project or road include complex features outside the experience of the Audit or Assessment Team Members, for example a complex traffic signal controlled intersection.

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.

Traffic Generator: Any development that generates traffic. Examples include schools, housing areas, leisure facilities, businesses etc.

Transitions: Changes in the type of road (e.g. from dual/divided carriageway to single carriageway) or changes in the posted speed limit.

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 for Project Team

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 5 provides information about each treatment 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.

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Table 5 : Treatment information

Treatment	Cost	Benefits	Implementation Issues
Additional Lane 	High	Reduced risk of overtaking crashes. 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. Signs telling drivers when an overtaking lane is ahead will reduce the likelihood of them overtaking in less safe areas. Overtaking lanes should not be installed at sites which include significant intersections or many access points. Vehicles travelling in the opposite direction to the overtaking lane must be prevented or discouraged from also using this lane. Physical barriers may be required.

Treatment	Cost	Benefits	Implementation Issues
Central Hatching 	Low	Fewer head-on and overtaking crashes. Can provide refuge for turning vehicles away from through-traffic lanes. 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. Can be used for opportunist overtaking opportunities increasing risk of collisions. Maintenance of markings.
Central Turning Lane 	Low	Improved traffic flow. Some reduction in speeds.	To be used only in areas with a high concentration of intersections/accesses. Two way turning lanes should not be used at intersections. Appropriate pedestrian protection should be used in areas with pedestrian activity. 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. Priority/usage should be clearly marked to avoid head-on crashes.

Treatment	Cost	Benefits	Implementation Issues
Delineation (includes lining, signing, marker posts etc.) 	Low	Road markings are very cost effective. Delineation improvements have been shown to reduce head-on road crashes. Helps drivers to maintain a safe and consistent lateral vehicle position within the lane. Reduction in night-time and low-visibility crashes.	In many countries line-marking is ignored (and physical barriers to crossing the centre line are needed). Poorly designed or located delineators can add to crash risk. Too many signs can confuse drivers. Road studs require a good quality road surface. Delineation needs to be consistent throughout an entire country. The retro-reflectivity of lines and signs is an important consideration for road use at night and in the wet. 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. Simpler traffic movements leading to less opportunity for conflict. Redirection of turning movements to safer locations. Protection for turning traffic. Reduced traffic congestion.	This treatment is costly, and other lower cost treatments (such as median barrier installation) should also be considered. Requires a large amount of land. Potential to increase pedestrian and lane change crashes. Community acceptance of the medians that restrict turning movements or restrict pedestrian movements may be an issue

Treatment	Cost	Benefits	Implementation Issues
Grade Separation 	High	Improved traffic flow. Simplifies potentially complex movements typical at 'T' and 'X' intersections. Can also include roundabouts for high traffic flows. Removes the cost of running at-grade traffic control hardware.	A range of design options should be considered before a grade separated interchange layout is chosen. Adding on-ramps and off-ramps to a freeway can increase high speed weaving and merging crashes. Interchanges can negatively impact the appearance of an area. They may separate communities due to their size. Difficult for pedestrians unless specific routes are provided 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 	High	Better traffic flow. 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. Horizontal curve realignments require considerable design and construction effort. These projects may also require the purchase of land.
Inter-Visibility Improvement -Sight Distance 	Low to med.	Adequate sight distance provides time for drivers to identify hazards and take action to avoid them. Improved sight distances	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. In some situations such as intersection approaches, excessive forward

Treatment	Cost	Benefits	Implementation Issues
		on the approaches to intersections and through curves can reduce crashes at these high-risk locations. Good forward visibility at pedestrian crossing facilities will give drivers more time to react. Rear end collisions can be reduced with improved forward visibility.	visibility can lead to high speeds on approach and take attention away from the intersection. 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. 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). Ensure traffic signs and signal heads are not obstructed by vegetation or street furniture.
Lane Widening 	Med. to high	Additional manoeuvring space. Space for two wheeled users.	Lane widening can be costly, especially if land must be purchased. 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. 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.

Treatment	Cost	Benefits	Implementation Issues
Median Crossing Control 	Low to med.	Reduction in intersection crash types. Improves local access. Provides an additional emergency access point leading to improved emergency service response times.	Additional road space may be required. 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. Roadside hazards need to be removed or sufficiently protected. 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.
Median Shoulder Sealing 	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. Edge-lining can be improved at the time of upgrading the shoulder (especially when sealing). Shoulders should not be too wide or drivers may use them as an additional lane. 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) 	Med. to high	Reduced incidence of head-on crashes. Can help to prevent dangerous overtaking manoeuvres.	Median barriers can restrict traffic flow if a vehicle breaks down, and can block access for emergency vehicles. Pedestrians are often reluctant to make detours and may attempt to cross median. In some regions the materials used in median barriers may be at risk of being stolen.

Treatment	Cost	Benefits	Implementation Issues
		Can relocate turning movements to safer locations.	The ends of median barriers must be well designed and installed. 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. Barriers may be a hazard to motorcyclists.
One-Way System 	Med.	Reduces head on collisions. Improves traffic flow.	Because speeds can increase on one-way networks, traffic calming measures may be required (especially if the lanes are wide). Before a network is made one-way, traffic circulation in the area surrounding the network must be considered. 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 	Low to Med.	Converting angle parking to parallel parking provides extra road space. 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. Converting angle parking to parallel parking requires replacement of line marking. Changes to parking signs and kerbs may also be necessary. The community and business owners often object to the removal of parking in commercial centres. Parked cars can obscure crossing pedestrians, particularly children.

Treatment	Cost	Benefits	Implementation Issues
Pedestrian Crossing - Unsignalised  	Low	A clearly defined crossing point where pedestrians are 'expected' to cross. Disruption to traffic flow is comparatively low. Reduced pedestrian crashes if installed at appropriate locations, and if pedestrian priority is enforced.	Un-signalised crossings – Not suitable where traffic volumes or speeds are high. Signalised crossings – Compliance with signals must be good if significant casualty reductions are to be achieved. 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. Consider incorporating a pedestrian refuge island. 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 visibility devices (such as flashing lights) may also be used.
Pedestrian Crossing - Signalised 	Med.	A clearly defined crossing point where pedestrians are 'expected' to cross. 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. Crossing will only be effective if other road users give way to pedestrians. Education and enforcement may be necessary to ensure pedestrians have priority.

Treatment	Cost	Benefits	Implementation Issues
Pedestrian Fencing  	Low	Helps to guide pedestrians to formal crossing points. Can help to prevent unwanted pedestrian crossing movements. Physically prevents pedestrian access to the carriageway. Can help to prevent motorists from parking on the footpath. 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. 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. Consideration should be given to the design of the fencing to ensure that the risk to errant vehicles is limited upon impact. 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.
Pedestrian Over-Bridge/ underpass 	High	Traffic flow improvements.	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 involved. Pedestrian fencing can be used to encourage pedestrians to use crossing facilities. Cyclists may also be able to use the facilities – ramps would be required which need more land space. Personal security at underpasses should be considered.

Treatment	Cost	Benefits	Implementation Issues
Pedestrian Refuge Island 	Low to med.	Separating traffic moving in opposite directions to reduce head-on and overtaking crashes. May slow vehicular traffic by narrowing the lanes. Ensures pedestrians need only cross one lane of traffic at a time.	Pedestrian refuge islands must be clearly visible to traffic during both day and night. Refuge islands should be placed where there is a demand from pedestrians to cross. Where cyclists are present, refuge islands must not narrow the lanes too much. Turning movements from driveways and intersections must be considered in planning the location of pedestrian refuges.
Regulate Roadside Activity 	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. Reduction in VRU crashes.	Roads should be designed to allow for changes in land-use over time. Building regulations should specify the limits beyond which buildings must not extend. Illegal development can only be controlled if there are alternative sites for commercial activity. 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 	Med. to high	Reduces the number of potential conflict points. Reduces traffic friction and improves flow on the main road.	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. Minor intersection closures can often be achieved in cooperation with the local

Treatment	Cost	Benefits	Implementation Issues
		Improved traffic management at upgraded access points.	road authority, especially when safety at these intersections has been a subject of repeated complaint.
Roadside Hazard Protection (Vehicle Restraint Systems - Roadside Safety Barriers) 	Med.	If properly designed, installed and maintained, barriers should reduce the severity of crashes involving 'out of control' vehicles. Provides protection for substantial structures.	VRS should only be built if the existing hazard cannot be removed (see Roadside Safety - Hazard Removal). The terminals or end treatments of VRS can be dangerous if not properly designed, constructed and maintained. VRS should be located to minimize high impact angles and should also allow space for vehicles to pull off the traffic lane. Roadside barriers can be a hazard to motorcyclists. Ensure appropriate clearance behind safety barrier is considered particularly for flexible and semi-rigid barriers. 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 	Low to med.	Reduced road furniture repair costs associated with crash damage. Improved recovery potential for vehicles.	The width of the safety zone required depends on traffic speeds. 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. Replacement of removed trees with more appropriate plants should be

Treatment	Cost	Benefits	Implementation Issues
		Improved survivability of run-off road crashes.	considered, otherwise re-growth or soil erosion may affect the site. It is not always possible to remove road-side hazards, particularly in urban areas where space is limited. Reducing vehicle speeds is an alternative solution.
Roundabout  	Med. to high	Minimal delays at lower traffic volumes. Little maintenance required. Crash severity is usually lower than at cross road intersections or T-junctions due to angle of crash impacts and lower speeds due to deflection on approaches.	Solid structures should not be located on the central island. High painted kerbs around the island can reduce the risk of it being run into. Poor visibility on the approach to roundabouts, or high entry speeds, can lead to crashes. Facilities to help pedestrians cross the arms of the intersection should be provided in most urban locations. Roundabouts can be difficult for large vehicles, particularly buses, to use. Designers should be conscious of the risk that roundabouts can be present for cyclists and other slow vehicles, such as animal drawn vehicles. Care must be taken in the design of roundabouts to ensure adequate deflection upon approach to reduce vehicle speeds.
Rumble Strips 	Low	Can be parallel or transverse. Warning to motorists approaching the centreline. Improved visibility of centre lines.	Gaps in the rumble strips may be needed in some areas to allow water to drain from the road surface. The noise made by rumble strips can be difficult for drivers of larger vehicles to hear. Consideration must be given to those living near to the road as rumble strips can generate noise.

Treatment	Cost	Benefits	Implementation Issues
		Raised awareness on the approach to other hazards or devices i.e. road humps.	Rumble strips can be a hazard to motorcyclists.
School Zones 	Low to med.	School zones and crossing supervisors can reduce pedestrian risk. School zones aim to reduce vehicle speeds. School crossing supervisors can help to control pedestrian crossing movements and provide a safe place to cross.	Traffic signs and road markings must make it clear to motorists that they have entered a school zone. Consider incorporating flashing beacons to complement the school zone signs and markings. Through-traffic must be able to see pedestrian crossing points in time to stop for them. Advanced warning signs should be located on approaches with adequate forward visibility. Parking provision should be carefully considered within school zones with adequate sight distances at pedestrian crossings.
Segregated Diverge Nearside - Signalised 	Low to med.	Reduced crashes between turning vehicles and oncoming through-traffic. Reduced severity of crashes throughout the intersection.	Adding diverge signals reduces intersection capacity. It may be necessary to lengthen diverge lanes to fit longer traffic queues. Other signal changes can be used to improve intersection capacity when signalised turns are implemented.

Treatment	Cost	Benefits	Implementation Issues
Segregated Diverge Nearside - Unsignalised 	Low to med.	Reduced loss of control while turning crashes. Improved traffic flow. Increased intersection capacity.	Painted diverge lanes must be clearly delineated and have good sight distance. Diverge lanes should be long enough to allow a vehicle time to stop within it (clear of through-traffic). If a diverge lane is too long, through drivers may enter the lane by mistake. Signs at the start of the diverge lane may help prevent this. Installing diverge 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 between lanes.
Segregated Facilities - Pedestrians 	Low to med.	Improves facilities for pedestrians (improves accessibility). May help to increase walking as a mode of transport (environmental benefits and reduced traffic congestion). 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. Signage should be used to warn drivers of pedestrians if the road shoulder is commonly used as an informal footpath. Street traders, public utility apparatus and street furniture should not be allowed to obstruct the footpath.

Treatment	Cost	Benefits	Implementation Issues
Segregated Facilities – Pedal/ Motor-Cycles  	Low to med.	Increased use of pedal and motor cycles (reduced road congestion). 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. Traffic calming treatments or narrow road sections such as bridges can force pedal and motor cycles out into traffic, resulting in conflicts. 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. Surface quality must be high or it will pose a safety risk. Cycle lanes should be maintained to ensure that it is preferable to use the facilities rather than the shoulder or roadway. Maintenance includes repairs to the pavement surface and vegetation clearance. Adequate sight distance must be provided around bends and at path intersections. This also aids personal security. 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. Adequate crossing facilities need to be provided.

Treatment	Cost	Benefits	Implementation Issues
Service Road 	High	Can reduce the number of conflict points (intersections) along a route. Can be used by local traffic and vulnerable road users as an alternative to the (often higher speeds and higher volume) main road. 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. Parking and other potential visual obstructions should be carefully controlled where service lanes re-join the main road.
Shoulder Sealing 	Med.	Wide shoulders allow vehicles to pull off the road in emergency situations. Sealed shoulders can provide a cycling space and can be marked as cycle lanes. Provide structural support to the road pavement. 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. Edge-lining can be improved at the time of upgrading the shoulder (especially when sealing). 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.

Treatment	Cost	Benefits	Implementation Issues
Side Slope Improvement 	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. Flatter side slopes are generally less likely to erode. The cost of providing a traversable slope may be less than the cost of stabilising and maintaining steep slopes.	Side slopes should be free of hazards and objects that may cause vehicle snagging. Maximum traversable gradient is 1:3. On downward slopes, a clear run-out area may also be required at the base of the slope. 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. The provision of traversable side slopes may have property impacts and require extensive land acquisition. 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) 	Med.	Can increase intersection capacity. Can reduce certain types of crashes (especially right-angle crashes). 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. 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. Well-designed traffic signals will usually reduce total crashes but will sometimes increase specific (low severity) crash types (e.g. rear-end crashes).

Treatment	Cost	Benefits	Implementation Issues
			Traffic signals should not be used in high speed locations. In urban areas it can be difficult to ensure that traffic signals have sufficient visibility. Before installing traffic signals, information on traffic volumes, pedestrian volumes, intersection approach speeds and previous crashes at the site should be considered. Traffic signals need continuous power. Traffic signals and vehicle detection equipment are prone to malfunction so good maintenance is required.
Signing 	Low	Signs help drivers to adjust their behaviour to deal with approaching hazards or decision points. If reflective, they can help reduce night-time/ poor visibility crashes.	Poorly designed or located signs can add to crash risk. The message they convey needs to be clear and unambiguous. Too many signs can confuse drivers. The retro-reflectivity of signs is an important consideration for road use at night and in the wet. Maintenance of signs in rural and isolated areas can be problematic. Signs may be stolen in some areas.
Skid Resistance 	Low to med.	Improved safety for roads where many crashes happen in wet weather. Resurfacing provides an opportunity to fix other road surface pro-	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. 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
		blems, such as crossfall and rutting. Provides the opportunity for adding or replacing road surface delineation such as painted markings or reflective road studs. Can extend life of pavement surface. Retexturing has environmental benefits (lower cost and energy) over some traditional hot mix asphalt resurfacing. Often quick and repeatable treatments with low traffic disruption. 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. Existing road surface must be sound, therefore pre-patching and repairs may be necessary prior to application. These treatments will not typically add any strength to the road pavement.

Treatment	Cost	Benefits	Implementation Issues
Speed Management   	Med.	Reductions in travel speeds save lives and prevent injuries. Lower speeds can reduce the severity of all crashes. Reduced speeds will also reduce the likelihood of crashes occurring. The wider benefits of reducing speeds include improved fuel consumption, lower green-house gas emissions and less traffic noise.	Reduced speed limits need to be signed clearly and repeater signs used to remind road users of the speed limit. Road engineering treatments should ideally accompany reduced speed limits in order to encourage compliance. Enforcement may be necessary to achieve compliance. Speed limits should appear credible so that drivers will adhere to them. Where there is a significant drop in speed limit (e.g. on approach to a village/urban 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). 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. Speed humps and other devices need to be well designed to provide maximum safety benefits and located appropriately. Traffic calming devices can impede emergency vehicles and cause discomfort for bus passengers. Some traffic calming devices are hazardous to motorcyclists. Community support and consultation is recommended before speed limits are changed or traffic calming installed.

Treatment	Cost	Benefits	Implementation Issues
Street Lighting 	Med.	Street lighting helps to reduce night-time crashes by improving visibility. Can reduce pedestrian crashes by approximately 50%. Can help to aid navigation. Street lighting helps people to feel safe and can help to reduce crime. Route lighting can help to reduce glare from vehicle headlights.	The provision of street lighting poles can introduce hazards to the roadside. Frangible poles should be considered particularly in areas where there is low pedestrian activity. Alternatively, the poles can be protected by roadside safety barrier. It is important to achieve the correct spacing of lamp columns to prevent uneven lighting levels along a route. The provision of street lighting requires an electricity supply and is associated with ongoing power costs. Solar panels may be considered as an alternative power supply. Adequate clearan ce must be provided to overhead lines. Low pressure sodium lamps may be used to reduce light pollution particularly in urban areas.
Turing Pockets Offside - Signalised 	Low to med.	Reduced crashes between turning vehicles and oncoming through-traf-fic. Reduced severity of crashes throughout the intersec-tion.	Adding turn signals reduces intersection capacity. It may be necessary to lengthen turn lanes to fit longer traffic queues. Other signal changes can be used to improve intersection capacity when signalised turns are implemented.

Treatment	Cost	Benefits	Implementation Issues
Turing Pockets Offside – Un-signalised 	Low to med.	Reduced loss of control while turning crashes. Improved traffic flow. Increased intersection capacity.	Painted turn lanes must be clearly delineated and have good sight distance. Turn lanes should be long enough to allow a vehicle time to stop within it (clear of through-traffic). If a turn lane is too long, through drivers may enter the lane by mistake. Signs at the start of the turning lane may help prevent this. 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.
Vertical Realignment 	High	Reduced risk of vehicle equipment failure (steep grades). 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. 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 : 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 RSA Team ensure that all the necessary general issues and aspects of a road are considered.

Two sets of prompts have been developed for use during each stage of RSA:

- The first set (B.1) are high level road safety issues
- The second set (B.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 Audit Teams and they should not be used as 'tick lists'.

B.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

B.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 RSA 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 C : Sample Road Safety Audit Report

City of Narusha Public Transport Improvement Saint Paul St. to Starlight Junction Stage 1 Road Safety Audit.

C.1 Introduction

This report results from a Stage 1 Feasibility Studies Road Safety Audit carried out for the Public transport improvement scheme in Centreville, Narusha. The Road Safety Audit was carried out at the request of the Highway Authority: Narusha City by Road Safety Audit Ltd.

The report indicates each of the problems identified together with recommendations to solve or mitigate the problems, the Audit Team Statement and a schedule of the documents reviewed.

The members of the audit team were:

- Stephen Leader MSc R Eng — Associate Director, RSA Limited
- Robert Member BSc R Eng — Senior Engineer, RSA Limited

The site visit was undertaken during the hours of 0930 to 1600 hrs. Weather conditions during the site visit were sunny and the carriageway surface was dry.

The terms of reference of the audit are as described in the AfDB Road Safety Audit Manual (May 2014).

The team has examined and reported only on the road safety implications of the measures as presented and has not specifically examined or verified the compliance of the designs to any other criteria.

No departures from standards have been notified to the Audit Team on the proposals.

C.2 Background Information

The scope of this audit covers St Paul Street from its junction with Bloom Street to the junction of Mandela Road. It then continues along Mandela Avenue and Mandela Road until it reaches Starlight Junction. There is a section of the route on St Paul Street from the chainages 3300 (Mayberry Street) to 4050 (Mandela Avenue) which is part of the works package and therefore did not form part of the audit.

The R101 A11 route is an at-grade dual carriageway with footpaths along part of the route through the semi-urban section with some controlled junctions incorporating pedestrian facilities; and others with a ‘Stop’ priority system of operation. There is no system of street lighting on this highway and the speed limit is 60km/h through the semi-rural area and 100km/h along Mandela Road. The route extends from the Central Business Quarter in the south towards Centreville North.

The works include the provision of an improved public transport access using the current lane 2 with widening to the nearside carriageway where necessary to accommodate the movement of general traffic and

the provision of pedestrian facilities. There are also a series of proposed bus stations in the centre of the highway with traffic signalled controlled pedestrian facilities to assist access to the stations. The proposal also includes upgrades to the traffic signal controlled junctions to provide enhanced bus movements.

Land use in the audit area is primarily semi-urban that predominately residential with a mix of small commercial outlets.

C.3 Findings and Recommendations

The following problems have been identified from the documents submitted and the site visit.

C.3.1 Problem 1

Location: East side of St Paul Street north of Mayberry Street

Summary: Lack of pedestrian crossing facility

Nature: At this location there is an existing layby which does not have facilities to assist pedestrians particularly the visually and mobility impaired. This may result in pedestrians inadvertently crossing the planned improved carriageway at inappropriate locations causing trips and falls when moving between footpaths and carriageway potentially causing injury to pedestrians.

Recommendation: Provide dropped kerbs and tactile paving at this location to guide and assist pedestrians.

C.3.2 Problem 2

Location: St Paul Street north of Mayberry Street
No image

Summary: Lack of pedestrian crossing facility

Nature: The submitted drawing indicates the installation of a bus station in the central reserve. However, there is no obvious controlled pedestrian facility adjacent to the station to assist pedestrians to access the facility in a relatively safe manner. There is a controlled pedestrian crossing proposed at the nearby junction at Mayberry Street but it is unclear whether this provides access to the station. The lack of formal pedestrian crossing may result in conflict between vehicles and pedestrians crossing the carriageway to access the station.

Recommendation: Provide a controlled pedestrian link between the footpath and the station.

C.3.3 Problem 3

Location: St Paul Street at junction with Mayberry Street

Summary: Insufficient pedestrian 'green time'

Nature: When pedestrians cross St Paul Street the amount of 'green time' allocated is approximately 25% the actual time taken to cross the existing carriageways. It is proposed to widen the carriageway at this location which will increase the time taken by pedestrians to cross it. This may lead to pedestrians having insufficient time to cross the carriageway in a relatively safe manner and potentially cause conflict between them and vehicles negotiating the junction.

Recommendation: Provide sufficient 'green time' for pedestrians to be able to complete their movement across the carriageway in a timely manner.

C.3.4 Problem 4

Location: St Paul Street south east corner of Throw Street

Summary: Lack of pedestrian crossing signal

Nature: At this location there is no pedestrian signal to assist pedestrians crossing from north to south across Throw Street (east). Increased usages as part of the improvements This may lead to indecision by pedestrians in respect of when it is safe to cross the carriageway and possibly result in collisions between them and vehicles on Throw Street. There is also currently a traffic sign sited immediately in front of the post carrying the traffic signal head for vehicles and this may obscure the view to a pedestrian signal at this location.

Recommendation: Provide a traffic signal for pedestrians at this location as part of the improvements which may can be clearly observed by pedestrians wishing to cross Throw Street and relocate the signal poles to give clear visibility to traffic as part of the improvements.

C.3.5 Problem 5

Location: Mandela Avenue at junction with St Paul Street

Summary: Insufficient Pedestrian 'green time'.

Nature: When pedestrians cross Mandela Avenue the amount of 'green time' allocated is approximately 25% of the actual time taken to cross the width of the existing car-

riageways. Improvements at this junction will increase crossing distances and could lead to pedestrians having insufficient time to cross the carriageway in a relatively safe manner and potentially cause conflict between them and vehicles negotiating the junction.

Recommendation: Provide sufficient 'green time' for pedestrians to be able to complete their movement across the carriageway in a timely manner

C.3.6 Problem 6

Location: Junction of St Paul's Street, Mandela Avenue and Empress Drive

Summary: Lack of continuity in pedestrian routes

Nature: There is new footway provision proposed, as part of the scheme, which does not appear to connect with any adjacent existing facility. There is also an existing bus stop on St Paul's Street, to the south of Mandela Avenue, which will not have a link to the proposed footways on Mandela Avenue. There is footway provision proposed for Empress Drive where there is currently no existing provision to provide continuity to the route. This lack of continuity of footway provision may result in pedestrians unnecessarily using the carriageway to due to the lack of connectivity.

Recommendation: Provide full connectivity between all proposed footways and existing provision.

C.3.7 Problem 7

Location: St Paul's Street east of Mandela Avenue

Summary: Use of verge to access carriageway

Nature: To the north of St Paul's Street there is a service road providing access to individual properties to the west of Mandela Avenue. There is evidence of vehicles accessing St Paul's Street from the service road using the verge between these two carriageways as there is a well-worn area of verge which has been traversed by vehicles. This may result in conflict between vehicles using the verge and those on St Paul's Street.

Recommendation: Provide a physical barrier on the verge adjacent to the service road to prevent the manoeuvre.

C.3.8 Problem 8

Location: Mandela Avenue and the service road to the north of St Paul's Street

No image

Summary: Light spill between carriageways

Nature: Mandela Avenue and the service road are contiguous at this location. This will result in the headlight glare from a vehicle on the service road spilling onto Mandela Avenue and vice versa. This may result in carriageway users becoming disorientated by the headlights of vehicles not on the same carriageway potentially causing conflict between vehicles leaving the carriageway to take evasive action.

Recommendation: Provide a barrier between the two carriageways to prevent headlight spill between them.

C.3.9 Problem 9

Location: a) Mandela Avenue east side between Boot Street and Francis Street; and b) Mandela Avenue east side between Vanderbilt Street and Louisiana Street

Summary: Use of existing service road

Nature: The submitted drawings indicate that the existing service road is to be incorporated into the mainline by removing the raised median to create an additional 'through lane' However, at the junctions the main line reduces from three to two traffic lanes which will be a possible conflict area between veh8icles competing for a traffic lane possibly resulting in side-swipe incidents. Also at the point of the merger between traffic lanes one and two, the motorist in lane one has very poor visibility to see vehicles in lane two due to having to look over their shoulder to observe on coming vehicles.

Recommendation: The nearside traffic lane should be provided with road markings which indicate it is a layby and not part of the main line carriageway.

C.3.10 Problem 10

Location: Mandela Road northbound approach to Lavender Road

Summary: Poor use of lane three

Nature: On the Mandela Road northbound approach to Lavender Road it is proposed to mark the carriageway into three lanes. However, when Mandela Road approaches the junction lane three reverts from a through lane for the main line to a dedicated right turn lane to enter Lavender Road. There is no indication given to carriageway users of the change in the use of the lane. This may result in vehicles suddenly changing lanes or motorist's braking when realising they are committed to turning right when they wish to proceed on Mandela Road.

Recommendation: Provide traffic signs and road markings to inform carriageway users of the change in the use of lane three. (Refer to problem 12 below)

C.3.11 Problem 11

Location: Junction of Mandela Avenue and Francis Street

No image

Summary: Excessively wide exit traffic lanes

Nature: The northbound and southbound approaches on Mandela Avenue to Francis Street are each divided into two ahead lanes and one right turn lane. The ahead-only lane two on the exit side of the junction is excessively wide which may result in side-swipe collisions as motorists adjust from the wide lane width to the standard width.

Recommendation: Modify the road markings in lane two on Mandela Avenue, on the exit side of the junction, to create two standard width traffic lanes.

C.3.12 Problem 12

Location: Mandela Road right turn lane into Lavender Road

Summary: Extensive vehicle queues in traffic lane

Nature: During the site visit extensive queue of vehicles was observed at this location. The right turn lane also acts as an ahead lane to the south of the junction and the road alignment is a left hand horizontal curve which may reduce visibility to queuing vehicles. This may result in rear shunt type accidents between vehicles in lane three.

Recommendation: Provide traffic sign to warn motorists that there may be stationary traffic ahead. This recommendation should be combined with that set out in problem 10 above.

C.3.13 Problem 13

Location: Mandela Road left turn into Lavender Road

Summary: Lack of junction control

Nature: At this junction the current arrangement is for vehicles turning left to give way to those turning right. The proposed layout is for these two movements to

merge when entering Lavender Road. This may lead to conflict between vehicles in the form of side-swipe accidents while vehicles attempt to merge or rear shunt collisions when a motorist suddenly brake when they realise they cannot safely complete the merge movements.

Recommendation: Retain the current give way priority.

C.4 Concluding Statements

We hereby certify that this Road Safety Audit has been conducted in accordance with the AfDB Road Safety Audit Manual, 2014. We have examined the plans and documents listed in Appendix A to this report. We have inspected the site. The Audit has been carried out for the sole purpose of identifying any features of the design which could be altered or removed to improve the safety of the proposed project.

The identified issues have been noted in this report. The accompanying findings and recommendations are put forward for consideration by the Client for implementation.

AUDIT TEAM LEADER:

Name:	Stuart Leader	Signed:
Position:	Principal Engineer	Date:

Organisation and address: Road Safety Audit Limited, 196 Freedom Plaza, Middle Town, Narusha

AUDIT TEAM MEMBER:

Name:	Robert Member	Signed:
Position:	Senior Engineer	Date:

Organisation and address: Road Safety Audit Limited, 196 Freedom Plaza, Middle Town, Narusha

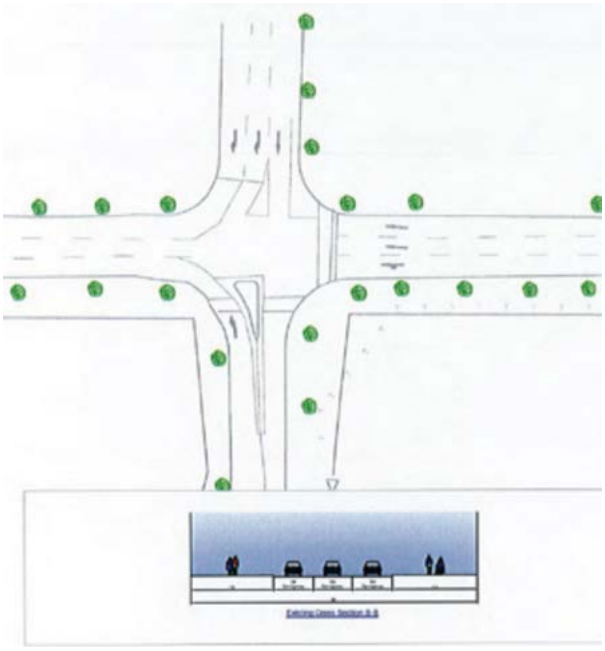
C.5 Documents Submitted to the Audit Team

The following documents were submitted as part of the Road Safety Audit:

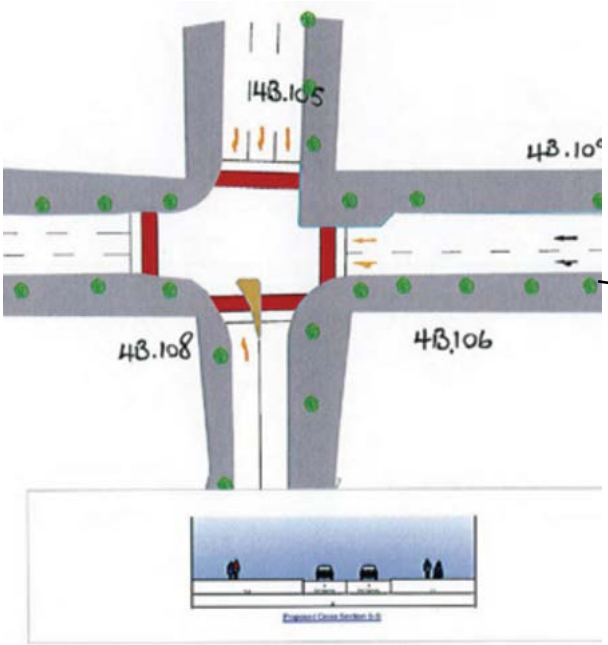
Document No.	Rev.	Description	Date
T-1258-BRTL1-WP-00	0	Key Plan	1/3/2013
T-1258-BRTL1-WP1 -001	0	Road Layout SV 0 to SV 760	14/3/2013
T-1258-BRTL1-WP1 -002	0	Road Layout SV 740 to SV 1440	14/3/2013
T-1258-BRTL1-WP1 -003	0	Road Layout SV 1360 to SV 2740	14/3/2013
T-1258BRTL1-WP2-001	0	Road Layout SV 2 560 to SV 3 480	14/3/2013
T-1258BRTL1-WP2-002	0	Road Layout SV 3 480 to SV 4 400	14/3/2013
T-1258BRTL1-WP2-003	0	Road Layout SV 4 400 to SV 5 320	14/3/2013
T-1258-BRTL1-WP3-001	0	Road Layout SV 5 320 to SV 6 400	14/3/2013
T-1258-BRTL1-WP3-002	0	Road Layout SV 6 400 to SV 7 320	14/3/2013
T-1258-BRTL1-WP3-003	0	Road Layout SV 7 320 to SV 8 180	14/3/2013
T-2258-BRTL1-WP1 -001	0	PT - Section 1 - WP1 Longsection (SV 50 - 900)	01/3/2012
T-2258-BRTL1-WP1-002	0	PT - Section 1 - WP1 Longsection (SV 900-1800)	01/3/2012
T-2258-BRTL1-WP1-003	0	PT - Section 1 - WP1 Longsection (SV 1800-2580)	01/3/2012
T-2258-BRTL1-WP2-001	0	PT - Section 1 - WP2 Longsection (SV 2580-3400)	01/3/2012
T-2258-BRTL1-WP2-002	0	PT - Section 1 - WP2 Longsection (SV 3400 - 4300)	01/3/2012
T-2258-BRTL1-WP2-003	0	PT - Section 1 - WP2 Longsection (SV 4300 - 5200)	01/3/2012
T-2258-BRTL1-WP2-004	0	PT - Section 1 - WP2 Longsection (SV 5200 - 5260)	01/3/2012
T-2258-BRTL1-WP3-001	0	PT - Section 1 - WP3 Longsection (SV 5280 - 6100)	01/3/2012
T-2258-BRTL1-WP3-002	0	PT - Section 1 - WP3 Longsection (SV6100 - 7000)	01/3/2012
T-2258-BRTL1-WP3-003	0	PT - Section 1 - WP3 Longsection (SV 7000 - 7900)	01/3/2012
T2258-BRTL1-WP1-002	0	Road Layout SV 740 to SV 1440	14/3/2013
T-1258-BRTL1-WP3-003	0	Road Layout SV 1360 to SV 2740	14/3/2013
T-1258-BRTL1-WP2-001	0	Road Layout SV 2 560 to SV 3 480	14/3/2013
T-1258-BRTL1-WP2-002	0	Road Layout SV 3 480 to SV 4 400	14/3/2013
T-1258-BRTL1-WP2-003	0	Road Layout SV 4 400 to SV 5 320	14/3/2013
T-1258-BRTL1-WP3-001	0	Road Layout SV 5 320 to SV 6 400	14/3/2013
T-1258-BRTL1-WP3-002	0	Road Layout SV 6 400 to SV 7 320	14/3/2013
T-1258-BRTL1-WP3-003	0	Road Layout SV 7 320 to SV 8 180	14/3/2013

C.6 Extract of Typical Problem Location Drawing and Reproduced Problem

Existing Layout



Proposed Layout



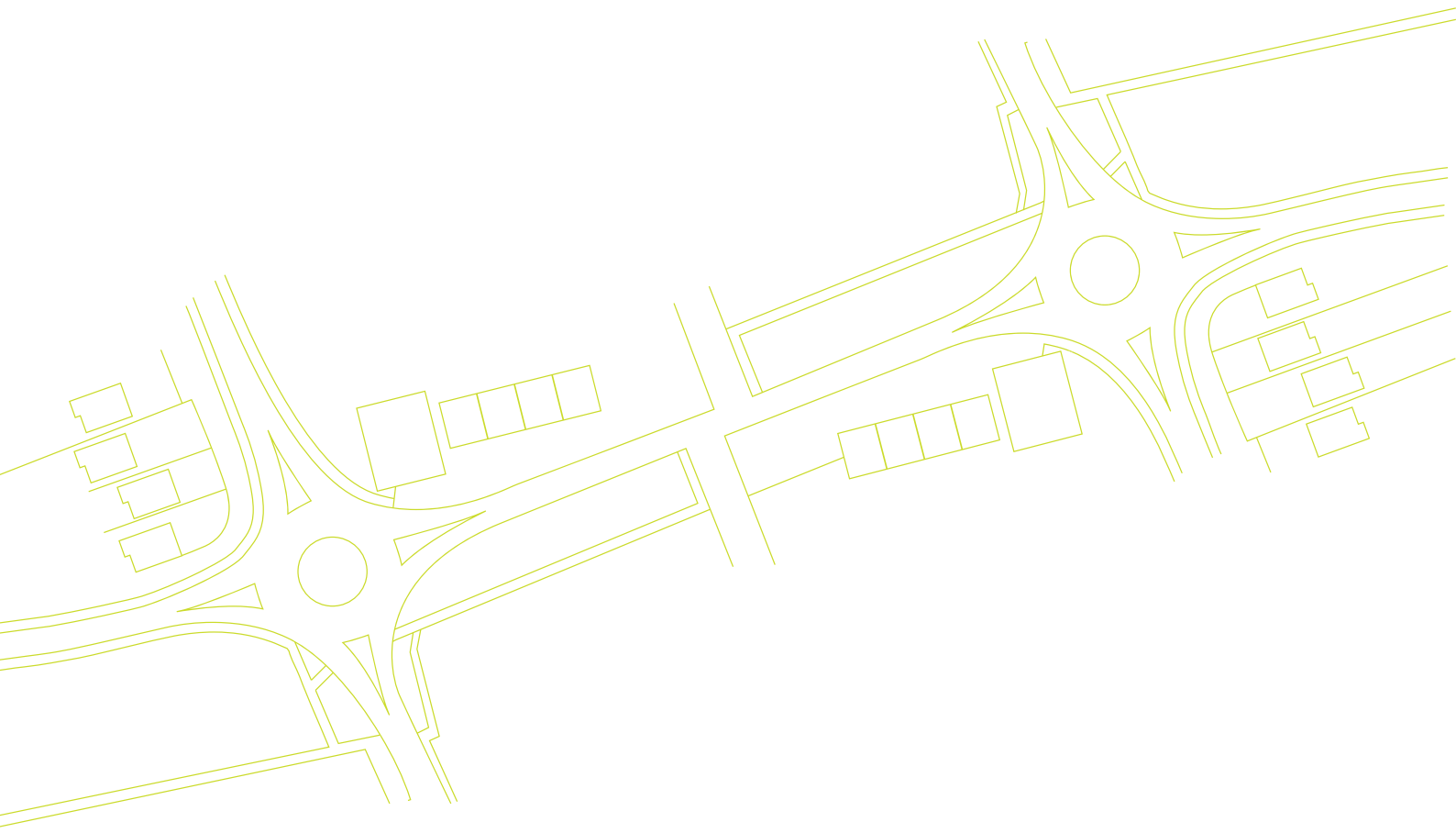
Problem 4B.105.

Location - Southbound to junction.

Summary - Risk of sideswipe collisions.

Description - Relatively wide 3 lane alignment to junction with 1 lane exit to south increases risk of sideswipe collisions.

Recommendation – Retain splitter-island to encourage single lane southbound movement.



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