# SOUTH AFRICAN ROAD SAFETY ASSESSMENT METHODS

# (SARSAM)

March 2022

Safe roads in South Africa'

The Road Traffic Management Corporation (RTMC) is an Agency of the Department of Transport (DoT) and a Member of the United Nations Road Safety Collaboration

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# Prelude

This Technical Recommendations for Highways (TRH) document, TRH29 consisting of three volumes compiled under the auspices of the Committee of Transport Officials (COTO) and is its current format as a COTO Draft Standard (DS). The document will follow the COTO approval process for TRH/TMH documents as outlined below. The approval progress of this document is in its current format, as a COTO DS, concluded up to Step 2.1 with the other Steps to be concluded in due course.

| COTO TRH/TMH DOCUMENT APPROVAL PROCESS | |
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| STEP | REMARKS |
| Step 1 | 1.1 COTO Subcommittee identify needs for new or revision of existing TRH/TMH<br>1.2 Panel Industry Experts appointed to assist |
| Step 2 | 2.1 COTO subcommittee and Industry experts draft new TRH/TMH number revisions<br>2.2 Once satisfied draft submitted to Roads Coordinating Body (RCB) for wider circulation and comments - Workshop held |
| Step 3 | 3.1 All comments received, reviewed, and incorporated where applicable<br>3.2 Final draft TRH/TMH prepared and submitted to RCB for approval recommendation to COTO |
| Step 4 | 4.1 Final draft submitted to COTO approval as "Draft TRH/TMH<br>4.2 Approved "Draft" released to wider industry for implementation |
| Step 5 | 5.1 Approved "Draft" TRH/TMH then introduced to industry through workshops<br>5.2 Approved" Draft'' TRH/TMH utilised in industry for 2-year period and comments/feedback provided to COTO subcommittee |
| Step 6 | 6.1 At the end of 2-year period all comments received are collated and industry workshop held to review all comments received and incorporated where applicable<br>6.2 COTO subcommittee then prepare final TRH/TMH |
| Step 7 | 7.1 Final TRH/TMH then submitted to RCB to recommend approval to COTO<br>7.2 COTO approval of final TRH/TMH |
| Step 8 | 8.1 Final TRH/TMH released to industry<br>8.2 TRH/THM use for minimum of 5 years before revision considered |

Notes:

1. A Draft Standard (DS) is approved by the RCB and implemented in Industry for a period of two (2) years, during which written comments may be submitted to the COTO subcommittee. A Draft Standards (DS) has full legal standing.
2. Final Standard (FS). After the two-year period, comments received are reviewed and where appropriate, incorporated by the COTO subcommittee. The document is converted to a Final Standard (FS) and submitted by the Roads Coordinating Body (RCB) to for approval as a final standard. This Final Standard is implemented in industry for a period of five (5) years, after which it may again be reviewed. Final Standards (FS) have full legal standing.
3. Standards (DS) have full legal standing.
4. The DoT assumes responsibility for the development of a web-based data management support system for the processing, management and warehousing of RAMS data.
5. Road users experience the same road standards throughout South Africa through the uniform application of COTO technical policies and standards.

South Africa

COTO

Committee of Transport Officials

# TRH 29: 2022

# South African Road Safety Assessment Methods (SARSAM)

# Volume 1: Network Screening

**Volume 1: Network screening**

Volume 2: Road Safety Assessment

Volume 3: Road Safety Audit

Part A - RSA Management: Policy and Procedures

Part B - Conducting Road Safety Audits

Draft Standard (DS) version 1.0

March 2022

UPDATE OF THE SOUTH AFRICAN ROAD SAFETY AUDIT MANUAL

RTMC REQUISITION: 1004535

Volume 1 - Network Screening Guidelines

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## Technical Recommendations for Highways

The Technical Recommendations for Highways consists of a series of publications that describe recommended practice for various aspects related to highway engineering. The documents are based on South African research and experience and have the support and approval of the Committee of Transport Officials (COTO). The documents are primarily aimed at ensuring uniform practice throughout South Africa.

Users of the documents must ensure that the latest editions or versions of the document are used. When a document is referred to in other documents, the reference should be to the latest edition or version of the document.

Any comments on the document will be welcomed and should be forwarded to the publisher. When appropriate, such comments may be incorporated in future editions of the document.

## Synopsis

This Manual is the official requirement for providing services in road reserves in South Africa. It provides guidance to National, Provincial and Municipal spheres of government on the provision of public and private engineering and related services (utilities) within the road reserve and building restriction areas.

# FOREWORD

## Compiled under the auspices of the:

Road Traffic Management Corporation (RTMC)
(RTMC Requisition: 1004535)

## Published by:

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## Existing publication:

This document forms part of the update of the South African Road Safety Audit Manual, 2nd Edition, May 2012 (SARSAM 2012)

## Document versions:

**Draft Standard:** This working draft document has been prepared specifically as a combined Volume 1 Network Screening guidelines and Volume 2 Road Safety Assessment guidelines for the Update of the South African Road Safety Assessment Methods manual and remains the intellectual property of the RTMC.

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## Comments:

Comments on this working draft should be provided in writing and e-mailed to the developers of the document, Messrs CSIR for the attention of the Project Manager, Mr Michael Roux at mproux@csir.co.za.

This document and its various parts will only be published in electronic format.

# PREFACE

TRH 29 consists of three mutually supporting volumes related to successive investigation and diagnostic practices to improve road safety on the South African road network. These volumes are:

- Volume 1: Network Screening
- Volume 2: Road Safety Assessment
- Volume 3 Road Safety Audit

The South African National Road Safety Strategy 2016-2030 (NRSS) accepted the vision of "Safe and Secure Roads". South Africa aims to contribute towards the reduction of an unacceptable global road safety problem that claims the lives of some 1,3 million people annually. NRSS aims to address this problem on a national scale across different subject areas. This document will fall under the Safer Roads and Mobility theme of the United Nations' 2$^{nd}$ Decade of Action for Road Safety, 2021–2030. One of the strategic themes adopted for achieving Safer Roads is the implementation of a Road Safety Audit Programme on new and upgrade road infrastructure projects.

Volumes 1 and 2 of TRH 29 provides guidelines on applying curative methods for the identification and improvement of hazardous locations, roads, and routes. They also provide proactive assessment methods for the identification and treatment of road safety deficiencies.

**Network Screening** (Volume 1) is a process for reviewing a transport or road traffic network with the objective of identifying and ranking sites from most likely to least likely to realise a reduction in accident frequency with the implementation of appropriate safety improvement measures.

**Road Safety Assessment** (Volume 2) is a two-tiered process, namely:

1) **Network Level Assessment (NLA)** which is a routine, programmed and systematic field survey on existing roads to identify risk factors that can be mitigated against to achieve enhanced safety, and
2) **Road Safety Inspection (RSI**) is an expert assessment of the road environment conducted in response to an identified road safety issue on a section of the road network. RSI involves an expert and in-depth review of the safety of existing roads. Apart from identifying safety problems, the assessment team should be looking out to identify and recommend viable and cost-effective measures which will improve safety.

Volume 3 provides guidelines on Road Safety Audit - a systematic assessment of plans for new road schemes (including on existing roads), intended to ensure that new roads have the lowest attainable accident potential across all kinds of road users. The audit process aims to avoid future accidents by removing unsafe features before they are constructed and to build in safety features that will limit casualty severity to the minimum feasibly possible.

**Road Safety Audit** is a proactive road safety engineering tool based on the philosophy that new road projects must have the highest achievable level of safety built into them and that road authorities do not have to wait for the accumulation of serious injury and fatal accidents statistics before positive steps can be taken to reduce the risks of such. It plays a significant role in ensuring that the road environment is forgiving, self-explaining and providing for the needs of all road users while being aligned with the principles of contemporary road safety management practices, e.g., the Safe System Approach.

Road safety audits may be conducted at all stages of the life cycle of a roads project (from conception to the final constructed project and post the opening to traffic, and on existing roads). Given that South Africa is currently in a process of road safety audit capacity development, road authorities should endeavour to introduce road safety audits at the earliest possible stage of specific projects - this will provide the highest road safety return on such investment.

A road safety audit is conducted by a qualified and experienced road safety audit team led by a road safety audit team leader recognised as a specialist road safety engineer and accredited as such by the Engineering Council of South Africa (ECSA). The size of the road safety audit team is determined by the size, complexity, and the stage(s) of the project to be audited. The road safety audit team will comprise a road safety audit team leader and at least one additional audit team member. The audit team leader is the lead auditor that is responsible for compiling the road safety audit report and representing the audit team in engaging with the roads' department/project owner (the client). The audit team members assist, collaborate, and contribute to the road safety audit.

The successful implementation of the entire road safety audit process and the implementation of the remedial measures recommended by the road safety audit team would make a meaningful contribution to ensure that road safety problems are not repeatedly introduced on the road network.

It is our firm belief that the South African Road Safety Assessment Methods 2022 manual, (this TRH 29) would pave the way for our real contribution to meeting the objectives of the NRSS and of the UNDoA2.

# ABBREVIATIONS

| | |
|---|---|
| AADT | Average Annual Daily Traffic |
| ABS | Anti-Lock Braking System |
| ARF | Accident Reduction Factors |
| ADT | Average Daily Traffic |
| AfDB | African Development Bank |
| AMF | Accident Modification Factors |
| ANRAM | Australian National Risk Assessment Model |
| AR | Accident Report |
| BCR | Benefit/Cost Ratio |
| CBA | Cost Benefit Analysis |
| CE | Cost Effectiveness |
| CHoCOR | Culpable Homicide Crash Observation Report |
| COTO | Committee of Transport Officials |
| CV | Coefficient of Variation |
| DCA | Definitions For Classifying Accidents |
| EA | Economic Appraisal |
| EAN | Equivalent Accident Number |
| EB | Empirical Bayes |
| ECSA | Engineering Council of South Africa |
| EPDO | Equivalent Property Damage Only |
| FSI | Fatal and Serious Injury |
| FYRR | First Year Rate of Returns |
| GIS | Geographical Information System |
| GPS | Global Positioning Systems |
| HCI | High Income Counties |
| HSM | Highway Safety Manual |
| IBCR | Incremental Benefit Cost Ratio |
| JTRC | Joint Transport Research Committee |
| iRAP | International Road Assessment Programme |
| LoSS | Level of service of safety |

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| LMICs | Low- and middle- income countries |
| MAIS | Maximum Abbreviated Injury Scale |
| MVE | Million Vehicles Entering |
| NLA | Network Level Assessment |
| NPV | Net Present Value |
| NRSS | National Road Safety Strategy 2016 – 2030 |
| OECD | Organisation for Economic Cooperation and Development |
| PD | Preliminary Design |
| PDO | Property Damage Only |
| PVB | Present Value of Benefits |
| PPE | Personal Protective Equipment |
| RAMS | Road Asset Management System |
| RSA | Road Safety Audit |
| RTMC | Road Traffic Management Corporation |
| RSI | Road Safety Inspection |
| RSINV | Road Safety Investigation |
| V-kmT | vehicle-kilometres travelled |
| VPD | Vehicles Per Day |
| VRUs | Vulnerable Road Users |
| SADC-RTSM | South African Development Community Road Traffic Signs Manual |
| SAPS | South African Police Service |
| SARSAM2012 | South African Road Safety Audit Manual 2012 |
| SARSAM2022 | South African Road Safety Assessment Methods 2022 |
| SARSM | South African Road Safety Manual 1999 |
| SARTSM | South African Road Traffic Signs Manual |
| SPF | Safety performance Function |
| SPIS | Safety Priority Index System |
| SSRIP | Safe System Road Infrastructure Program |
| TRH | Technical Recommendations for Highways |
| UNDoA1 | United Nations Decade of Action for Road Safety, 2011 - 2020 |
| UNDoA2 | Second United Nations Decade of Action for Road Safety, 2021 - 2030 |

# ACKNOWLEDGEMENTS

This Manual describes the network screening process, together with practical guidance for road safety practitioners. It is recommended reading for all practitioners and decision makers who are responsible for road safety, for designing new road projects and for managing roads.

As the science of road safety auditing is constantly developing, this Manual recognises the benefits of standardising road safety audit procedures and practices and has drawn extensively on the experiences of countries or organisations where road safety auditing is being done and, on the guidelines and procedures in use in these countries.

The RTMC would like to recognise and acknowledge the references that had been made to the following international road safety manuals:

- African Development Bank, Transport and ICT Department, Road Safety manuals for Africa, July 2014.
- Asian Development Bank, Road Safety Audit, CAREC Road safety engineering manual 1, March 2018.
- AUSTROADS, Guide to Road Safety Part 6: Managing Road Safety Audits, Austroads publication No. AGRS06/19, Edition 1.2, February 2019.
- AUSTROADS, Guide to Road Safety Part 6A: Implementation of Road Safety Audits, Austroads publication No. AGRS06A/19, Edition 1.0, February 2019.
- FHWA, Road Safety Audit Guidelines, Publication No. FHWA-SA-06-06, 2006.
- Highways England, UK Design Manual for Roads and Bridges: Road Safety Audit, GG 119, October 2018.
- Indian Roads Congress, Manual on Road Safety Audit (First revision), August 2019.
- Institution of Highways and Transportation, Road Safety Audit, October 2008
- National Roads Authority Ireland, Road Safety Audit Series: GE-STY-01024–01027, 2017.
- New Zealand, Interim RSA procedures for projects, 2013
- PIARC Technical Committee on Road Safety (C13), Road Safety Manual, 2018.
- United Nations Economic Commission for Europe, Road Safety Audit and Road Safety Inspection on the TEM network, 2018.

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# VOLUME 1: NETWORK SCREENING

# 1 Overview of road safety management and relevant methods

Saving more than 6,000 lives per year on our roads is a shared responsibility which needs to be supported by efficient Road Infrastructure Safety Management procedures. Such procedures need to cover the whole lifecycle of a road infrastructure from early planning to operation. International best practice guidelines and tools for increasing road safety have been developed based on successfully applied procedures in countries across the world. These guidelines and tools can serve to give scientific support and direction to practitioners concerned with road design and road traffic safety in the development of locally applicable practices that take account of local conditions, limitations and opportunities, and expectations.

The development of Road Safety Infrastructure Programs that give effect to road safety targets and outcomes specified in either local level strategies and/or aligned with those specified in guiding strategic road safety documents, e.g., the National Road Safety Strategy 2016 – 2030 (NRSS), is an ongoing process that needs to be supported unequivocally through programmes and budgets. Currently, however, it is not typical that the analysis of the achievability of the road safety targets is based on or directed by funding provisions or forecasts. Nevertheless, all the tiers of road authority need to endeavour to quantify the funding required for achieving specified road safety targets. The NRSS can only be realised through effective infrastructure programs. That which could be achieved with more funding also needs to be made known. Reciprocally, what would be achieved with lesser levels of funding (with a concomitant lesser impact on road fatalities, injuries, and damages) needs to be estimated. There needs to be a deep understanding of the implications of diverting investment away from the improvement of road safety over the next decade or two.

In line with international strategic road safety guiding documents, the NRSS has the Safe System philosophy as a foundational principle. However, South Africa (and numerous other countries) **does not have all processes in place** to give effect to the Safe System. It is, however, encouraging knowing that embedding the NRSS Safe System approach into road safety management processes will make it possible for road authorities on all tiers to not only deploy current best-practice processes, but to also develop the necessary systems for harnessing state-of-the-art road safety management with a focus on achieving road safety results.

This TRH 29 addresses ‘road network screening’ and ‘road safety assessments’, respectively in Volume 1 and Volume 2. Road network screening (Volume 1) refers to the curative process that involves identifying those ‘accident locations with promise’ that will through appropriate treatment or with remedial measures contribute to the reduction in future road casualties. Road safety assessments (Volume 2) includes the processes of ‘network level assessment’ and ‘road safety inspection’ to proactively identify road safety risks and to devise solutions and treatments to mitigate against such at those accident locations with promise –

according to a suitable priority ranking method. Volume 3 addresses 'road safety audit' which also includes road safety audit of existing facilities (known as road safety investigation, formerly road safety appraisal). To clarify the application of this TRH 29 in the broader road safety management context, the outline for the more generally used tools available to road safety practitioners is provided graphically below in **Error! Reference source not found.**. Since the terms and definitions of m any of the tools varies across international literature and manuals, the outline also serves to demarcate the application of the tools within the framework of the stages of the whole lifecycle infrastructure planning and operation stages. The tools highlighted are of specific relevance to this TRH 29.

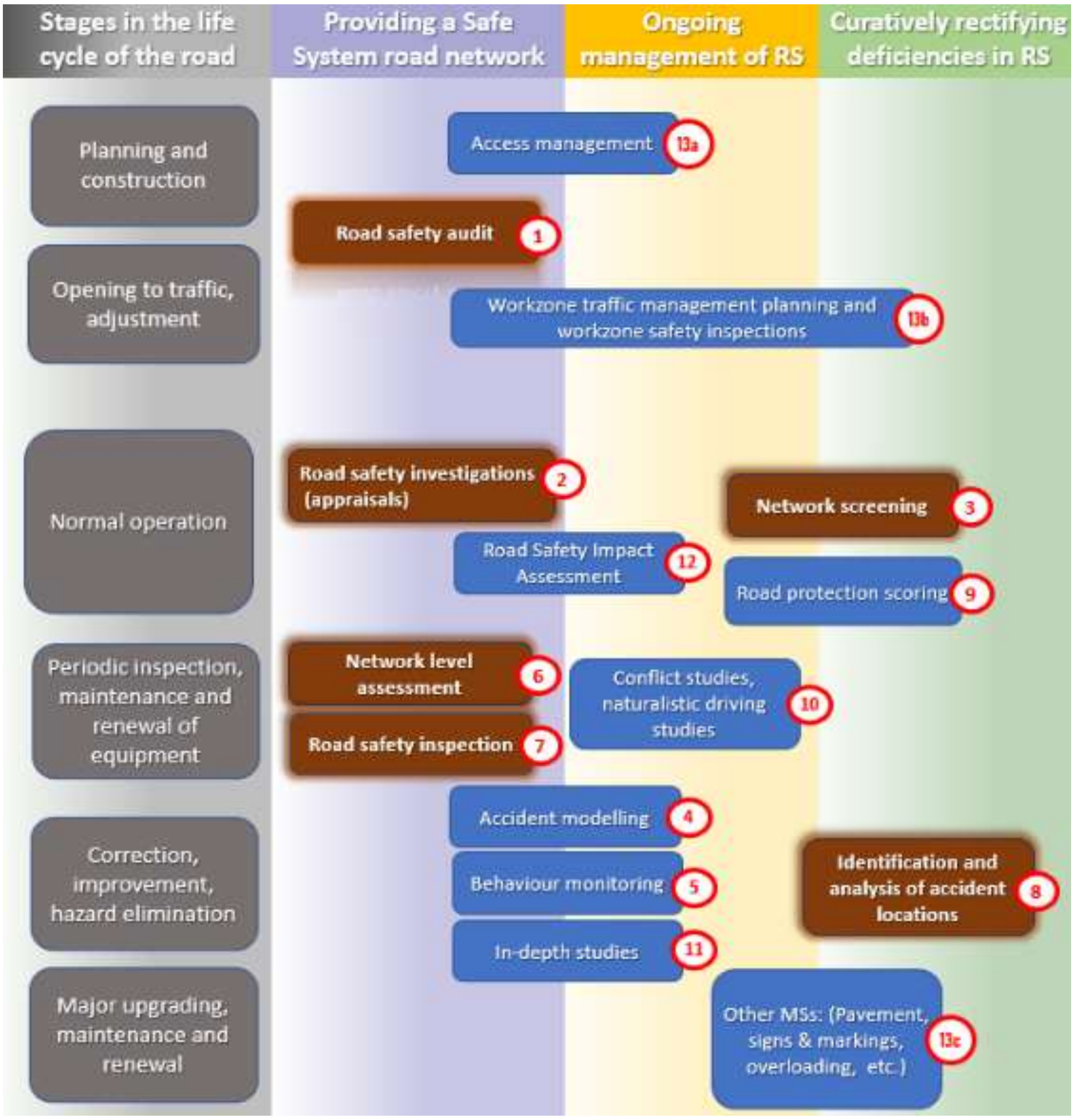



*Figure 1-1: Outline of road safety management tools*

| DESCRIPTION OF TOOL AND APPLICABLE UTILISATION CONTEXT | WHERE AND WHEN USED | NOTES AND OTHER DESCRIPTIONS |
|---|---|---|
| **Road safety audit**<br><br>The definition adopted in SARSAM 2022 is: "A Road Safety Audit (RSA) is a formal technical assessment process of a new or upgrading road or traffic project, in which an independent and qualified team pro-actively identifies potential road safety concerns that may lead to serious injuries or fatalities of all road users. and suggests measures to mitigate such risks applying Safe System principles." | Road Safety Audit is applied during the planning and construction stages of a road. Audits can be carried out several times during planning and construction. The final stage of auditing is often a test drive of the road a brief time before it is opened to traffic, permitting last-minute corrections to be made. | In literature the general description of RSA is that it is a systematic assessment of plans for new road schemes, intended to ensure that new roads have the lowest attainable accident potential for all kinds of road users.<br><br>The audit process aims to avoid future accidents by removing unsafe features before they are constructed. |
| **Road safety investigation**<br><br>A Road Safety Investigation (RSINV) is <u>a formal systematic examination</u> of an existing road location, in which an independent and qualified team reviews on-site conditions and historical evidence to identify existing or potential road safety problems and suggest measures to mitigate those problems.<br><br>The aim is to identify problem features which are not yet apparent from the accident history, or new problems introduced by engineering changes to the road or by modifications in the way it is used. RSINVs are therefore performed according to the same procedures as road safety audits. RSINVs can be organised as thematic inspections, for example, an inspection of guard rails only. Thematic inspections will often cover a larger proportion of the road system than general inspections will.<br><br>The selection of roads for RSINV can either be based on the results of network screening or a programme of periodic inspection, e.g., Network Level Assessments (NLA), in which all sections of the road network are inspected at fixed intervals. | RSINV is applied:<br>i. during the normal operation of a road, i.e., when the road is open to traffic and no major maintenance or upgrading works are in progress<br>ii. when normal or extraordinary maintenance is planned.<br><br>RSINV may also contribute to error correction and hazard elimination.<br><br>RSINV would generally be warranted when the estimated cost of a road safety improvement project is higher than a policy-based threshold value, e.g., R 1 000 000. | In the SARSM 1999, this was named *Stage 6 Road Safety Audit: Existing Facilities*. In SARSAM 2012, this was named *Road Safety Audits on Existing Roads* or *Road Safety Appraisals*. The workshop** resolution suggested a name change to "Road safety investigation (RSINV)."<br><br>In literature, the general reference to the RSA process includes both the road safety audit of new road projects and of existing road alteration or upgrading projects. In this TRH 29 reference to RSA will impart this meaning unless there is specific reference to RSINV. |
| **Network screening**<br><br>Network screening is a process where the variation in the number of accidents between sections of a road network is analysed statistically. The objective of network screening is to identify road sections that have safety problems – either in the form of an abnormally high number of accidents, a high proportion of severe accidents or a high proportion of a particular type of accident. Screening may comprise the entire road system under a road authority or be limited to a particular type of road or traffic environment.<br><br>There are several versions of network screening, ranging from simple rankings of road sections according to the recorded number of accidents to statistically advanced techniques based on accident prediction models.<br><br>Scoring roads by risk according to the protocol developed by the International Road Assessment Programme (iRAP) can be viewed as a form of network screening. iRAP awards from 1 to 5 stars depending on the level of built-in safety of a road. However, there are limited validation studies on the relationship between the star rating scales and accidents.<br><br>**Accident modelling**<br><br>Accident models are developed by statistically assessing how variation in the number of accidents is explained by a range of measured variables and factors, generally using advanced regression techniques. The purpose of accident modelling is to identify factors which significantly influence the number of accidents and estimate the magnitude of their effects. | Network screening and accident modelling are usually based on the entire road system. No roads are selected for a particular reason, and the objective of both network screening and accident modelling is to describe normal variation in safety on roads that are in normal operation.<br><br>iRAP relies on accident rates or accident costs per kilometre. Apart from problems with the availability of such information, this approach incorrectly assumes a linear relationship between accident frequency and the measure of exposure. It also does not control for the confounding effect of regression to the mean. | HSM definition: Network screening is a process for reviewing a road network to identify and rank sites from most likely to least likely to realise a reduction in accident frequency with implementation of a countermeasure. Those sites identified as most likely to realise a reduction in accident frequency are studied in more detail to identify accident patterns, contributing factors, and appropriate countermeasures. |
| **Monitoring road user behaviour** | The monitoring of road user behaviour also has several purposes. It is both intended to give a representative picture of normal road user | |

| DESCRIPTION OF TOOL AND APPLICABLE UTILISATION CONTEXT | WHERE AND WHEN USED | NOTES AND OTHER DESCRIPTIONS |
|---|---|---|
| One of the most important factors influencing road safety is road user behaviour. Several national road safety programmes contain a number of safety performance indicators that are based on road user behaviour. The most frequently monitored forms of behaviour include:<br>• Speed<br>• Seat belt wearing<br>• Driving without a driving licence<br>A very important form of behaviour is drinking and driving or driving under the influence of drugs. These forms of behaviours are rarely monitored systematically, and data available on their prevalence are unreliable and incomplete. Other potentially important types of behaviours that are rarely monitored systematically and reliably include use of mobile phones and driving when fatigued (self-reports should not be treated as reliable). | behaviour and help identify risky behaviour that may be a target for interventions.<br><br>It therefore represents roads both in normal operation as well as the identification and correction of errors or departures from normal operation. | |
| **Network level assessment** ★<br><br>A network level assessment (NLA) is a routine, programmed and systematic field survey on existing roads to identify risk factors that can be mitigated to achieve enhanced safety.<br><br>NLA is a proactive safety management tool. It comprises a routine, programmed and systematic field survey which is conducted proactively on existing roads to identify risk factors and to achieve enhanced safety.<br><br>NLA results in a formal report detailing road hazards and safety issues supported with videos and photographs. A NLA is a standardised survey conducted to collect prescribed data relating to existing road characteristics (road and environmental features). This allows the identification of sections of road that warrant further investigation, such as a Road Safety Inspection (RSI) or further for a RSINV. | The NLA is primarily a mechanistic data collection exercise that can be conducted by trained staff who need not be experienced road safety assessors. They could be part of the general area maintenance teams who then prepare a summary report for consideration by specialist staff experienced in road safety and accident investigation or RSA to consider the findings and develop the detailed road safety investment plan. NLAs are applied:<br>i) during the normal operation of a road, i.e., when the road is open to traffic and no major maintenance or upgrading works are in progress<br>ii) when normal or extraordinary maintenance is planned.<br>NLA may also contribute to error correction and hazard elimination. | In the African Development Bank literature this is defined as Road Safety Inspection. The workshop** resolution suggested the use of "Road Safety Assessments (Network Level)" to associate with the pro-active nature of the assessment. "Network level assessment (NLA)" was adopted based on the latter. |
| **Road safety inspection** ★<br><br>Road safety inspection (RSI) is <u>an expert assessment of the road environment conducted in response to an identified road safety issue</u> on a section of the road network. RSIs involve the expert and in-depth review of the safety of existing roads. In addition to identifying safety problems, the assessment team should seek to identify and recommend viable and cost-effective measures which will improve safety.<br><br>These recommendations can be in the form of preliminary designs. Depending on whether the estimated cost of implementing such a preliminary design would exceed a policy-based threshold cost, e.g., R 500 000, the preliminary design will need to be subjected to an RSINV. | Once a high-risk road has been identified through an NLA, an RSI can be conducted in more detail to determine whether any of the physical deficiencies detected through the NLA can be treated.<br><br>This approach can be conducted irrespective of the detail and accuracy of accident data that are available. | In the African Development Bank literature, this is defined as Road Safety Assessment. PIARC defines a Road Safety Inspection as a *systematic, on-site review, conducted by road safety expert(s), of an existing road or section of road to identify hazardous conditions, faults and deficiencies that may lead to serious accidents*.<br><br>The workshop** dealt with road safety audit and not with any other road safety management tools. |
| **Identification and analysis of accident locations (leading to the ranking of high accident concentration road sections)**<br>i) Accident locations should be identified from a population of sites whose members can be enumerated. This permits the formulation of precise statistical criteria for the identification of accident locations.<br>ii) Accident locations should be identified in terms of the expected number of accidents, not the recorded number of accidents. This is best done by identifying accident locations according to the Empirical Bayes (EB) estimate of safety at each site | The identification and analysis of accident locations, as well as road protection scoring, are intended to identify factors related to road design or traffic control that may lead to accidents or make the accidents more severe. Ideally speaking, there should be no need for these procedures if the road design has been properly audited before construction, and if regular inspections have kept emerging problems under control. | The existing guideline is *The Revised K21: Identification and improvement of hazardous locations* of 1991, which may be considered outdated in several respects. |

| DESCRIPTION OF TOOL AND APPLICABLE UTILISATION CONTEXT | WHERE AND WHEN USED | NOTES AND OTHER DESCRIPTIONS |
|---|---|---|
| iii) Accident locations should belong to the upper percentiles of a distribution of sites with respect to the expected number of accidents.<br>iv) A suitable period of data for identifying an accident location is 3-5 years. This is a compromise between the need for detecting accident locations quickly and the need for accumulating a sufficient number of accidents to permit analysis.<br>v) Accident severity can be considered when identifying accident locations, provided the expected number of accidents can be reliably estimated at each level of severity.<br>vi) Specific types of accident can be considered when identifying accident locations, provided reliable estimates of the expected number of accidents by type are available.<br>**Road protection and road user exposure scoring**<br>Road protection and road user exposure scoring is an assessment of how forgiving a road is or how well road users are protected.<br>E.g., a road is scored as safe with respect to running-off-the-road accidents where:<br>vii) the speed limit is not higher than 50 km/h, or<br>viii) a safety or clear zone exists of at least 4 meters wide and the speed limit is not higher than 70 km/h, or<br>ix) it has a safety zone of at least 10 meters wide and a speed limit higher than 70 km/h.<br>A safety or clear zone is a level area beside the travelling lane which does not contain fixed obstacles that may cause injury in the case of an accident. Examples of fixed obstacles include rocks, trees, bridge supports or above-ground portions of water-containing structures. | However, many roads were built according to other design standards than those that apply today and long before the advent of road safety audits or safety inspections. Moreover, changes in traffic patterns that were not foreseen when a road was built can lead to the development of accident locations even if a road complies with design standards. One must therefore expect accidents to occur even on the seemingly safest roads and try to detect patterns in accidents as early as possible in order to develop remedial measures.<br>The procedure proposed in the Outdoor Advertising Engineering Manual (SARTSM Volume 2, Chapter 22), utilises a form of protection scoring for the Safe System compliant clear zone element of the warrant structure. | |
| **Objective studies, e.g., conflict studies, naturalistic driving studies**<br>A traffic conflict is any event that would have resulted in an accident if road users had continued travelling without changing direction or speed. Conflicts can be rated according to their severity. A serious conflict is one that nearly results in an accident (near-hit), in which the road user makes evasive manoeuvres at the last moment.<br>Another technique that permits an objective assessment of the severity of traffic conflicts and their relationship to accidents is naturalistic driving studies. | Conflict studies and naturalistic driving studies also mainly shed light on actual or potential accident problems. These tools are therefore most useful in analysing problems that have not been successfully prevented, in particular problems that are the result of interactions between human factors and infrastructure elements. | |
| **In depth analysis of accidents**<br>Official road accident statistics are, in most countries, not sufficiently detailed to enable an in-depth analysis of accidents. In-depth studies try to reconstruct in detail the events that lead to an accident and identify the factors that produced injuries and damage. In-depth studies often focus on human factors, as these are normally only recorded in fairly crude terms in official accident statistics.<br>Important elements of in-depth studies that are not always part of official accident statistics include the reconstruction of pre-accident speed, the estimation of impact speed, the identification of technical defects in vehicles and a comprehensive assessment of the role of human factors, such as blood alcohol content, traces of illicit drugs, seat belt wearing (which is often incompletely or inaccurately reported in official statistics), the sudden onset of illness immediately before the accident, indications that the driver had fallen asleep before the accident or indications of driver distraction.<br>**Road Safety Impact Assessment of investments (e.g., strategic road network planning, land development) and road safety measures** | In-depth studies of accidents have several applications. Such studies may obviously identify problems of road design or traffic control, but they can also identify problems related to vehicles. The assessment of the impacts of road safety measures is important when choosing the most effective measure to reduce a certain road safety problem. There will usually be more than one measure that can help reduce a given road safety problem. Impact assessments should therefore be based on a broad survey of all potentially effective road safety measures.<br>The use of RSIAs is non-uniform. It can concentrate on one single project, for instance a new access interchange, and can in this way be based on:<br>• expert opinion | TMH 16 would be (somewhat) applicable as to include a type of RSIA, although the road safety impact reference is with respect to heavy goods vehicle movement generation. |

| DESCRIPTION OF TOOL AND APPLICABLE UTILISATION CONTEXT | WHERE AND WHEN USED | NOTES AND OTHER DESCRIPTIONS |
|---|---|---|
| Road Safety Impact Assessment (RSIA) denotes the estimation of the expected effect on accidents and/or injuries of investments or road safety measures, performed as part of the planning process.<br>When decisions on large projects or new road schemes are made, their impact on road safety is an important matter. A RSIA can help to identify the safety effects of different proposed road or traffic schemes (alternatives) or policy actions (e.g., changing speed limits). It usually covers the whole or a large portion of the road network which is affected by the measure. | • guideline or literature<br>• traffic models including risk factors or accident prediction models<br>• traffic models including cost-benefit modules. | |
| **Other safety management tools**<br>x) Setting safe and credible speed limits<br>xi) Management of outdoor advertising targeted at road traffic<br>xii) Access management<br>xiii) Work zone traffic management planning and work zone safety inspections | The speed of traffic is one of the most important factors influencing road safety.<br>The objective is to set speed limits that are both safe and credible, i.e., accepted by road users as reasonable and therefore eliciting a high level of compliance. | SARTSM Volume 2 Chapter 20: Setting of speed limits and SARTSM Volume 2 Chapter 22: Outdoor Advertising Engineering Manual are currently in the approval process.<br>TRH 26: South African Road Classification and Access Management Manual is relevant regarding road access management.<br>SARTSM Volume 2, Chapter 13 is relevant for accommodation of traffic during construction. |

** The Working Document Workshop of the National Road Traffic Engineering Technical Committee held on 05 May 2018 regarding the “Review of the South African Road Safety Audit Manual”

# 2 Introduction to the investigation and correction of accident locations

The identification and improvement of 'hazardous locations' have been a core element of road safety management plans for many countries for more than half a century. South Africa had its first guidelines to support hazardous location remedial programmes in circulation before 1972.

The *Revised K21: Identification and improvement of hazardous locations* was published in 1991 as Research Report 88/095/2b under the South African Roads Board Research and Development Advisory Committee. It is still a relevant process, except in recent literature, the reference is more consistently to 'accident locations' instead of 'hazardous locations' (or accident blackspots). Sustainable safety policies meant a shift from merely recognising a hazardous location when accidents and casualties exceed a certain minimum level to an 'accident location' which demonstrates common hazardous features, causal to the occurrence of specific types of accidents that can be effectively treated. In the remainder of the document, the term 'accident location' is consequently used. Importantly, as part of the Safe System philosophy is the paradigm of road safety being a public health issue. This brough about favouring the term 'treatment' instead of 'improve,' 'remediate', etc. (World Health Organisation, 2017).

Treating accident locations has been the mainstay of actions to reduce road traffic casualties to the extent that, in recent times, countries considered to have the world's safest roads are moving on from this type of reactive intervention to more proactive efforts to eliminate/prevent road-related risk that can potentially result in road traffic accidents with fatalities and serious injuries (Bonnet, 2018). The reason for this is that these countries have remediated their definable accident locations (or black spots) and are now focusing on the more systemic issues that can be foreseen to be potentially harmful to road users, thereby eliminating or avoiding accident locations as they endeavour to achieve sustainable safety (zero-harm) policy objectives. Accident locations manifest as sites, routes or areas of the road network where accidents with identifiable similar attributes occur at a frequency that will allow engineering investigation for potential treatments (Bonnet, 2018). Accident locations become identifiable through the study of recorded accident incidents. Together with retrospectively addressing them, this is typically referred to as a curative or reactive approach (Federal Highway Administration, 2018).

The process of identification and treatment of an accident location thus relies on the collection of historical data of accidents and the collation of intelligence to correlate road safety problems with effective feasible treatments in a systematic and consistent manner (World Health Organization, 2010). This requires significant investment and diligence particularly in the collection, processing and analysis of accident data through a network screening process.

In the sections following, the term ‘curative approach’ is preferred over ‘reactive approach’ (Federal Highway Administration, 2018). ‘Curative’ carries the meaning of ‘taking care’ entailing a monitoring of the road network with the purpose of learning about existing problems so that these can be addressed. It thus suggests a pro-active intent to prevent further harm. ‘Reactive’ tends to instil a sense of ‘waiting for something to happen’ or “waiting for the data to reveal a problem” that is somewhat defiant of the objective to actively manage road safety.

Figure 2-1 shows the outline of a process, with eight pertinent tenets, for ensuring that curative responsibility for road safety management continues to be institutionalised with the focus on the network screening process. Network screening in road safety practice is followed by the identification of accident locations, road safety inspection of accident locations, developing treatments for accident locations and the prioritisation of, and budgeting for accident location treatment projects.


*Figure 2-1: Institutionalisation of the network screening process with Tenets 1 to 8*

### Tenet 1: Recognition of vested obligations and responsibilities

There are several curatorship responsibilities vested through various legislation and their delegations, with particular reference to the subsidiarity of national, provincial and municipal spheres of government, that are becoming better entrenched to advance the management and performance of the transport system. Fiscus rules and associated funding frameworks, e.g., the Division of Revenue Act, are being expanded to include road safety investigations and remediating actions more specifically for funding grants, prerequisites, and compliances. With the cost of accidents being quantified (RTMC 2016), it is imperative that road authorities assist with communicating the health burden of road accidents on their respective communities. Road authorities need to seize the opportunity to act on the road accident health burden as part of the NRSS to achieve a 50 % reduction in road fatalities by 2030. Reacting to the evidence as to why accidents take place is a proven method for achieving curatorship objectives and to assume the shared responsibility for road safety management with the necessary diligence. Responsibility for road safety rests primarily with every mandated authority – this solemn responsibility needs to be supported at the highest political level at every sphere of government.

#### Tenet 2: Develop and commit to a standard operating procedure

A Standard Operating Procedure (SOP) needs to be compiled and adopted as formalised protocol for conducting network screening and associated road safety investigation and analyses work. This should include specification of:

- The person or department with specific responsibility for investigation of road safety issues (normally a dedicated road safety team in a roads department). The road safety team needs to comprise dedicated professionals whose focus is predominantly, if not entirely, road safety. They need to be trained and provided with high quality advice and technical assistance until they have gained sufficient experience.
- The level of resources (financial and personnel) necessary to achieve a focused improvement in road safety. The level of resources required will depend on the extent of the road network for which the road authority is responsible. At a very minimum, there will need to be data analysts and road safety engineers so that the statistical analyses can be conducted. Thereafter, identified accident locations are to be investigated through site visits and remedial treatments to be conceived, designed and planned.
- The detailed process to be followed as set out in formally adopted manuals or guidelines. These documents should specify the approach to be taken in analysing data to identify high priority locations, conducting site visits and development of a treatment plan.
- Requirements for the extent of improvement to be achieved and over what period. This may be a numerical target associated with treatment of a proportion of the highest risk sites/sections or roads. Longer term casualty reduction targets associated with the improvements can also be developed.
- Mechanisms for monitoring performance. These may include formal monitoring of casualty numbers or the evaluation of remedial treatments.

#### Tenet 3: Dedicated road safety team

A road safety team should consist of appropriately qualified personnel with mathematics, engineering or statistical training to perform the analyses of collected information and to execute the prescribed procedures and with due regard for all relevant regulations and guidelines. Initially this team may have limited knowledge and experience of road safety analyses, in comparison with the level of detail that is required for the assessment task. This team may also be part of the general engineering department who have been given responsibility for road safety as part of other network management duties. However, as part of the organisational responsibility they will be required to develop the necessary skills and gain experience over time to provide improved accuracy and analytical detail. To deliver on these various functions reliably, the organisation will need to develop and offer structured training to the team to enable them to conduct accident location analysis, route/corridor analysis and/or area analysis.

In addition to the analysis team, experienced road safety engineers are required to investigate the results of the analyses conducted and develop appropriate treatments and prioritised road safety investment plans.

**Tenet 4: Business case development, funding requirements and budget.**

Conducting the curative tasks requires anticipating the financial resources required to implement a planned programme of interventions. Therefore, an annual budget needs to be established for the treatment of road safety problems identified on the existing road network – irrespective of how these have been identified. Economic appraisals that can demonstrate acceptable returns on investment will be a good motivation for consistent year-on-year funding. **Arguably, investment in road safety will 'always' (in the short term) present a positive business case. The internal rates of return that are reported for investments on road safety projects can be expected to be of the order of 3 to 70 times the investment (iRAP, 2021).** There are several different approaches to economic appraisal. Adopting a specific business approach will depend on a selected method and the development of some formal protocol for economic analysis.

**Tenet 5: Collection of data and investigative work.**

The curative techniques described in this TRH 29 require systematic collection of data (the detail and complexity of the data vary across the respective techniques discussed in this TRH 29). The collection and improvement of accident data quality is described in detail in Section 4. Naturally, precise accident location references are important for conducting of accident location analyses.

Regular and systematic collection of traffic flow and speed data, along with comparable population and network length data is an important function of road authorities. Well established rules exist regarding maintaining road asset management systems. Accurate information about road assets, including operational information is key.

- Traffic flow data significantly enhances the quality and utility of route/corridor studies. Population data can enhance the quality of area studies. Often these data are collected by a road authority (or district/local municipality) for other projects (e.g., planning, environmental impact studies, etc.) and so may already be available.

- Collating such information as an integrated effort with other departments is advisable (also see TMH 18: Road Asset Data Electronic Exchange Formats).
- Speed data can also be extremely useful when conducting site reviews. Some important facets are noted below:
  - As now entrenched in the Safe System approach, speed is a key factor in determining both the likelihood of an accident happening and the severity thereof.
  - Speed data should generally be collected at the same time as traffic flow surveys.
  - As a standard configuration, automated traffic logger equipment is already setup to record traffic flow and spot speed information.

Tenet 6: Capacity development and training.

It is well known that every road authority should have the in-house capacity necessary to take ownership (and responsibility) of the overall road safety problem. Capacity may be expanded (e.g., through contracted services, etc.) for specific reasons to achieve specific short-term objectives, but there has to be core capacity to ensure commitment, rigor and continuity of effort to drive road safety improvement programmes over the long-term, i.e., 10+ years. A road authority should consider the following activities:

- Training of staff (potentially as internships by local consultants/practitioners)
- Mentoring of staff (potentially by local consultants/practitioners) so that they gain experience and fulfil the experience requirements for those conducting site visits and development of a treatment plan
- Training for designers on road safety engineering to adequately interpret the safety interventions/treatments proposed.

Tenet 7: Monitor and review

Before implementing proposed treatments (as described under Tenet 4), it is normally necessary to assess their potential impact to make a business case for investment. Information on the efficacy of treatments has been compiled from research conducted in countries in Europe, the USA and Australia. Little is known about the true effectiveness of the treatments under different circumstances in Africa  (African Development Bank (b), 2014).

An understanding of local effectiveness can only be established if road authorities monitor and evaluate the performance of any (and all) measures implemented. Organisations therefore need to introduce a system for monitoring and reviewing the performance of any treatments that are installed (see Section 8). Such evidence can subsequently be used to identify the most appropriate safety improvements to incorporate in revised design standards.

This is particularly important in any country where development of the road network is occurring at a fast pace and where research concerning road characteristics and their impact on road safety outcomes is not available.

**Tenet 8: Review results, goal achievement, research and development, skills audit and skills development.**

Research and development, and knowledge transfer concern the systematic and ongoing creation, codification, transfer and application of knowledge that contributes to the improved efficiency and effectiveness of the road safety management system to achieve the desired focus on, and of, road safety results. Continuous feedback is thus essential to monitor progress towards the achievement of road safety results, improve the efforts from lessons learned, to demonstrate needed impact and to become more efficient. It is the mechanism to build understanding of what is required in terms of executing effective and efficient road safety improvement programmes that will deliver on the endeavour to reduce road traffic deaths by 50 per cent by 2030.

# 3 The curative approach concept

Using intelligence to direct and inform road safety programmes and individual interventions is known as taking a curative (or reactive) approach. This involves using accident data to identify accident locations (previously referred to as hazardous road locations or accident blackspots), routes or areas across the road network. Once an accident location of interest (based on quantifiable risk level, accident frequency, accident rate, accident type, design feature, etc.) has been identified, the site is reviewed in detail and a treatment project or programme devised.

## 3.1 Curative approach as part of 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 at all stages of road network development and maintenance project lifecycles. Effective road safety management programmes need to provide an optimal balance between curative and proactive strategies.

Curative approaches are used, along with proactive approaches (NLA and RSI, RSA and RSINV), to manage the safety of the existing road network. Most of the existing road network will pre-date modern road safety approaches and design standards, so it is important to ensure that the roads are assessed and treated to be as safe as they can reasonably be. The recording of accident information to sufficient detail and accuracy to facilitate ‘evidence based’ road safety business case development and effective treatment programmes, is an ongoing challenge – and not only in South Africa.


*Figure 3-1: Managing road safety on existing roads with different levels of quality and availability of accident data (adapted from African Development Bank, 2014)*

Figure 3-1 provides an indication of the curative methods that can be applied to manage the safety on existing roads when accident data availability/content is at different maturity levels in terms of quality and availability.

Conducting accident location analysis (Section 6.3) is reliant on the quality of accident data (i.e., must include accurate descriptions and locations of the incidents). Sketch drawings with proper reference points, road names, route descriptions and the like are currently more generally used to indicate accident locations, but precise accident coordinates that are established at the scenes of accidents have important advantages. Apart from the ease of recording made possible through using GPS devices in conjunction with Geographic Information System (GIS) and other advanced applications, more sophisticated analyses and information visualisation options become available. It is possible to derive accident coordinates from sketches and other descriptions, however, this is a very labour-intensive process and one in which introducing significant error is hard to avoid. Recording accident coordinates from the onset, will thus contribute to better efficiency in the data validation and collation work. On the negative side, the accident database and system need to be geared towards the incorporation of accident coordinates (as well as other conventional location referencing) to avoid other validation and inconsistency issues. Improvements to the accident register system are currently underway by the RTMC, the authority responsible for the electronic national administration traffic information system (eNaTIS) in which the accident information reside (or is intended to reside).

A detailed discussion of the accident data as an important topic in road safety management is provided in Section 4 below. In the interim, it may continue to be necessary to use road names or sections to identify routes/corridors that are of interest through route/corridor analysis (Section 6.4). This can only be done if accident data are systematically collated in an accident database and if road names are spelt and entered in a rigorous manner.

If road names are not recorded in a sufficiently accurate or systematic manner, it is sometimes possible to conduct area analyses (Section 6.5) using the police precinct reference (e.g., SAPS station name) which is often included in an accident report (AR form) or Crime Administration System (CAS) register.

## 3.2 Curative approach and the Safe System

The Safe System Approach (SSA) reframes the way in which road safety is managed and viewed. Fundamental to SSA is the 'shared responsibility' among stakeholders, which entails that all elements of the transport system be addressed in an integrated manner to ensure that the accident potential is limited, and the human is protected in the event of an accident. A key aspect of Safe System working is the focus on perceivable risk, based on known risk factors which can be applied universally regardless of the differing levels of road safety performance. Slight variations in the conceivable interventions might be appropriate, however.

The road transport system is a road network in continuous development through changes and additions. Under the Safe System working, the aim is for the road transport system to evolve to be forgiving of human error - taking the vulnerability of the human body into account. The Safe System accepts that even the most law-abiding and careful of humans will make errors. The Safe System endeavours to also ensure that road users who 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 law enforcement.

The challenge under a Safe System is to manage the interaction between vehicles, travel speeds and the road to not only reduce the number of accidents but, more importantly, to ensure that when accidents occur, they do not result in death or serious injury.

When road users 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 accidents (e.g., electronic stability control (ESC) and Anti-lock Braking System (ABS) brakes) and safety features that protect road users in the event of an accident (e.g., airbags, crumple zones 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 accidents 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 accidents.
- Safe speeds: Vehicles travel at speeds that suit the function and the level of safety of the road to ensure that accident 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-accident 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 to manage the interaction between road users, vehicles, travel speeds and roads (African Development Bank, 2014).

### 3.2.1 The importance of speed

At lower speeds a driver will have greater opportunity to react and avoid an accident. Speed also affects the severity of accidents. Higher speed accidents involve more kinetic energy (kinetic energy is proportional to the speed squared). The more energy that is dispersed in an accident, the more severe it tends to be. Four main accident types, account for most fatal and serious injuries:

- Accidents involving Vulnerable Road Users (VRUs), i.e., pedestrians, motorcyclists, cyclists, public transport users and road-side vendors.
- Side impact accidents at intersections
- Head-on accidents
- Run-off-the-road accidents

Other accident types do occur across the road network, but they are less likely to have fatal or serious injury outcomes. The graphs **Error! Reference source not found.**from Wramborg (2005) (see Figure 3-2) plot accident speed against fatality risk and show that with increasing speeds, the risk of fatality increases very sharply for the first three accident types listed above.

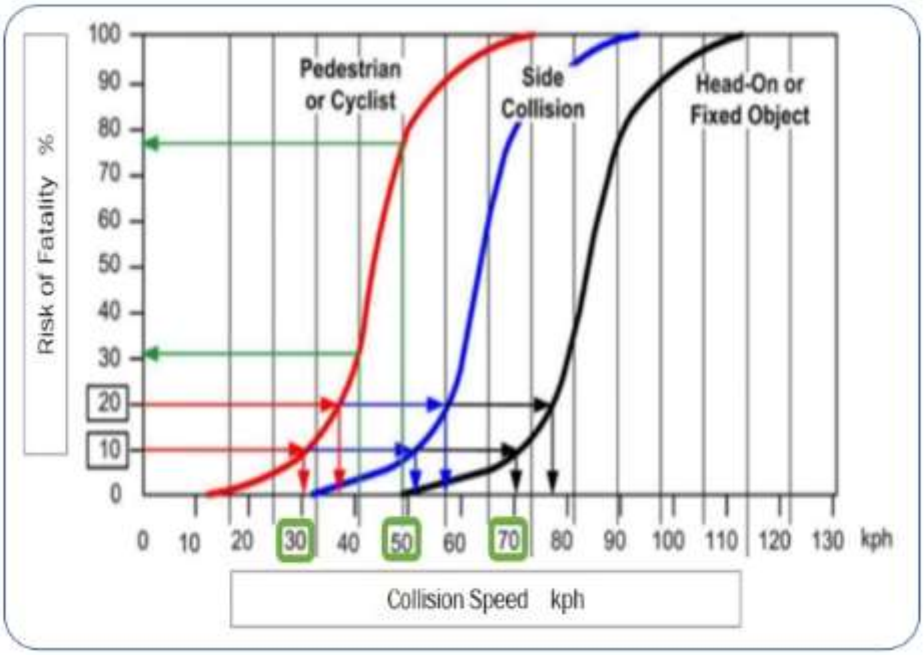



*Figure 3-2: Survivable speeds according to Wramborg (2005)*

Several guiding principles for survivability emerge from the aforementioned:

- 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 series
- Where side impacts are possible at intersections and T-junctions, the speed at which most will survive is 50 km/h – this is represented by the blue series
- Where head-on accidents 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 black series. Similar research on run-off-the-road accidents was undertaken by Stigson (2009). According to this work, a road is considered 'safe' (or survivable) for run-off-the-road accidents if it has a:
    - Speed limit not higher than 50 km/h, or
    - Safety zone of at least 4 metres wide and a speed limit not higher than 70 km/h, or
    - Safety zone of at least 10 metres wide and a speed limit higher than 70 km/h.

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

### 3.2.2 Applying safe system principles to curative approaches

The collection and use of data are very much at the heart of the Safe System philosophy. It embraces evidence-based inferencing and action. The target of reduced or even zero road fatalities and serious injuries must be attained in the most efficient and economical way possible (International Transport Forum, 2016).

Safe System working has a clear emphasis on monitoring and evaluation to identify what works and what does not. Monitoring and evaluation can only be conducted if a range of data are systematically collected and analysed. An important focus of the Safe System is to reduce road fatalities and serious injuries. This 'ultimate' goal can only be assessed by using appropriately detailed accident data – whether collated from SAPS, medical or other sources. In addition to accident data, intermediate indicators of road safety performance can be measured and used to inform the curative approach. In particular, speed data can be particularly useful when considering engineering treatments.

At the heart of any effective programme targeted to significantly improve road safety there needs to be credible and systematic use of data to guide decision making. There needs to be well thought-through analysis to develop strategies based on the best evidence available and objective efforts to monitor the performance. Safe System working strongly recommends the proven public health approach as a basis for improving road safety. This way of working is relevant to tackling road safety, which is essentially a public health problem. In this approach, data are used to identify issues, develop treatments and then continually assess the impact of interventions.

Although it is often said that 'we know what works to improve road safety', most approaches and treatments have generally only been evaluated in countries which have been systematically tackling their problems for many years. These countries have very different traffic mixes and driver behaviours compared with typical South African conditions. Safe System working emphasises that research is vital to identify specific local issues and effective treatments. Currently there is a major gap in knowledge as to how measures actually perform in any of the low- and middle-income countries, chiefly because data are not of sufficient quality and because robust evaluation is rarely a priority (Odonkor et al., 2020; Turner et al., 2021).

Therefore, the collection and analysis of data, evaluation and monitoring of the effectiveness of treatments must be pursued as a priority to ensure an effective road safety programme in the future. Proactive approaches such as Road Safety Audit, Network Level Assessment and Road Safety Inspection can be conducted while high quality accident data are collected and accumulated. **However, without accident data it will not be possible to determine the true impact of these approaches or the treatments that are recommended as a result.**

## 3.3 An overview of curative approaches

Application of curative approaches can be done at three distinct levels of detail, depending upon the quality of the initial data available. These are described in turn in the subsections of Section 6. Below are short descriptions of the curative approaches.

### 3.3.1 Accident location analysis and treatment

Accident location analysis is concerned with identifying locations on the network where there is a concentration or high rate of accidents. Problem locations are identified by reviewing the accident history across the network and locating short sections or confined places, e.g., intersections, which have higher accident occurrence than would otherwise be expected given the road character and features (De Souza et al, 2017).

The accidents at the identified accident locations are analysed to identify common patterns (e.g., by types of accidents) that may relate to an underlying safety problem (Mohanty, 2015). Site visits are then conducted to identify aspects of the road that could be treated to reduce the types of accidents that have occurred. Where a clear localised road defect can be identified this can often be treated effectively at low cost (e.g., simply requiring some maintenance intervention). This means that accident location analysis and management can be a very cost-effective way to improve road safety (PIARC Technical Committee C2 Safer roads and infrastructure, 2018).

Accident locations analysis requires the accurate location of all accidents on the network - precise geospatial coordinates will be a great advantage. Where such accurate information is not available, route/corridor analysis or area analysis may be possible. These approaches are described in more detail in Section 6.4 and 6.5 of this TRH 29.

### 3.3.2 Route/corridor analysis and treatment

Route/corridor analyses are conducted to identify high risk sections that require further investigation and treatment. The high-risk sections are then reviewed in depth during a site visit and treatments developed (African Development Bank, 2014). Ideally, route/corridor analysis will be conducted alongside accident location analysis since they tend to identify slightly different issues. Whereas accident location analysis is concerned with identifying localised safety problems, route/corridor analysis is concerned with identifying longer road sections which may be treated in a consistent manner to improve safety. Once high-risk sections have been identified, the nature of the accidents occurring on each section is analysed, the site is visited, and treatments developed. Route/corridor analysis is typically applied on the higher flow rural network rather than on local urban roads and streets since rural roads tend to be more homogenous in character and lend themselves to consistent treatments. This approach is described in more detail in Section 6.4 of this TRH 29.

### 3.3.3 Area analysis and treatment

Area analysis can be applied where it is possible to identify common accident themes by area, often using a South African Police Service (SAPS) precinct or station name to link accidents to a network area. Such areas need to be relatively small and have a high concentration of accidents for the method to be productive, and it will thus be more applicable to urban areas. Identification of common accident types can also help identify potential area-wide remedial treatments. This approach is described in more detail in Section 6.5 of this TRH 29.

## 3.4 Benefits of taking a curative approach

Taking a curative approach to road safety programmes has several clear benefits:

- Interventions can be targeted and designed to be as effective and efficient as possible
- Effectiveness of treatments can be evaluated.

When the evidence base is lacking, interventions may be inefficient at best and at worst may have a negative impact. Taking a curative approach aligns with the approach taken for other public health issues (Figure 3-3) and has been demonstrated to be very effective. It is typically reported that major accident location programmes have an overall benefit to cost ratio of 10 or more to one. Reports also indicate that accident location treatments reduce accident occurrence by between 20% and 40% for targeted accident types (Candappa, et al, 2007).

Individual treatments of some accident locations have been reported to be extremely effective. The impact of route/corridor and area analyses and treatment is not documented as well as accident location programmes since these are relatively new approaches (African Development Bank, 2014).

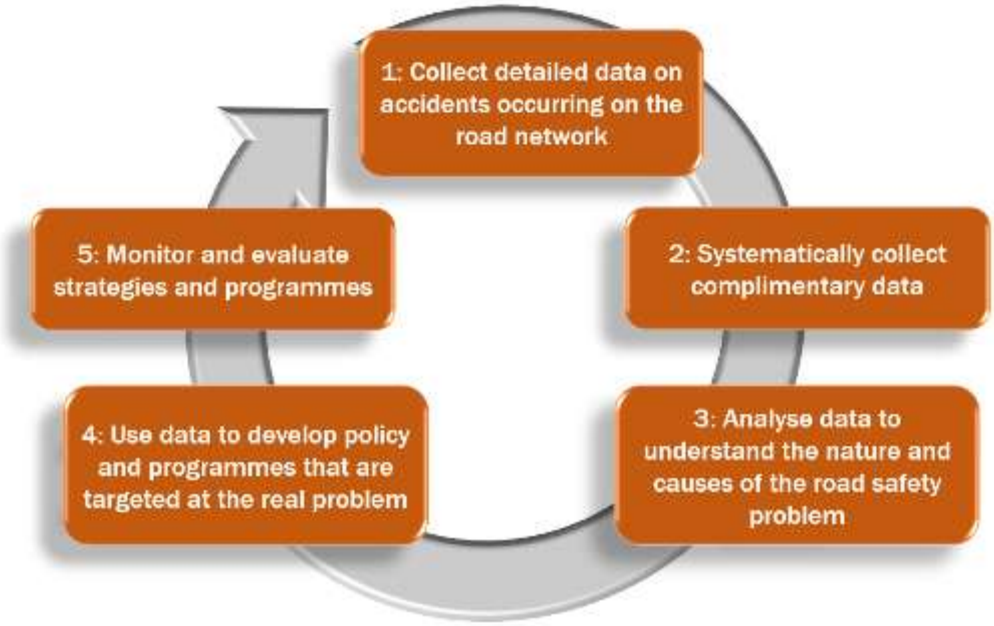



*Figure 3-3: The public health approach to road safety*

# 4 Road traffic accident data

## 4.1 Importance of accident and road data

The process of accurately investigating, analysing and effectively treating accident locations relies on the use of comprehensive and accurate accident data and data related to the road and traffic characteristics at the accident locations (World Road Association, 2014).

Comprehensive and accurate data enables:

- assessing and communicating the scale of the road accident problem, and making the case for increased investment in road safety
- determining accident locations accurately
- identifying events associated with accidents
- identifying accident contributory and severity factors, thus providing the basis for selecting targeted remedial treatment options
- identifying common factors across a number of accidents
- determining the cost consequences of a single accident, identifying all accidents at one location or several accidents with common factors
- accident sites to be ranked so that treatment can be applied to those sites that will derive the greatest safety benefits.

A variety of sources of accident data are used to support the development and monitoring of road safety programmes internationally. The quality of accident data and of other sources such as medical information on road casualties tends to be poor. The inferior quality and availability of the range of accident and injury data is an ongoing major impediment to obtaining significant and measured improvements in road safety levels across the world.

## 4.2 Accident reporting and data availability

There is a minimum set of data about each accident which is necessary as a basis for the sound and satisfactory identification and investigation of an accident location. A reasonable knowledge of accident data definitions and limitations is required to accurately interpret this information in any given jurisdiction.

Currently, it is required by law that all casualty, as well as damage-only, accidents must be reported to the SAPS. The SAPS and other road and traffic departments record motor vehicle accident data using the formal Accident Report (AR) forms. The data collection procedure is conducted on behalf of the Road Traffic Management Corporation (RTMC), which has a legislated responsibility to report the information. In the past, capturing authorities were commissioned to receive copies of all AR forms, to capture the data (or otherwise forward it to the RTMC for capturing). Under normal circumstances, the RTMC would consolidate the data and conduct analyses and interpretations for its annual State of Road Safety Report, in additions to making data available to road and traffic departments. However, due to various reasons, including the processing of AR forms, poorly completed forms, etc., the reliability, in terms of availability and content, of accident data has drastically deteriorated over the past decade or more. Fatal accidents are, however, reported within 24 hours using the so-called quick response form – i.e., the Culpable Homicide Crash Observation Report (CHoCOR). The RTMC receives all the SAPS CHoCOR forms from the various SAPS stations and captures, processes and verifies the data – allowing some consolidation for purposes of reporting on fatalities and fatal accidents. Although locality information is required on the CHoCOR, this critical information is often incomplete or absent.

There are continuous engagements with provinces and other role players to improve the situation and some authorities have made gallant efforts to capture accident incidents and to follow-up to validate incident and accident information - also through Road Incident Management Systems (RIMSs) where these are in operation. Notwithstanding, the general state is that accident data is not readily available. Attempts to collect copies of AR forms at SAPS stations often involve cumbersome processes to get data captured. Reliability, particularly with respect to statistical parameters, remain a problem, as does the absence of locality information in which case the locality will at best be within the precinct of the SAPS station.

Whilst there are great endeavours to improve the accident data situation, from a road safety perspective, casualties remain the key indicator of the road safety problem. In close alignment with Safe System principles and objectives, fatal and serious injury accidents are used as road safety key performance indicators. Lower severity outcomes as well as property damage data (where available) can provide valuable additional data that can be used to support proposed countermeasure treatments.

The scale of accident severities is defined as follows:

- fatal accidents - one or more persons killed or died within 30 days
- serious injury accidents - one or more persons admitted to hospital (more typically based on whether a person was injured and taken by ambulance to hospital)
- minor injury accidents - one or more persons injured who were not admitted to hospital (more typically based on a person not being taken by ambulance to hospital but requiring medical treatment)
- damage only accidents - where no injuries are apparent.

## 4.3 Purposes of accident data collection

Road traffic accident information is used by a wide variety of people for a wide variety of purposes. Although not always the case for South Africa, the following parties typically collect accident data:

- road safety practitioners - for developing remedial or pro-active road and traffic measures

- SAPS - who may be investigating whether to charge a person with a criminal offence in relation to a specific accident
- hospitals and health centres - to monitor their health service requirements
- lawyers – for acting on behalf of clients in civil litigations regarding compensation for injuries and other losses sustained
- insurers – for developing strategies and to manage claim risks, contribute to improving road safety (e.g., repairing potholes), etc.
- those with responsibility for road safety education and publicity - to ensure that their efforts are well-targeted
- the media
- SAPS and traffic departments – for strategies in relation to enforcement activities, e.g., establishing the location for speed cameras or breath testing stations
- road safety managers – for exercising their duty to report statistical information on road accidents
- researchers - who need access to an accurate, reliable database to conduct rigorous research
- vehicle and component manufacturers and suppliers of road materials - who may wish to assess the safety of their products from a viewpoint of litigation, marketing or product enhancement.

The primary purposes for data collection within different organisations vary in that the information collected, the way in which databases are established, the opportunities for data aggregation and analysis, and interpretation of information is diverse. Therefore, the opportunities to supplement information on one database with information from another is severely limited. For example, the database of a motor vehicle insurance company may not record accident location by a numerical geographic system, as this information is peripheral to their insurance claim assessment concerns and financial management. The database will typically not be in a format which can be used by someone seeking information about the safety performance at a particular location. There should thus be continuous awareness of the opportunities that may be afforded through greater integratability of road safety relevant data (within the bounds of information regulations).

Other data sources are as follows:

- Traffic data, such as traffic volumes (including traffic composition and turning volumes), pedestrian flows and vehicle speeds will be helpful, depending upon the particular circumstances and problems at the site. In some cases, these will be immediately available, but in other cases they may need to be collected.
- Hospitals and other trauma centres typically record the causes of injuries as well as their nature, extent and treatment. Accident data sourced from the SAPS or emergency services information may indicate whether someone was taken by ambulance or not, but typically does not give information as to whether that person was hospitalised, for how long, or

whether the injuries sustained resulted in long-term impairment. With advances in technology, and greater collaboration between the casualty evacuation role-players, it is possible to link this information together, allowing for road safety treatments to be focused on those resulting in the most debilitating injuries.

- In special circumstances, provided confidentiality of patient information is secure, hospital data may be made available for research purposes. This has been done with good effect in the development of countermeasures to reduce the severity of road accident injuries.
- Insurance companies require claimants against policies to provide a description of the circumstances in which the loss, damage or injury occurred. This information is not usually released, although it has been released as consolidated data by some insurers. It provides a potential for establishing the true extent of lower cost accidents which are not reported to the police. Unfortunately, it is generally not in a form which is compatible with the needs of accident location analysis and treatment.
- A further source of information on accident occurrences is tow-in services providers' records. Tow-in contractors have mobile phone applications to capture information on-site, including registration numbers, licence information, photographs, GPS coordinates, etc. and to transmit to relevant insurance companies (there is currently no formal system in place to utilise this information).
- From time-to-time in-depth accident studies are conducted into the nature and cause of accidents in a particular area or in the case of high-profile accidents involving multiple fatalities, for instance. These studies are costly to undertake and involve specialist teams attending accident scenes, taking measurements and recording accident features. The results are usually published in special reports. The RTMC has a unit that investigates high-profile accidents (accidents with five or more fatalities) and there is the intent to publish reports on these on an annual basis.
- Local knowledge and so-called anecdotal evidence are important sources of information about safety problems on the road network. Although such accounts are often subjective and need to be regarded cautiously, they can be a pointer to problems or prompt further investigation. Information sources can include local residents, businesses, community safety groups, emergency service personnel, local medical practitioners, maintenance contractors and local road authority staff.
- Interviews of road users, including people who have been involved in an accident at a site of interest, in a structured format have been used by some traffic authorities to gain information for the development of accident countermeasures.
- Traffic conflict surveys may be used where the collection of accident data is not practical. These involve field observations or video recording of

conflicts (near-misses). Technological developments in this field are aiding with a more consistent assessment of road traffic conflicts through machine-based techniques. Traffic conflict surveys using electronic means are thus becoming more feasible as sources of site-specific surrogate accident data.

- Coroners' reports can be a useful source of additional information concerning specific fatal accidents. The RTMC has established an arrangement with the DOH to collaborate and verify road accident deaths with mortuary information.
- Site investigations are a necessary component of any treatment or countermeasure development program and will often yield insights into the accident history at a site. By spending time at the location that has seen serious accidents, aspect that cannot be appreciated by merely reading reports (or watching footage) will be appreciated.
- Speed survey data also provides a source of information regarding speeding behaviour.

## 4.4 Technology available for data collection

Computer based technology is being developed in two significant ways to improve the accuracy of data collection.

### To improve the accuracy of location information

Global positioning systems (GPS) or satellite navigation systems are being used by most authorities for accurate determination of an accident location. The person attending the accident scene uses the system instead of, or in addition to, documenting the location in traditional terms (ABC Road, xx metres N/S/E/W of XYZ Street or road number R##, kilometre marker XX.YY). This method has great potential in rural areas where recording of the distance and direction to identifiable features can be subject to significant error.

It should not be a problem for any road or traffic department to now use a geographical information system (GIS) or digital mapping to record accident locations. This permits accident data to be incorporated within a relational data base, allowing accident sites to be overlaid on plans showing other geographical information such as road features, traffic flows, intersection layouts and land uses.

Modern technology makes the initial collection and assessment of safety-related data easier and more useful. It is not uncommon to find an ordinary smart mobile phone with camera applications that records GPS information and can pin pictures to map applications with up-to-date route information. Although there needs to be awareness of personal information protection, this is available technology that can greatly assist in conducting initial accident investigations. Furthermore, research is currently underway on incorporating inventory data, e.g., road geometry data and accident data with the video information. This is to assist high risk route assessments for the identification of proposed accident mitigation measures. This research is in its early stages of development.

#### To improve the accuracy and completeness of accident data

Menu-driven accident data capture programs (or applications) can be used with laptop computers or tablets (or even some smart phones) by an attending officer to ensure that all desired information is collected at the scene of an accident. These programs can include built-in logic and consistency checks on the data as it is entered.

Accident report forms can be arranged so that the information can be scanned into the database that will minimise costs and reduce the risk of error in the data capturing process.

## 4.5 Limitations and accuracy of accident data

It is crucial that practitioners using road accident data understand the limitations of the data and take steps to resolve any anomalies which may occur. The limitations below, some of which may be more profound in the specific context of South African authorities, include:

- Under-reporting of accident data – although significant attempts are made to collect and record all relevant accident data, not all non-fatal accidents make their way to the relevant accident database. Even in countries with good systems and capacity, research indicates that only around 60% of serious accidents are recorded in the accident database, with significantly less for minor injury accidents and that reporting rates also vary by type of accident – e.g., reporting rates were lower for cyclists, pedestrians and motorcyclists.
- Systematic reporting bias – numerically, damage only (non-injury) accidents constitute the bulk of accidents: there are 58 non-injury accidents for every fatal accident (RTMC Cost of crashes 2016).
- Random reporting bias – it is well known that accidents involving children, cyclists, pedestrians and those with minor injury casualties are substantially under-reported. A similar situation applies to accidents involving illegal activity, such as under-age driving and driving while intoxicated.
- It is common for some human factors (e.g., alcohol and drugs) and roadway factors (e.g., the presence of a roadside culvert) not to be recorded. The absence of this information on the accident report form could mean the absence of the factor or the failure to record it. Erroneous conclusions can be made from the wrong interpretation of this absence of data.
- Subjective bias – on the AR form, space is provided for an assessment of possible contributing causes of the accident. This adds a subjective element, as the range of possible responses to the question of what caused the accident will be affected by the recorder's experiences and the purposes (other than accident recording) for which the information may

be used. For example, 'failure to give way' may be seen as a cause by someone regularly involved in traffic law enforcement, whereas the same situation may be seen as 'control device not visible' by someone regularly involved with road environment safety matters. In the same vein, speed and fatigue are not typically based on direct observation.

- Reporting errors – it is important to recognise the circumstances under which an attending officer obtains information to complete an AR form. There will often be more pressing matters at an accident scene. The officer may not have local knowledge or adequate training in incident investigation, so some data items may be inadequately or wrongly recorded. Accidents do not always fit 'standard' formats and motivation to fill in the AR form comprehensively may be lacking.
- Recording errors – these can occur throughout the process - from filling out the accident report form, to the data entry at the computer terminal. It is estimated that errors of this type occur in 5% of accident files (Ogden 1996). They are unlikely to be revealed unless the data are used for detailed investigation at individual sites. Typical problems include wrong direction for the north point, wrong direction for one of two vehicle movements, selecting the wrong type of accident, for example 'rear-end' instead of 'rear end into right turner', and numerical recording errors.
- Location errors – the location may be imprecise or wrong in the original AR form and this will be carried through into the database. The location reference system may also be imprecise, so that a user of the data may not be able to accurately determine the location (e.g., all mid-block accidents may be recorded as being midway between the adjacent intersections).
- Discontinuities over time – definitions or interpretations of field data may be changed over time by those responsible for recording and reporting, so that data from one time period cannot be compared with that of another. An abrupt change in recorded accident experience at a site should lead an analyst to enquire as to whether there has been any discontinuity, e.g., where the recording changes hands at a particular SAPS station.
- Delays – personnel, units or departments responsible for data processing may not be sufficiently resourced: it may be many months before information is available for analysis. Data may only be released annually. This means that countermeasure development may be responding to historical accident patterns which may be out of date.
- Masked or hidden problems – it may be the case that a location is perceived as being so dangerous that people avoid using it. In this situation the safety problem results in a reduction of amenity (e.g., as pedestrians choose to cross the road somewhere regarded as safer) rather than risking accidents. The use of the other data sources outlined in Section 4.3 can help overcome this kind of data limitation.

## 4.6 Recording of accident types and accident location

One of the basic tools for understanding what happened at an accident location is by ascertaining the type of accident. On the AR form, this is indicated in easy identifiable pictures that need to be ticked. The pictures are representative of the movements of road users when the accident happened and provide very important information about the accident. Together with the location information, an analyst will quickly be able to identify any accident pattern at a particular location, which will aid the identification of common contributing factors and providing leads to common treatments (Gopalakrishnan, 2012).

Accident locations, regarded as critical information for road safety engineers, can be captured in various ways. The level of sophistication or type of technological support should not determine the accuracy with which a location can be marked. It is very important information and requires diligent effort to capture it as accurately as possible. Critical parameters are:

- Route number and chainage
- Accident location sketches (with street names and any other references identifiable on a map or in the field)
- GPS coordinates at each node relevant to the accident – mobile devices with GPS-enabled applications are useful to automatically capture at the scene coordinates.

### 4.6.1 Distance markers

Kilometre distance marker posts are a standard requirement on regional or strategic roads. Other kilometre indications along roads, e.g., on direction signs, are a commonly used method to locate places, boundaries, interchanges and as well as assets and features along major roads. These can be used by the SAPS and attending officials as a way of indicating the location of accidents fairly accurately.

*In its simplest application, the police indicate that the accident occurred between 'marker post x' and 'marker post y'. The order in which the marker posts are entered can also be used to indicate which direction the driver at fault was travelling prior to the accident. This system gives the location of accidents within a defined 200 m road section, which, with some inferencing (distance in metres from marker XXX.xx) can pin an accident location within 10 m to 100 m – sufficiently accurate on the type of roads typically equipped with kilometre markers.*

gives an example of a kilometre marker on a national road.

Features such as bridges and culverts along routes can also be given known kilometre locations on strip maps which could also be used as a relatively simple way to give the location of the accident sites. Figure 4-1 gives an example of a strip map. This system can only be used on major roads which have consistent and clearly provided and maintained marker posts in place along the route. It is also reliant on the police being diligent in carrying out the reporting to a good standard.

Precise accident coordinates would still need to be determined from this kilometrage information by staff using mapping systems in the office.

Benefits:

- Low-cost option for use on rural roads with kilometre marker posts
- Accuracy can be enhanced using a strip map

Considerations:

- Not suitable for use in urban areas
- Poor levels of accuracy
- Requires high levels of diligence
- Accurate accident coordinates will still need to be coded by office staff based on information provided


*Figure 4-1: Typical kilometre marker with explanations*

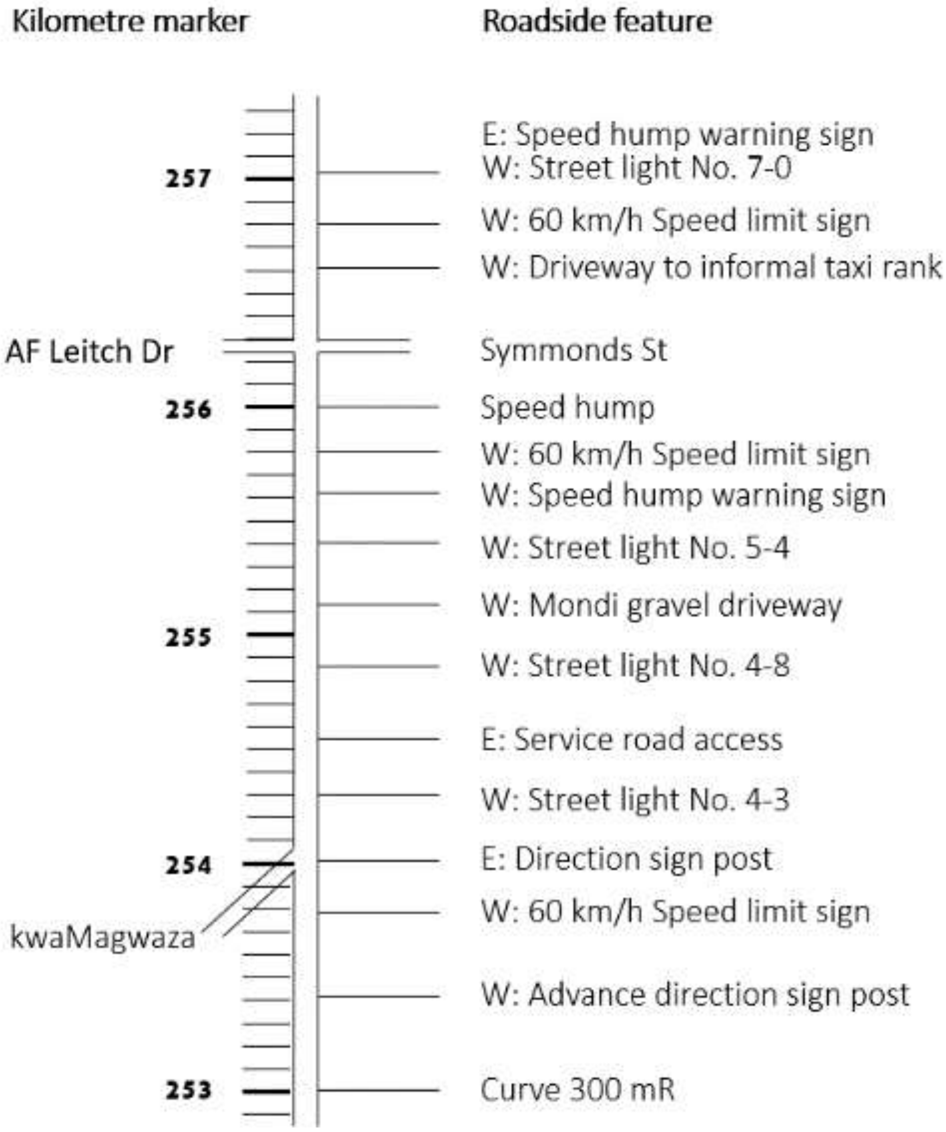



*Figure 4-2: Example of a strip map*

### 4.6.2 Accident location sketch

A common way police indicate the accident position on report forms is by means of a location sketch. The officer draws a simple diagram which shows the accident location in relation to identifiable locations on the road network. These diagrams should provide enough information for staff to give the accident an accurate map coordinate using digital maps when they are entering the record into the computer database system in the office (World Road Association, 2014).

The simplest way to obtain good map locations is to relate the accident position as distance in metres to major intersections. Intersections are easy to locate on digital mapping. Ideally the sketches are accurate enough such that allocating a map coordinate is a simple task. However, it is common that the quality of the sketch is not good enough in a considerable number of cases (World Road Association, 2014). It is often the case that police officers have no understanding of what the sketch on the AR form is used for - neither what constitutes a useful sketch nor what features should be included. Dialogue between the office data entry staff and the officers completing the AR form can improve the quality through constructive feedback. It should also be possible to contact the officer that originally filled in the AR form to check key details if information is unclear. An important reason to contact the officer that collected the data is to check that the recorded location is indeed correct. The AR form provides for a location sketch in addition to the very detailed fields for location information (including coordinates) – the first section on the AR form to be filled out. There is also space for a written description of the accident that may include unambiguous clues about the location of the accident to verify the location text.

Benefits:

- Low-cost option

Considerations:

- Often sketches are vague and do not contain the required information for accurate allocation of an accident coordinate by office staff
- Accuracy low

### 4.6.3 Global positioning system devices

Global Positioning System (GPS) devices have become readily available and relatively inexpensive. GPS positioning is an option that can be utilised to improve the convenience and accuracy with which the location coordinates of accidents can be obtained and recorded at the scene of an accident. GPS units use the differences in time that radio signals take to be received from several of orbiting satellites to obtain accurate map coordinates at a given point on the earth's surface.

The price of GPS handsets has reduced significantly in recent years and battery life has also improved greatly making these a viable method for police and other response services to collect map coordinates for accidents. A handset needs to pick up a number of satellite signals - the stronger the signals that are locked onto, the more accurate the coordinates will be. Obtaining the lock onto the satellites can take a few minutes, but a handset can be left unattended whilst the officer attends to other tasks. A clear view of the sky will ensure the best operation of the handset. Tree cover and tall buildings have been reported to cause some issues with obtaining accurate positioning using GPS.

The main problem with the GPS device is that it needs to be with the officer when attending the accident site, it must have charged batteries and the police staff must remember to actually use it. The unit needs to be set to the correct coordinate system and the officer needs to correctly transcribe the reading onto the paper form. Accuracies of between 1 and 3 metres are readily obtainable which is sufficient for spatial analyses such as accident location analysis.

Benefits:

- High level of accuracy
- Low levels of error

Considerations:

- Relatively high cost
- GPS units may not function well among tall buildings and under dense tree coverage
- Units need to be maintained and charged
- Accurate transcription is required

### 4.6.4 Data capture with mobile devices

Data capturing using mobile devices, e.g., smart phones, tablets, etc. is now available and these generally have built-in GPS capabilities. As these devices become less expensive, they become an option not only for the recording of accident coordinates but also filling out the AR form electronically (Siuhi and Mwakalonge, 2016). Capturing and attaching photographs and videos to the accident record file (or electronic AR form) is also possible. Using such an approach can remove the need for labour intensive and error prone data entry since the data are uploaded directly to the accident database either remotely through the mobile data network, through a USB (Universal Serial Bus) or WiFi connection at the police station. Validation/completeness checks can also be conducted at the point of data collection. Work to enable some of these functionalities on the eNaTIS is underway.

Benefits:

- High level of accuracy
- Low levels of error
- Removes the possibility of transcription error
- Removes need for data entry in the office
- Validation of data/checking for completeness can be conducted at the time of data collection

Considerations:

- Relatively high cost
- Smart phones/tablets need to be maintained and charged
- High sun glare levels may mean using smart phones/tablets outdoors is problematic (details can be filled in at the police station by the attending officer as an alternative)

## 4.7 Accident databases and analysis software

Whilst it is possible to store data using paper-based filing systems, there are some significant disadvantages:

- Paper records can become spoilt, torn, faded or even lost, photocopies or duplicates can be of poor quality

- Meticulous filing of records is required in order that they can be accessed in the future
- Even the most basic of analyses can be extremely time consuming (e.g., if a particular junction needs to be investigated, all accidents occurring within the confines of the junction must be found)

Whilst using an accident database system is indispensable, it can remove the engineer/technologist/technician from the realities of the raw data. The original records should be kept accessible to allow for retrospective checking of information. Electronic systems have the capability to hold scanned copies of the AR form (and crucially copies of accident sketches) together with the other recorded data.

# 5 Road safety assessment basics

The road safety assessment process is a combination of scientific evaluation, the investigator's knowledge and experience, and good judgment. The investigator is piecing together many clues as to why accidents occurred without having the benefit of actual first-hand knowledge. The investigator must search for clues from a detailed analysis of accident data and a thorough investigation of field data. These clues can then be evaluated to identify preventable accidents. For these 'target' accidents, the investigator can identify feasible and effective treatments and/or countermeasures, make recommendations, and document the entire process. What follows is a brief overview about basic philosophy and information needed for accident assessments.

## 5.1 Principles of road safety assessment

There are two principles that are useful to keep in mind when attempting to diagnose an accident problem. First, accidents should be rare events. Even though there are an estimated 832 000 accidents (RTMC, 2016) across South Africa's Road network per year, the vast majority of interactions between vehicles, users, and the infrastructure do not result in accidents.

For an accident to occur, several events must occur simultaneously. For example, if a rear-end accident occurs at a signalised intersection, one or more of the following events must have transpired: two vehicles approach a traffic signal as it turns red; the driver in the following vehicle is following too closely or is inattentive; braking (if any) is not sufficient to stop the trailing vehicle in time due to inattention or a slow reaction; the driver in the lead vehicle then stops abruptly; an accident. If any one of these sequential events leading up to the accident were altered in some way, the accident may have been avoided.

Road users may take decisions in the early phases of an accident that may cause an accident in a later phase. The example demonstrates the importance of recognising the opportunity for early intervention. Accidents are very rarely the result of a single unsafe action; they usually involve a chain of circumstances and events that result in an accident. Figure 5-1 is a visual representation of a combination of latent errors present in the traffic system. This 'Swiss cheese model' indicates that several different errors will have to occur simultaneously (shown linearly in the schematic representation) to cause an accident. Clearly, an accident can happen even with a "perfectly" engineered, signed, and enforced facility (Larsson, 2010).

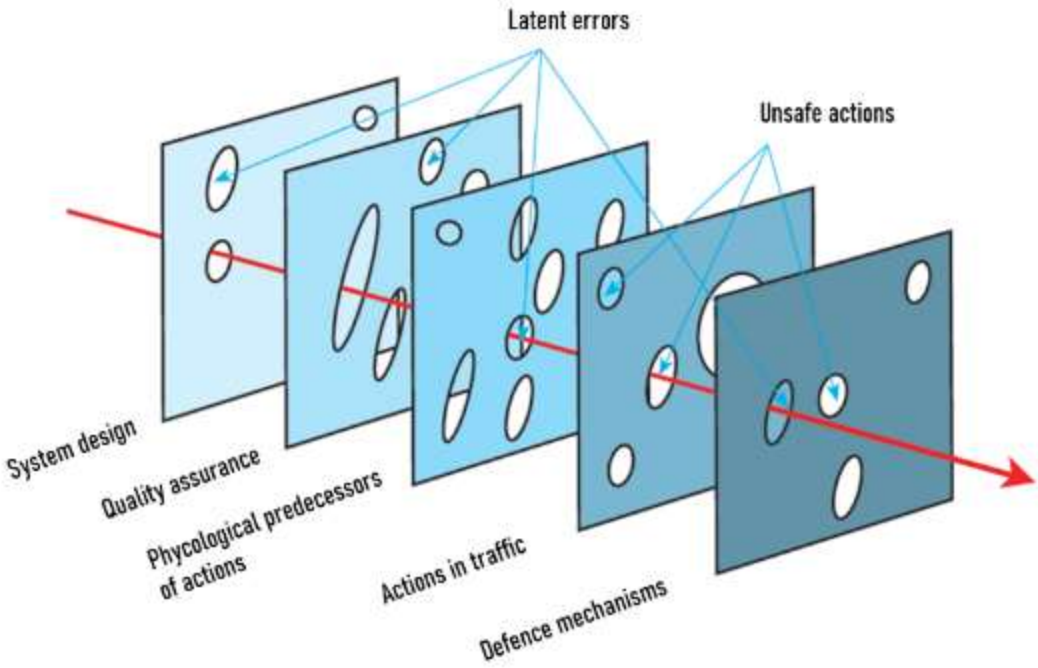



*Figure 5-1: Schematic representation of the development of an accident (red arrow) because of latent error and unsafe actions*

In taking a longer-term view (over several years), a reasonable number of accidents can be expected on any given section of the road network. This long-term view can be thought of as the "expected accidents" or the "average over the long run." These expected accidents vary across different environments (e.g., a rural regional connector or urban street) because driver expectations, trip purpose, potential conflicts, traffic volumes, design standards, etc., are different. It should be emphasised that the "expected accidents" concept does not mean that this number of accidents is acceptable to society at large. This concept reflects a measure of the prevailing safety performance (which can be improved).

<u>Second</u>, we assume that most drivers, cyclists, and pedestrians would prefer to avoid an accident and will take evasive action in most situations. However, we know that errors will occur. While we might expect some accidents to happen, if accidents exceed what we expect then something is most likely correctable at our investigated location (Saunier, 2016). Therefore, investigative efforts need to be toward searching for a pattern of accidents that is out of the ordinary. If these patterns can be detected, they are the most reliable guide to the remedial action. This is described in Section 6.

Once the pattern is found, the next step in the diagnostic effort is to try to determine what might be "causing" these accidents to occur. Interpreting the accident pattern data, field investigation, and other inputs to identify contributing causes and countermeasure selection is discussed in Sections 6.6 and 6.7.

## 5.2 What factors contribute to accidents?

The tri-level study of Treat et al. (1979) assigned that single event that, had it not happened, the accident would have been avoided, to three categories: driver, roadway, and vehicle. The familiar outcome of this study is that in almost all accidents, there is likely a driver (or road user) related component. There is also a strong overlap with the other elements, particularly the roadway. Roadway defects or vehicle defects are only a small percentage of the total of all components. The results of the Treat-study have been closely replicated by several other authors.

This does not imply that driver/road user errors are not preventable. On the contrary, the strong overlap with the roadway causes means that our investigative efforts should focus on these driver (or road user) elements, also called "human factors." If we recognise that driver abilities, behaviours, attitude, speed, risk taking (e.g., driving while intoxicated), fatigue, physical abilities (vision, ability to turn head), and cognitive decisions or reactions are important contributing factors to accidents, we can better identify engineering solutions that might improve the situation.

While some driver elements can only be changed through education or enforcement, there are driver/road user related errors that can be linked to the roadway (including operations) environment. Therefore, the most important concept to consider when investigating accident locations is called "driver expectancy." This concept means that drivers are conditioned to expect certain events to happen (Russel, 1998). For example, drivers know that the yellow signal indication means that a red signal indication is to follow, and they should be prepared to stop. This "expectancy" decreases reaction time and improves operations. If there is an unusual situation, driver confusion or overload is more likely to occur, and this can result in accidents. Other "human factors" often need to be considered such as visual clutter or competing stimuli, experience and age of the drivers, and driver comfort or satisfaction. For example, drivers are more likely to take risks if they have become impatient due to a long delay. In this situation, a solution to turning movement accidents may be an operational one[1].

[1] A worthwhile resource on human factors is the Highway Safety Manual, 2010 and 2016 (AASHTO, 2009; NHCRP, 2016) and NCHRP Report 600: Human Factors Guidelines for Road systems, 2012.

## 5.3 Rates as expressions of exposure to risk

The rates at which events occur can be a useful parameter in road safety management. The most basic rate that can be applied, is accidents per kilometre of road. The use of this rate is obviously limited unless it is used to compare similar facilities carrying similar traffic volumes (Archer, 2005). More often used, are rates of accidents or casualties (fatalities, fatal and serious injury (FSI), injury accidents, all accidents) per 100 million vehicle-kilometre travelled. One benefit is that they simply control for differences in traffic volume (i.e., the influence of traffic volume is removed to allow direct comparison). Rates are most appropriate when comparing similar conditions or “apples to apples.” Importantly, rates are best used when comparing the same functional road class, volume range, intersection type, or other distinguishing features. However, the use of rates can lead to incorrect conclusions if comparisons are made across widely different facilities (Committee of Land Transport Officials (COLTO), 2012). For example, one would not compare a national road accident rate to a rural principal arterial accident rate since they are different facility types. Examples of average rates by facility type are shown in Appendix A.

In the absence of detailed accident data, there should be the endeavour to at least compile information on average accident rates by road classification and/or road type that can be useful as a view of what roads carry the higher accidents risks and for the use in risk assessment applications.

When comparing rates over time, it is important to remember that rates can change by modifying the number of accidents (numerator) or the volume, duration, or segment length (denominator). For example, a facility could be made “safer” if volumes increase but accident counts do not (the rate would be lower). If no actual improvements have been made to the facility, the road is not any safer in the physical sense - only the risk has changed. There is some evidence that cyclists and pedestrians have lower risk with increased bicycle and pedestrian volumes. This is generally attributed to the “safety in numbers” concept. This means that motor vehicle drivers are more likely to expect these users (and drive accordingly) if they routinely see more cyclists and pedestrians.

### 5.3.1 Exposure for pedestrians and cyclists

The exposure of pedestrians and cyclists to accident risks requires special attention. Depending on the determination need, there are various ways to measure exposure (Saunier, 2016). Below is a summary of different exposure measuring methods.

- Exposure based on volumes/counts
    - Estimating pedestrian and bicyclist volume and risk in a specific location.
    - Assessing changes in pedestrian volume or characteristics due to countermeasure implementation at that site.

- Exposure based on distance
  - Estimating exposure at the micro or macro level.
  - Estimating whether risk increases in a linear manner with distance travelled.
  - Assessing how crossing distance affects risk.
- Exposure based on time
  - Estimating total pedestrian and bicyclist time exposure for specific locations.
  - Comparing risks between different modes of travel (e.g., walking vs. riding in a car).
  - Estimating whether risk increases in direct proportion with walking time.
  - Comparing risk between intersections with different crossing distances and between bicycles or individuals with different travel speeds.
- Exposure based on trips
  - Assessing pedestrian and bicyclist behaviour in large areas, such as cities, states, or countries.
  - Examining changes in pedestrian and bicyclist behaviour over time.
  - Making comparisons between jurisdictions.
  - Assessing common characteristics of walking trips, such as purpose, route, etc.
- Exposure based on population
  - Used as an alternative to exposure data when cost constraints make collecting exposure data impractical.
  - Used to compare jurisdictions over time because population data are available for many geographies (including districts, regions, etc.) and time periods.

## 5.4 Accident frequency

Accident frequency is often applied as a safety performance indicator of a facility (Forum, 2016). It is a direct measure of the number of accidents, fatalities, FSIs or casualties on a facility – typically controlled for the period of the measurement (e.g., per year). Although this may be a positive indicator of high-risk problem situations, it will provide a skewed picture of the relative risk priority and exposure level. Facilities with high usage will show higher numbers of incidents.

## 5.5 Relationship of accidents to traffic volume

It would be a fair assessment to say that as traffic volumes increase, if nothing else changes, the number of accidents is also likely to increase. This is the reason accident rates are calculated - to normalise for different exposures over time or between different locations (Ambros, Sedoník and Křivánková, 2018).

The accident rate calculation for road segments is calculated per million vehicle-kilometres-travelled (MV-kmT). Since we typically express the rate per 100 million vehicle-km travelled for FSIs, the rate is calculated as

$$Rate = \frac{C * 100\ 000\ 000}{V * D * L}$$

where

C = number of accidents in study period

V = volume, in AADT (vehicles per day or vpd) [this value is usually for both directions of travel]

D = number of days in study period

L = length of segment (kilometres).

For intersections, the rate is calculated per million vehicles entering (mve)

$$Rate = \frac{C * 1\ 000\ 000}{V * D}$$

where

C = number of accidents in study period

V = the sum of volumes entering from all approaches, in AADT (vpd)

D = number of days in study period

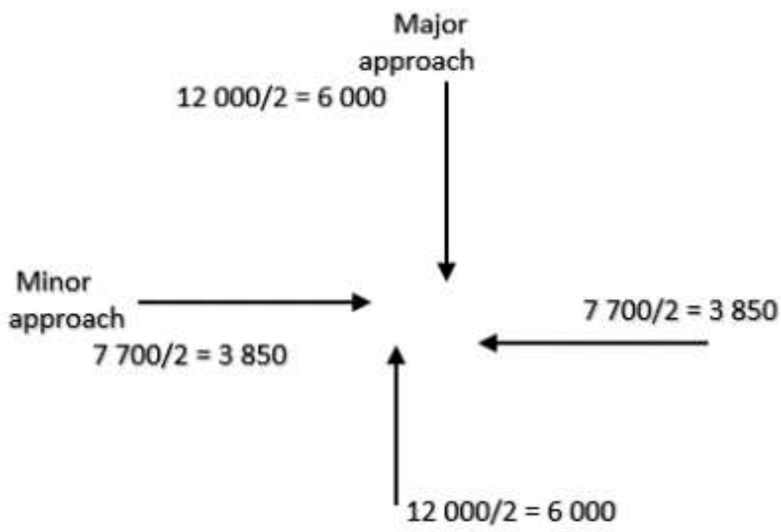
**Example 1:**

- Observed 40 accidents on a 17,5 km segment in one year. The AADT was 5,000 vpd.

$Rate = \frac{40*100\ 000\ 000}{5\ 000(365)(17{,}5)}$ = 125,24 accidents per million Vehicle-km travelled

**Example 2:**

- Observed 25 accidents in 6 years at a 4-Leg intersection. The AADT for the minor approach was 7,700 vpd and the major approach was 12,000 vpd. Recall that a typical year should have 365 days.
- AADT volumes are always expressed for both directions of travel. To get **entering** volumes the AADTs can be summed since the volume of traffic that enters from each direction is assumed to be approximately one-half the ADT – unless information indicating a different distribution is available. If the intersection was a T-junction, only one-half of the AADT from the T-leg would be used. It may be helpful to do a quick sketch such as:




$$Rate = \frac{25 * 1\,000\,000}{12\,000 + 7\,700(6 * 365)}$$ = 0.579 accidents per million entering vehicles

**Example 3:**

- Observed 20 accidents in 6 years at a 3-Leg intersection. The AADT for the minor approach was 5,100 vpd and the major approach was 10,500 vpd. Recall that a typical year should have 365 days.
- AADT volumes are always expressed for both directions of travel. To determine **entering** volumes, the AADTs are summed since the volume of traffic that enters from each direction is approximately one-half the AADT. Since the intersection is a T-junction, only one-half of the AADT from the T-leg is used in the exposure.

$$Rate = \frac{20 * 1\,000\,000}{(10\,500 + (5\,100/2))(6 * 365)}$$ = 0.6998 accidents per mve

## 5.6 Length of period of accident data to study

On the question of how many years of accident data to use:

- if a too long a period is chosen, there is more likelihood that there will have been changes to site conditions (volumes, drivers, reporting thresholds, periodic maintenance, etc.).
- if a too short a period is selected, there is likely not enough data to analyse, and the accident patterns may not be representative of the long-term performance of the facility.

A general recommendation is to use 3 years of accident data for analysis. In some situations, 5 years may be appropriate if there is limited accident data to evaluate. The 5-year period may also be appropriate if there was construction activity during part of the study period or other unique site conditions. The period of abnormality should then be excluded.

## 5.7 Concept of severity

Total number of accidents are more likely than not, not providing the full picture in an investigation for mainly two reasons (Gopalakrishnan, 2012). Firstly, accident patterns may differ across severity levels. By considering severity separately, a significant problem may be uncovered. Secondly, severe accidents represent a greater cost to society. More effort and funding should be directed at mitigating these accidents.

Serious injuries are currently classified as being serious over a broad-spectrum of injury levels. In accordance with general protocol, South Africa records a death due to an accident as death within 30 days of an accident; the proportion of deaths after 30 days of an accident is not known. The SAPS records road fatalities at the scene on a CHoCOR form and on the AR Form. Deaths that occur after evacuation within 30 days need to be tracked afterwards.

Serious and slight injuries due to road accidents are reported by the SAPS via AR-Forms with an indication of 'severe injury' and 'slight injury'. The RTMC records these parameters and report thereon to the National Minister of Transport. The recorded fatalities, serious injuries and slight injuries are also used to calculate the cost of accidents (RTMC, 2016).

Various international research has shown that serious injuries reported by police services are grossly overestimated. United Kingdom (UK) research, for instance, indicated in 2015 that only an estimated 20.3% of reported serious injuries were actually being in the serious band according to the Maximum Abbreviated Injury Scale (MAIS). Research on "Identifying MAIS 3+ injury severity collisions in UK police accident records (Nunn et al., 2018)" has similarly shown that various classes of serious injury are prevalent in police-reported accident injury severities. The RTMC has, in the meantime, commissioned research to establish the situation in the country – results are expected by 2023.

Currently, serious injuries due to road traffic accidents in South Africa are estimated at a ratio of 3.6 per fatality on a macro scale (RTMC, 2016). This amounts to an estimated 59,464 serious road crash injuries in 2018. The unit cost per serious injury is estimated at R 496,624 and a total contribution to the 2018 Cost of Crashes in SA has been estimated at R 30.993 billion or 18.6% of the total Cost of Crashes for 2018.

The ratio for fatal: serious injury: slight injury damage only accidents is 1: 3,6: 11,9 : 58,2[2]. The so-called FSI accidents are targeted in terms of the Safe Systems approach since these are the accidents with a profoundly debilitating impact on society. They are also the accidents that contribute 64% to the total cost of accidents of R 170,6 billion (RTMC, 2018) whilst they only represent 6% of the total number of accidents. The FSI ratio (as proportion of total accident cost) of 1:3,6 in comparison to Europe is high from some perspectives. iRAP applies a ratio of 1:10 in some countries. However, several reasons contribute to differing FSI ratios. Some of these are:

- Under reporting
- Injury severity reporting by non-medical persons who exaggerate the injury level
- Inadequate follow-up on deaths in the 30-day period after the accident
- Poor emergency response times, trauma care at the accident scene and evacuation that result in a higher fatality risk (the so-called platinum 10 minutes and golden hour thresholds)
- Poor post-accident care
- NCAP[3] rating of the car park or crashworthiness of vehicles

It is possible to decrease the severity of some accidents while increasing the frequency of less severe accidents. For example, installing a median barrier will increase property damage accidents (vehicles will hit an object that was not there before) but head-on accidents will be virtually eliminated. This trade-off in severity can be analysed using the benefit-cost methodology presented in Section 7.

## 5.8 Risk assessment and management: Linking ‘curative’ and ‘proactive’ safety approaches

The history of previous accidents, whether at defined points on the road, on routes, or across areas, has been used for many years to predict locations where accidents are most likely to happen in future (Gopalakrishnan, 2012). This approach is especially useful where there are high concentrations of accidents. Over time in some countries there have been substantial improvements in safety, and in some cases the number of accident locations has decreased, making it harder to identify potential accident locations based on this information. In such countries, e.g., The

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[2] Cost of Crashes 2016 report (RTMC, 2016)

[3] The New Car Assessment Program (NCAP) tests new cars and allocates a safety rating from one to five stars. A rating of one star means people in the car would have a higher chance of being injured or dying in a crash and a rating of five stars means people in the car would have a much lower chance of being injured or dying in a crash.

Netherlands, Norway, Australia, New Zealand, the majority of accidents are estimated to occur outside what would traditionally be classified as 'hazardous road locations. Conversely, a sizeable proportion of more serious accidents occur at locations where there is no existing accident history. Particularly on lower volume roads, accident locations tend to be more scattered making it harder to predict the location for future potential accidents. This is especially the case when considering fatal and serious accident locations – the reduction of which is the key focus of the Safe System approach.

Methods for identifying potential accident locations have evolved with new approaches developed to complement the accident-based, or 'curative' approach. 'Proactive' tools and approaches are also used, and some of these do not rely on knowledge of accident locations to identify high risk locations. As an example, Road Safety Audit of existing roads (Road Safety Investigation - RSINV) assesses risk based on knowledge about the road and roadside factors that contribute to risk. These tools and approaches are important, as they can identify locations where there is a high risk of severe accident outcomes, and to address these before serious injury does occur.

There are countries that, after years of experience in accident analysis and treatment of accident locations, indicate much improved understanding of the road and roadside elements that contribute most to accident risk, and the amount that each of these elements contribute to that risk. For instance, there are extensive resources providing information on the effect of different infrastructure treatments on safety outcomes, and there are programs that can be applied to identify and treat high risk locations before accident occur (i.e., in a proactive manner) with estimates of risk based on road and roadside elements. This knowledge has led to the development of tools to identify risk locations, regardless of whether accident data is available (Austroads, 2010a).

The curative and proactive approaches are often used in conjunction. As an example, for a rural route with high numbers of run-off-the-road accidents, it is desirable that all potential high severity locations be treated, regardless of whether accidents have already happened there or not (the route-based approach is described in Section 6.4). This contrasts with an accident-based analysis that addresses only those points on the road where accidents have previously occurred. **Equally risky locations (in terms of road and roadside features) should not be ignored** (World Road Association, 2014).

This TRH 29, Volume 1 provides details of the processes used to identify and treat high risk locations based on accident data. Generally regarded as a curative approach, the approach uses accident data to identify and address risk, but as in the example provided above on rural run-off-the-road accidents, this does not mean that an accident needs to have occurred at a specific location before improvements are made.

Road Safety Audit during the different stages of design (e.g., feasibility, preliminary design, detailed design, pre-opening) are discussed in Volume 3 as are other types of audits (e.g., of road works, land use development, audits for different road user groups, and review of existing roads). The audit process is discussed, as are the procedures for responding to audit recommendations.

## 5.9 Developing a program to address high accident risk locations

Reducing the fatality count (and the number of accidents in general) by 50 per cent in the decade leading up to 2030 requires a concerted effort by all role-players and particularly all road departments and those functionaries responsible for the management of road safety on the road networks. There should be a clear mandate to these departments to address the road safety scourge, to develop unambiguous plans to achieve the target set for 2030 and to report on the progress toward achieving their respective targets. Such plans need to include comprehensive programs to identify and treat the existing accident locations based on, and proportionate to the reported deaths in every region, district, municipal area, or other demarcated area of responsibility. This implies better coordination among all tiers of government and the respective agencies responsible for roads and road safety. These measures are all crucial to achieve the focus on road safety results as the most fundamental institutional management function as well as to practically share the responsibility. This will drastically improve road safety by pursuing the target of a 50 per cent reduction in road fatalities by 2030.

Fundamental to developing such programs is the opportunity to apply the Safe System approach – to eliminate what is now known to contribute to fatal and serious injury. The Safe System approach has demonstrated through its application in countries with diligent road safety policies that the *reduced harm* objectives are achievable. Demonstrating the significance of the societal consequences of the road safety problem (in terms of fatal and serious accident outcomes, as well as the full impact on communities and economic well-being) will be important for the development of such programs. This means that road safety information, need to be captured, collated, organised, and made available, to an appropriate extent and content to meaningfully contribute to the business of managing road safety and more specifically to effectively treat existing high-risk locations. It is also important to demonstrate that the problem can be addressed in a cost-effective manner. This includes understanding the benefits that targeted road infrastructure improvements can provide. With knowledge of these issues, a business case can be put to treasurers, funders, and policy makers to ensure appropriate investments are made in road infrastructure (World Road Association, 2014).

The response to accident risk will need to consider a combination of curative and proactive approaches. Both are typically used, although in situations where high severity accidents persist, but demonstrated accident locations (whether at points or along particular road sections) become scarce (which will happen over time as implementing effective treatments eliminate such locations), the reliance typically moves to more systemic safety improvements based on proactive risk-based approaches (World Road Association, 2014).

Reducing accident risk requires a departmental strategic approach to addressing the different elements contributing to accidents within their mandated areas. By recognising that in the broader organisations where responsibility for road safety vests, there will be a range of other demanding activities, many opportunities for the integration of road safety with other functions will present. Coordination will be crucial with the structures responsible for related activities (like data collection, driver and vehicle registration and vehicle operation). Good practice can crucially enhance road safety (World Road Association, 2014).

As part of a treatment program, a clear process needs to be put in place to identify accident locations, analyse the risk at these locations, select appropriate responses, prioritise these, and monitor and evaluate the outcomes from these efforts. This TRH 29 focuses on these aspects as they relate to existing accident locations (World Road Association, 2014).

Along with the process for identifying and addressing risk, there are institutional arrangements that need to be in place to assist in effective treatment of accident risk. This includes the availability of good quality road safety data (including accident data, which is of greatest relevance to this document). There is also a reliance on appropriately trained staff (whether inside road departments, or outside as part the service provider corps). Although this document provides information on the appropriate processes to be conducted when addressing risk, there is reliance at all stages on experts who will often be called upon to use their professional judgement. A well trained and experienced set of experts is required to ensure the success of the risk assessment and accident reduction process. Where the extent of the road network, and of road safety management, requires so, there needs to be the necessary in-house capacity in the responsible department to ensure appropriate participation in road safety programs and to actively contribute with actions that will reduce casualties and accidents (World Road Association, 2014). Also see Section 2, Tenet 6.

## 5.10 Taking action to improve road safety

### 5.10.1 The countermeasure approach and the role of infrastructure

At the core of an effective road safety program is how well remedial treatments target the causes of accidents and/or the factors that play a role in how severe the accident outcomes are (Turner, 2021). A selection of various countermeasures may be applied to a particular safety problem, including:

- various engineering treatments (ranging from low cost to capital-intensive)
- speed management
- application of new technology
- training, education, etc.

These and other treatments in combination as a package are often the most effective way to address road safety risk. However, recognising the substantial role of human error in road accidents, the traditional tendency is to narrowly focus on road user education and training (including enforcement) for solutions. This tends to downplay the role that infrastructure plays in achieving Safe System outcomes. It is now accepted that road infrastructure has a significant role to play in reducing the likelihood of accidents. Moreover, when an accident does occur, road infrastructure has the major influence on how severe the consequences will be. Therefore, improving infrastructure in a particular way, e.g., in accordance with the Safe System principles, can contribute substantially to reductions in death and serious injury - assuming that, as mentioned above, the treatments selected directly target the cause or the severity outcome of an accident (World Road Association, 2014).

### 5.10.2 The Safe System Approach

The guiding principles of the SSA are:

- People make mistakes and there is recognition that humans are fallible and will continue to make mistakes on the roads
- Human physical frailty means that humans can only withstand limited kinetic energy exchange when an accident occurs before death or serious injuries result.
- Create a ‘forgiving’ road transport system that addresses the problems that encompass road users, vehicles, roads, speed and post-accident care solutions (there is a wealth of literature on the Safe System and its ‘pillars’ structure – the Austroads Guide to Road Safety, 2021 (Austroads, 2021) is an up-to-date resource to consult).

Appropriate infrastructure is required to take into account road user vulnerabilities and fallibilities to avoid death or serious injury should an accident occur. The SSA implies a shared responsibility for addressing fatal and serious accident outcomes. While individual road users are expected to be responsible for complying with traffic laws and behaving in a safe manner, it is no longer acceptable that the burden of road safety responsibility simply rests with the individual road user. The ‘system managers’ have a primary responsibility to provide a safe operating environment for road users. It is not acceptable to blame the road user for an accident outcome when there are infrastructure solutions that may be applied to help reduce this risk.

Haddon (1980) identified a systematic framework for road safety based on an epidemiological model (see Figure 5-2). This comprises infrastructure, vehicles and road users in pre-accident, in-accident and post-accident stages (Bonnet, 2018). An understanding of these three phases permits possible countermeasures to be considered. Road safety engineering treatments can be applied to reduce the probability of an accident occurring in the first place (pre-accident) and secondly to reduce an accident’s severity should it occur (accident). Thirdly, although to a lesser extent, road safety engineering can ensure that rescue services can reach an accident site promptly (post-accident).

Although it has been long understood that a priority is to address more severe accident outcomes, the Safe System brings this concept into further focus. The key objective of the SSA is to address fatal and serious accident casualty outcomes. In some cases, this has meant a re-shaping of how accident analysis is conducted, and how treatments are selected (including the types of treatments) to address risk.

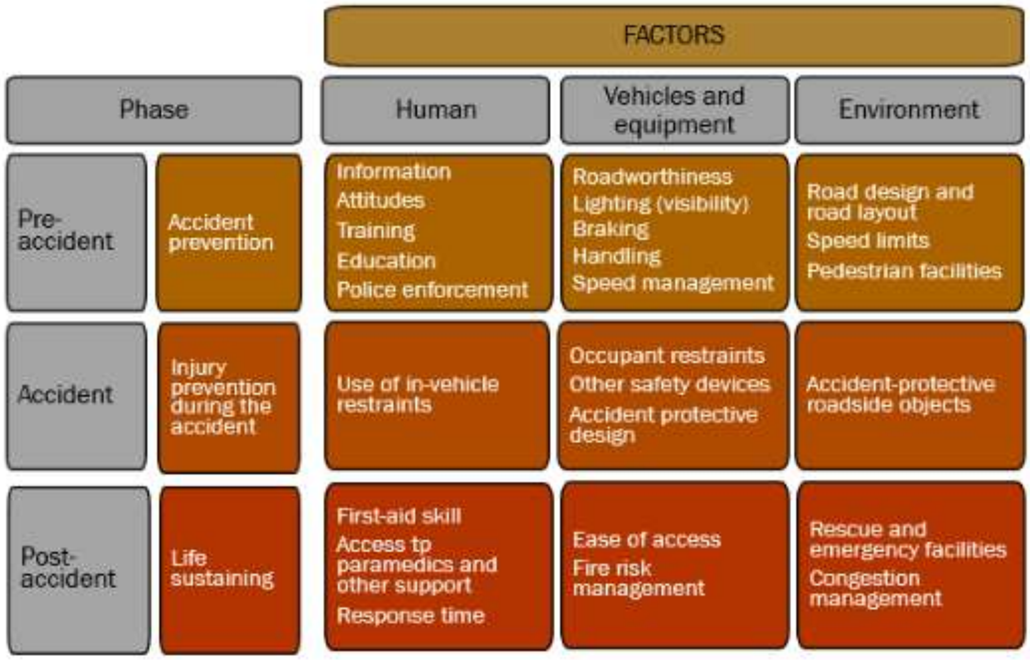



*Figure 5-2: Haddon matrix*

Safe speeds, which are integral to a Safe System, influence causation and play a key role in severity (International Traffic Safety Data and Analysis Group, 2018). There is a strong relationship between safety outcomes for any given speed environment given the prevailing infrastructure. In brief, the survival impact speeds for different accident types are reasonably well understood. At impact speeds above 30 km/h, the chance of survival following impact between vehicles and pedestrians reduces dramatically. The figure for side impact at intersections is 50 km/h, while that for head-on accidents is 70 km/h. This strongly implies that if death and serious injury are to be eliminated, either infrastructure must be provided to prevent these accident types from happening (e.g., provision of median separation to prevent head-on accidents) or the speeds need to be reduced to these Safe System speeds (e.g., 70 km/h or lower where there is no median separation). These are the parameters founding the aspiration of the SSA and that should guide a program framework for delivery of road safety infrastructure into the future (International Traffic Safety Data and Analysis Group, 2018).

### 5.10.3 Accident risk

As risk is the product of three elements: probability, exposure and severity, a road safety strategy must address all three elements. For a roads department, these may include examples such as:

**Influencing the probability of an accident**

- applying sound traffic engineering and road safety engineering techniques through the audit of new road designs and the treatment of known accident sites
- modifying road user behaviour by appropriate design elements
- using well targeted education and enforcement programs
- applying appropriate speed management, including speed limits.
- Influencing the exposure to an accident
- providing alternative, safer routes for vulnerable road users
- promoting safer forms of transport in preference to fewer safe forms.

**Influencing the severity of an accident**

- providing a more forgiving roadside environment (e.g., removing rigid obstructions, providing safety barriers)
- providing appropriate speed management
- providing good access for emergency services to reach accident sites.

The treatment of accident locations is just one element of a road safety strategy, but it is an important and potentially very cost-effective part.

### 5.10.4 What is an accident location?

An accident location is:

- an individual site (e.g., an intersection or a curve in a road)
- a length of road or a section of a route (which could be e.g., urban or rural)
- an area of the road network (e.g., residential precinct, local traffic area or an entire suburb)
- locations across the road network which have a common hazardous feature (e.g., substandard guardrail end treatments) and/or accident type (e.g., pedestrian accidents, run-off-the-road accidents, etc.).

The classification of a location with traffic incidents as an 'accident location' (accident blackspot) will likely be determined by a process of identification and prioritisation that applies policy criteria for the selection of sites that can be investigated in further detail. Selected sites can become candidate sites for treatment subject to feasibility, benefit/cost and budget considerations. The prevalence of accidents at only some locations, or the clustering of accident types at a specific location, e.g., usually indicate that there are common causes for the accidents. It is the objective of accident location treatment to identify these common causes and to counter them by applying appropriate countermeasures.

As more individual sites are treated, the number of sites featuring accident clusters will continue to diminish. At a certain point, the number of FSI accidents occurring at a particular site cannot necessarily indicate a likelihood of a recurrence of similar accidents. At this point, the focus of road safety practitioners needs to shift to treating routes featuring high accident frequency sites. For instance, to address FSI crossover accidents occurring along a particular road, the use of wire rope safety barriers along the median, as a cost-efficient treatment, could be considered. However, although this treatment has been indicated to be successful in reducing the occurrence and severity of crossover accident type in many countries, its transferability to the South African environment requires circumspection in the context of poor driver discipline and poor maintenance practices. This emphasises the need for thorough investigation of the specific accident problem and, after implementation, also close monitoring and reporting on its operational performance and effectiveness.

### 5.10.5 Treating accident locations

The treatment of accident locations involves a step-by-step process. Each of these steps needs to be followed (World Road Association, 2014) and it needs to be accepted that they require resources. Firstly, to obtain/provide the accident information on which all investigations are based. Secondly, to permit investigations and analysis to take place and, thirdly, to permit the identified problems to be treated. For example:

- A data collection and verification system and an accident positioning protocol are needed, so accident locations can be identified as accurately as possible.
- A comprehensive database is needed, which includes details about enough accidents and accident features so that problem locations and common accident features can be identified.
- An appropriate criterion needs to be selected for defining ‘high’ accident locations. These criteria may vary as the number of ‘high’ accident locations are effectively treated. The criteria may also differ across programs funded by various levels of government (i.e., national, provincial and local).
- A thorough diagnosis of the accident problems at a location is needed, so that the correct conclusions may be drawn about contributing factors.
- Countermeasures need to be selected on the basis that they are known to be effective against the problems identified, so that the problems are resolved (e.g., countermeasures with associated published AMFs may be considered with a check on transferability issues).
- Safe design principles and road safety audit need to be applied to countermeasure design, so that the countermeasure does not cause harm or result in new types of problems.

- An appropriate project ranking system is needed so that scarce resources can be applied effectively to a program of potential countermeasures.
- Monitoring and evaluation of the effectiveness of countermeasures at site, route or network level is needed to ensure that the targeted remedial treatments achieve their intended purpose, while also continuing to improve knowledge associated with the treatment of accident locations.

### 5.10.6 Who should investigate accident locations and develop solutions?

Most of the steps in the accident location treatment process are summarised in Section 5.11 and detailed in Sections 6.3, 6.4 and 6.5 and onward can be conducted by a practitioner with an analytical mind who has had training and experience in an engineering or scientific field. However, the following steps will require the inclusion of someone who also has road safety engineering skills and experience:

- inspecting the accident location
- drawing conclusions from the accident data and site inspection
- selecting countermeasures which address the factors leading to the types of accidents which are happening.

It is also better at these stages of the process to use a team (ideally two to five people), rather than one person. The benefits of having a multi-member team include:

- the diverse backgrounds and different approaches of different people
- the cross-fertilisation of ideas which can result from discussions
- simply having extra sets of eyes/different perspectives of each member.

The types of skills and experience which should be considered for an accident location study team include:

- someone experienced in road safety engineering (an essential requirement)
- someone with local knowledge (e.g., a road superintendent or municipal engineer involved with traffic management)
- emergency services personnel (typically a traffic police and/or community safety officer) who has experience in traffic and safety and who is familiar with the location
- someone involved with the behavioural aspects of road safety.

### 5.10.7 What are road safety engineering skills?

A road safety engineer may be described as a practitioner with:

- sound knowledge in traffic engineering and road design practice
- an appreciation of road user behaviour and the contribution it makes to road accidents
- competency in accident investigation (i.e., accident data analysis, and identification of accident causation and severity factors), and

countermeasure development (i.e., identification of targeted cost-effective remedial treatments)

- competency in monitoring and evaluation methods.

## 5.11 Steps in the accident location treatment process

The treatment of accident locations should be a methodical, step-by-step process. The steps are briefly outlined in this section and further explained in the following sections.

### Step 1: Decide on the criteria for listing accident locations

Define the physical limits of individual locations, so that sections with similar characteristics are considered together. Decide on the time period over which accident patterns are to be investigated. All sites need to be compared using an agreed selection criterion. The preferred criterion is 'cost of accidents by accident type' rather than a number of or rate of accidents. If necessary, select an accident threshold, above which locations will be considered for inclusion as accident locations.

### Step 2: List all accident locations to investigate

Examine the information in the accident data base to identify locations which meet the definition of accident location. Establish the cost of accidents at each location, over the agreed time period. Make a list of all the locations which meet the minimum cost threshold selected. Ensure that locations are sensibly defined, so that no location worthy of investigation is missed through being subdivided in the data. Plan for later monitoring.

Having identified all the sites worthy of investigation, each one should be examined in a step-by-step fashion to identify the factors leading to accidents, develop solutions and organise having those solutions implemented, as set out below. Then, for each accident location:

### Step 3: Obtain all the relevant information

Obtain the accident data for the location. Be aware of the limitations on the availability and accuracy of accident data. Obtain other information such as traffic volumes, recent changes in the road network or traffic generating land uses, and any documented concerns about safety at the location.

### Step 4: Diagnose the problems

This is a three-step process:

i. analyse the accident data (including accident rates and densities) for any clustering by common accident types or factors such as common approach legs, common weather or daylight conditions, common age of those involved, etc. Construct a factor matrix and draw an accident diagram. Is examination of the original accident report forms warranted?

ii. inspect the site from the perspective of the involved road users, as well as conducting a close-up examination of the site's features and its users' behaviour.

iii. make any other investigations, then draw conclusions about the contributory causes of accidents for which there are common factors. There may be other types of contributing factors (e.g., speeding), but focus on what it is about the road or traffic environment which is leading to accidents.

**Step 5: Select the countermeasures**

Match the solutions to the problems. The key to the selection of countermeasures is to concentrate on the particular accident types which have been identified in the diagnosis phase (Section 6.6) and which are amenable to treatment with road or traffic engineering measures. Select the countermeasure(s) and take account of the accident modification factors for each countermeasure.

**Step 6: Prepare a preliminary design**

A preliminary design is required, so that its practicality can be confirmed, and the cost of the remedial treatment can be estimated. This design then needs to be road safety audited. Prior to implementing the project, the design needs to be finalised, taking account of any audit recommendations.

**Step 7: Establish the benefits and costs**

Conduct an economic appraisal. Establish the costs (i.e., the initial design and construction costs only) and the benefits (including reductions in accident costs by accident type). Decide whether to use net present value (NPV) or benefit/cost ratio (BCR). Conduct sensitivity testing. Also note the underlined text under Step 9.

**Step 8: Document the findings**

Draw together the documentation which has been conducted through Steps 3 to 7 and set it out in a format which allows this project to be assessed against other potentially worthy accident countermeasure projects.

**Step 9: If there are several locations to treat - rank all treatments**

Compare all projects' NPV or BCR. An alternative 'goals achievement approach' can be used, whereby projects are ranked but no attempt is made to assess their economic benefits against their costs. These formalised forms of appraisal are simply an aid for decision making. <u>They should not be the only criterion for selecting safety improvement projects and their numerical answers should not be a replacement for sound decision making.</u>

**Step 10: Implement the treatment**

Once the countermeasure treatment has obtained funding it can be installed. It is important that the design which is being implemented accords with the results of the accident investigation. During the implementation phase, traffic safety will continue to be important. Once the works have been completed, the project should (where feasible) be the subject of a pre-opening road safety audit.

**Step 11: Monitor the treatment and evaluate its effectiveness**

Monitoring is the systematic collection of data about the performance of road safety treatments after their implementation. Evaluation is the statistical analysis of that data to assess the extent to which the treatment (or a wider treatment program) has met accident reduction objectives. These tasks are important to ascertain the positive and negative effects of a treatment and thus improve the accuracy and confidence of predictions of that treatment's effectiveness in subsequent applications. It may take several years to collect sufficient data.

# 6 Screening for accident locations

## 6.1 Defining accident locations

The accident location treatment process can be applied to individual sites, to routes and to areas (i.e., elements of the network of roads) where accident clusters occur. Over time, as more accident locations are treated effectively, it is to be expected that identifying further sites that could benefit from treatments may become increasingly more problematic, particularly with the endeavoured reducing number of accident incidents towards the ultimate objective of eliminating FSI outcomes (African Development Bank (b), 2014). For now, the focus is on halving the current level of fatalities and serious injuries by 2030. At the onset of an accident location treatment programme, the threshold criteria for the selection of such sites may be set high to contain the number of candidate projects for countermeasure treatment to a manageable level with respect to capacity and budget. With the programme gaining momentum and the top priority projects get implemented (and the expected impact realise), the threshold criteria may be set lower to allow the next group of accident location projects to be selected and treated with fatality and serious injury reducing measures. At some point and in some areas the numbers of fatal and serious injury accidents will be too low to be used as a metric to assess risk or conduct an accident reduction study. Alternative metrics that may then be considered is the use of FSI casualty equivalents as, for example, by New Zealand Transport Authority (NZTA, 2013). Other responses include greater use of route or area-based approaches and taking a broader risk assessment approach, including a mixture of curative and proactive approaches.

Intersections are typically defined as the area bounded by the projections of the property boundaries, plus 50 m of the approach roads. Accidents occurring within this area are classified as intersection accidents and all others as mid-block accidents. However, some accident types (e.g., rear end or lane change accidents resulting from traffic control at an intersection) can occur much farther away than 50 m. These should be included in the investigation of the intersection (African Development Bank (b), 2014).

In urban areas with frequent minor intersections on arterial roads, individual mid-block sections and minor intersections may need to be grouped together into a complete route length between major intersections. If this type of grouping is not conducted, the fragmentation of accident information in the database may hide a serious accident problem along a route.

When subdividing a route into sections, bear in mind that (Ogden 1996):

- Roadway and traffic characteristics should be fairly uniform within the section.
- The section length should be in keeping with the level of precision and degree of error in reporting accident locations.
- Statistical reliability should be maintained.

Regarding the last point, it is obvious that as the section length becomes very short the probability of either zero or one accident in the period increases. Conversely, as the section length becomes very long, the effects of isolated hazardous features will be submerged and lost. Zegeer (1982) (referenced in Ogden, 1994) suggests that data for road segments less than about 0.5 km long or carrying less than 500 vehicles per day are unreliable.

The accident location treatment process can also be applied in mass action programs to address:

- groups of accidents of a similar type (e.g., run-off-road), occurring across several sites
- a series of accidents that have common features, such as road features (e.g., curves, bridges), vehicle features (e.g., bicycles), road user features (e.g., pedestrians) or contributory features (e.g., driver fatigue)
- series of `high profile' accidents such as those involving vehicles carrying dangerous goods, or accidents at railway crossings.

In this case the location will be numerous locations with common characteristics.

Accident location countermeasures can be applied on a site/route area or mass action basis. A brief discussion on these various actions is outlined in Sections 6.4 and 6.5.

### 6.1.1 Time period for the analyses

Accident data for a five-year period is typically used, as this period usually provides statistical reliability. A three-year period may be adequate, for example if the database includes property damage accidents and accident frequencies are high at the sites being considered. A period longer than five years can be used (e.g., for remote or low volume roads), but it is more likely that changes to road features will have occurred which will affect accident causes. A data interrogation system which looks at both short term (one year) and long term (three or five years) data will allow problem locations to be identified sooner.

When deciding on the time period to be used:

- avoid environmental trends (e.g., traffic growth), other trends and changes to road layouts or roadside activity which could affect results
- use accident data for whole years to avoid the effects of cyclic or seasonal variations in accident occurrence
- be aware of any changes in database definitions which might introduce discontinuities in the data.

### 6.1.2 Criteria for selecting locations to investigate for countermeasures

There will be many accident locations vying for treatment and it will be required to select those which are the most warranted of treatment – deliver on 'value for money' requirements. Consistent with the Safe System approach, the focus should be on preventing future FSI accidents. Thus, requiring that roads with a high number of fatal or serious injury accidents should be prioritised over roads that present a high number of minor injury or property damage only accidents.

Several criteria of varying formats to identify accident locations for further investigation can be considered. The most appropriate depends on the overall road safety program objectives, which may indicate the criteria that will be the most efficient (World Road Association, 2014).

#### Accident cost criterion

The more advanced method is to compare accident locations using the cost of accidents by accident type as the criterion. This means that there needs to be a cost determination available for each accident type and the accident types that present at an accident location over the selected analysis period are then grouped together for a total cost of accidents at the location. Standard accident costs by accident type can be quite different, depending on several factors including the reporting rates of non-injury accidents compared to casualty accidents, whether rural or urban, etc. By implication averaged accident costs by accident type already account for severity and there is no need to assign different costs to different accident severities within a particular accident type. This is a far more accurate way of establishing accident costs than by using separate average accident costs for all fatal accidents, all serious injury accidents, all minor injury accidents, etc. The use of accident cost by accident type also overcomes the problem of a single fatal accident distorting the analysis because of its high cost (Harmon, Bahar and Gross, 2018).

The current accident cost publication, Cost of Crashes (RTMC 2016), accident cost by accident type was not determined because of feasibility issues in collecting the respective data at the time of the research and publication. Future updating of the publication may consider, as part of a possible update of methodology, to explore the more detailed costing by type of accident. This may be a relevant consideration in the context of the SSA where the focus is on eliminating accident types that are more directly related to fatal and serious injury accidents. Nevertheless, in instances where accident by type costs become available, the following are of note.

- Accident costs by accident type are assigned to each accident at every location where an accident occurred. Accident locations are then ranked and those with the highest total accident costs added to the 'identified' list. A threshold cost can be used to select accident locations for further investigation.
- Some accident locations will not experience a clustering of common accident types. These locations with single unrelated accident types are more difficult to treat because there is no observable accident pattern. Consequently, it is important to include for consideration more locations than will be treated, as some locations with significant total accident cost values may not be economically treatable due to a lack of common accident factors.
- For comparison purposes, the total accident costs at the different locations can be expressed as a cost per year over the appraisal period. Ranking of these locations is done by decreasing accident costs per year.
- This approach is consistent with the Safe System approach, and similar to the FSI equivalent approach. Both have the same key benefits of smoothing out random variation (i.e., a fatal accident that might be a once in 100-year event would not dominate the accident listing), as well as more accurately predicting locations for future fatal and serious injury. As an example, a head-on accident in a high-speed environment that only resulted in a minor injury would be recognised for its potential as a high severity outcome event.

#### Other criteria

Other selection criteria are described below. By comparison with the cost by accident type criterion, they are all less effective, as they are less accurate in identifying the costs of accidents at a location and therefore less efficient in ranking sites to maximise the benefits of accident countermeasures:

- The number (i.e., frequency) of accidents (or accidents per kilometre of road) within the adopted time period. This takes no account of exposure or the different costs/severities of different accident types. This method may be appropriate in managing the allocation of resources in programs that treat a single accident type or where the overall program objective is to reduce accident numbers.
- The rate of accidents (per volume of traffic) within the adopted time period. This takes account of exposure. Rates are usually expressed in terms of accidents per 100 million vehicle kilometres travelled for road sections. The accuracy of a rate is dependent on the accuracy of traffic volume information.
- The number or rate of accidents both exceeding some defined threshold value.
- The rate of accidents exceeding a critical value, derived from statistical analysis of rates at all sites. This method determines whether the accident

rate is significantly higher than a predetermined rate for similar locations, based upon a Poisson distribution (Zegeer 1982, referenced in Ogden, 1994).

- The difference between the observed and expected accident numbers, calculated from the site and traffic flow characteristics (McGuigan 1981; 1982). It is similar to the previous method, using frequencies (number of accidents) instead of rates.

Whichever method is used to determine whether a location is hazardous (and warranting consideration for treatment), there needs to be sufficient flexibility to ensure that:

- sites which have recently become a problem for obvious reasons do not have to experience another two or four years of accidents before they are considered
- sites with few accidents, but requiring low-cost treatments are not excluded.

### 6.1.3 Using a threshold method

If the accident database does not allow the cost of accidents at each location to be directly compared, then a threshold method can be used to obtain an initial list of sites. Once these sites have been listed, accident costs by accident type can be applied so the sites may be ranked.

A threshold can also be used to provide an initial indication about whether a particular location has an accident problem. The threshold could be in terms of the total number of accidents, but a threshold which identifies a pattern for a particular accident type may be more useful.

### 6.1.4 Random variation

Accident data are subject to random fluctuations and it is therefore possible to subject them to statistical analysis in order to distinguish between significant factors and those occurring through random variation (Lord and Mannering, 2010).

It is important to assess whether an abnormally high number of accidents in a time period (e.g., one year) should be taken as evidence that the site has become hazardous or whether the fluctuation can be taken as mere random variation.

An ‘accident location’ is defined in Section 5.10.4. This TRH 29 outlines three types of data analysis and investigation techniques. The requirements for them are broadly similar and so are described in Section 6.2 to avoid repetition. The descriptions of the techniques then follow in Sections 6.3, 6.4 and 6.5

## 6.2 Requirements for accident data analysis

### 6.2.1 Equipment

For the desk-based analyses, the following software may be required or will make it easier to conduct the analyses:

- Accident location analyses – accident data analysis software can make network screening and analysis of patterns significantly more straightforward; GIS or accident data analysis software may be necessary for spatial analyses
- Route/corridor analyses – assigning accidents to sections may be done using GIS software, otherwise analysis of patterns can be done using basic spreadsheet software (e.g., MS Excel); accident data analysis software can make analysis of patterns significantly more straightforward
- Area analyses – can be conducted using basic spreadsheet software (e.g., MS Excel) For the site visits, similar equipment is necessary as for Road Safety Audit/RSI. This includes Video camera(s), GPS, tape measures, maps, digital cameras, spirit levels, notepads, a vehicle and personal protective equipment (hard hats, high visibility clothing, etc.). It may not always be possible to inspect the site safely without temporary traffic management such as warning signs/cones. It may be appropriate to temporarily close the road.

### 6.2.2 Personnel

Data analyses can be conducted by a member of staff with an engineering, mathematics, or statistics background. Though they would have the prerequisite skills to conduct such analyses in a systematic manner, formal training in conducting accident location analysis is recommended.

Once the initial analyses have been carried out, the site visits and assessment of potential remedial measures should be conducted by experienced road safety engineers with similar qualifications to those described for Road Safety Assessment and Road Safety Audit (in Volumes 2 and 3). Personnel need to have conducted basic training in road safety and accident investigation or road safety engineering.

In addition to the involvement of engineering specialists and other technical personnel, there is usually a management process to review the schemes and to sign-off on the individual schemes for implementation. This may well be a committee-led process.

## 6.3 Accident location analysis and investigation

Accident location analysis and investigation is a technique used by road authorities that have access to accident data with precise geo-locations. Where the precise locations of accidents are recorded, this allows spatial analyses to identify locations where excessive numbers of accidents are occurring. If detailed and accurate accident data with precise locations are not available, then alternative techniques described in following sections may be deployed. If sufficient resources are available, it is beneficial to conduct those analyses alongside accident location analysis since these methods will identify slightly different road safety issues.

Some common misconceptions about accident location analysis are:

- Locations with the most accidents will always be the highest priority for countermeasure treatment
- Locations with higher accident occurrence always result from an underlying safety problem

Care must be taken to ensure that the analysis has not just detected a ‘random statistical fluctuation’. Interpretation of the results of an accident location analysis requires caution since the analyses may just identify locations with high traffic flow or particularly busy intersections.

Once high-risk sites have been located through accident location analysis, they need to be followed up with further interrogation of the accident data to identify any patterns in the types of accidents occurring and a site investigation conducted by an experienced road safety engineer. The site visit is essential to determine where the road infrastructure itself has contributed to the occurrence of a concentration of accidents. It is also necessary to determine whether the accident problem is likely to be rectified through the implementation of economically viable engineering treatments.

The definition of an accident location varies depending on the context and who is using the word. To the road safety professional:

“An accident location is a location where more accidents have been identified as occurring than would be expected given the road circumstances and conditions” This can be further developed as being: “A location where an identifiable and treatable underlying problem has been identified that is contributing to the accident occurrence”.

To a member of the public or a politician, a hazardous location may be “any location that accidents frequently happen and possibly a single location where one serious or fatal accident has happened”.

### 6.3.1 When to conduct accident location analysis

Accident location analysis is typically conducted every year after all accident records have been captured and published for the previous year. The current international recommendation is that (fatal) accident reports are closed within 30 days of their occurrence i.e., if a severely hurt person dies of their injuries within 30 days, the accident records should be amended, however, if they die after 30 days the record is not amended to reflect this change. Accident data sets for a year are, however, seldom closed by February of the following year because submissions from different stations and offices may fail to return the information in a timely manner.

Conducting accident location analyses every year is advised since a severe localised problem can emerge very quickly. It is also useful to monitor accident locations on a regular basis to detect any changes in accident occurrence across the network.

### 6.3.2 Methodology

Accident location analysis is typically conducted in 7 steps. Once accident locations have been identified these need to be fully investigated through a site review and a treatment plan developed if appropriate.

#### 6.3.2.1 Step 1: Investigate background data

General and longer-term trends

As a preliminary step the data for the whole country, network or jurisdiction should be investigated and analysed to gain a broad understanding of the data and general trends. The main types of information required are:

- General trends in the data across the available years of data
- Typical numbers of casualties per accident severity
- Separately for high speed and urban roads if possible
- Average number of accidents per year for:
- Different types of roads (links/sections) – a classification based on TRH 26 may be used
- Different types of junctions/intersections
- Etc.

**Casualties per accident by severity**

The number of casualties per accident varies. As part of the exercise to economically appraise efforts, it is useful to understand the average number of casualties of different severities in each severity of accident.

By definition:

- A fatal accident must have at least one fatality and any number of serious and slight casualties
- A serious accident must have at least one serious casualty, no fatalities and any number of slight casualties
- A slight accident has no fatalities or serious injuries but any number of slight casualties

Table 6-1 shows the accident type proportions by accident severity. Accidents on higher speed roads are expected, on average, to be more severe than those on lower speed roads, however, the table shows the contrary with respect to single vehicle accidents, which could be attributed to the high incidence of pedestrian casualties that is skewing the picture.

Accidents occurring on rural roads are likely to have higher severity due to increased speeds, though this could also result from lower reporting rates of less severe accidents compared to urban accidents. These statistics can be used to calculate average accident costs.

*Table 6-1: Accident type proportions by accident severity*

| Accident type proportions | Anywhere | | | | | |
|---|---|---|---|---|---|---|
| | Death | Serious | Slight | Total | Vehicles | Accidents |
| % Single vehicle | 5.8% | 61.9% | 50.2% | 53.6% | 16.4% | 27.5% |
| % Multiple vehicle | 34.2% | 38.1% | 49.8% | 46.4% | 83.6% | 72.5% |
| Object % of single | 8.1% | 8.8% | 13.4% | 11.9% | 30.4% | 30.4% |
| Object % of total | 5.3% | 5.5% | 6.7% | 6.4% | 5.0% | 8.4% |
| **Accident type proportions** | **Urban** | | | | | |
| | Death | Serious | Slight | Total | Vehicles | Accidents |
| % Single vehicle | 77.1% | 63.7% | 44.8% | 49.7% | 12.0% | 21.2% |
| % Multiple vehicle | 22.9% | 36.3% | 55.2% | 50.3% | 88.0% | 78.8% |
| Object % of single | 10.5% | 10.6% | 6.4% | 14.6% | 35.9% | 35.9% |
| Object % of total | 8.1% | 6.8% | 7.4% | 7.3% | 4.3% | 7.6% |
| **Accident type proportions** | **Rural** | | | | | |
| | Death | Serious | Slight | Total | Vehicles | Accidents |
| % Single vehicle | 58.3% | 59.8% | 59.6% | 59.6% | 28.8% | 42.6% |
| % Multiple vehicle | 41.7% | 40.2% | 40.4% | 40.4% | 71.2% | 57.4% |
| Object % of single | 6.0% | 6.5% | 9.5% | 8.4% | 23.8% | 23.8% |
| Object % of total | 3.5% | 3.9% | 5.6% | 5.0% | 6.9% | 10.1% |
| Source: RTMC Cost of Crashes 2016 – for illustrative purposes only | | | | | | |

#### Normal accident rates

To understand whether a cluster that has been identified from the network screening process (see Step 2) really represents a site with excessive occurrence of accidents, it helps to understand what a ‘normal’ or ‘expected’ rate of accidents is for different road types and junction types. Ideally accident rates by traffic volume (per 100 million vehicle kilometres) should be calculated. Where consistent flow data may not readily be available to permit estimation of these rates, accident density (number of accidents divided by length of road) can be calculated instead.

It is frequent practice to identify sites with the most accidents and worst severities of accidents, and to construct lists of these without referring to expected numbers of accidents. This is a simple approach that can be successful at the start of a programme to improve road safety where there are many locations that compete for funding. Arguably methods that compare accident occurrence at suspected accident locations with normal or expected accidents are accepted as being superior, since this should help to reduce the instance of investigating ‘false positives’ or missing ‘false negatives’.

### 6.3.2.2 Step 2: Screen network for accident locations

Consideration of whether a site constitutes an accident location is often based on simple rules and definitions. To achieve a robust result, three years of accident data need to be used as a minimum. Under some circumstances (i.e., where there is significant under-reporting) it may be necessary to use up to five years of data.

The number of years of data used is a trade-off between using the most recent accidents (which are more likely to be relevant to the network state as it is currently) and obtaining enough accidents per typical cluster identified so that random fluctuations are reduced. Cluster sites should ideally have enough accidents so there is a better chance to identify patterns in the characteristics of the accidents occurring. Ideally sites identified should have greater than 10 - 15 accidents if possible (this is a basic rule of thumb).

Low volume rural roads may require longer periods of data to be used since accidents will be rare on these. However, it becomes questionable if accidents from the earlier years are relevant to the road network at the time of analysis. The main methods used to identify accident locations are based on spatial analyses of the locations where accidents occur. The methods used all aim to identify road sections which have higher numbers of accidents occurring at them compared to other road sections. The methods that can be used differ according to the quality and type of location information available for accidents, and the nature of the network being screened (different approaches may be needed for a dense urban network when compared with a rural network). The methods and modules available in dedicated accident data system packages or GIS software vary. The following sections outline some of the more common methods used.

#### Accident density (nearest neighbour method)

This method effectively finds discrete areas of higher accident densities. In this method accident database or GIS software search a fixed radius from each individual accident and if there is another accident which falls within the radii they are clustered together. The program continues to cluster accidents until no more are within range. This system is simple to understand and produces a series of cluster sites with defined, but variable, lengths along roads or at junctions.

#### Fixed radius (accidents with most neighbours)

A variant of the accident density nearest neighbour method is a similar technique in which circles with fixed radii are drawn around every accident and the software counts the number of other accidents that occur within the fixed distance of the circles. This method effectively fixes the size of the section that will be identified. This is a relatively inflexible method, and the process means that some longer sections may not be identified and similarly some very treatable shorter sections may be missed.

#### Heat maps

The heat map method produces an overlay over the road network which shows up areas of higher accident densities with 'hotter' or brighter colours. Superficially the results are similar to the accident density method; however, this method requires some additional user interpretation to decide which sites are the worst and what their extents or lengths are.

#### Fixed length methods (roads)

Where accidents are assigned to more major roads by their location relative to kilometre marker posts (typically located every 200m), these section positions can be used as a search basis for identifying accident location sections. Suitability of this method depends on the accuracy of the recording of accident location. Link and junction sections should be analysed separately as far as possible since accidents can cluster naturally at intersections.

### 6.3.2.3 Step 3: Prioritise accident locations for further investigation

It is unlikely to be possible to investigate all accident locations in detail; therefore, it is necessary to prioritise further review and treatment. Traffic and road department may wish to focus their efforts on strategic/important roads that have higher traffic flows or those locations that have a greater number of higher severity accidents. Embedded in the Safe Systems approach is a clear focus on reducing the most severe accidents; those which result in fatalities and serious injuries. Economically it is also more efficient to tackle these more serious accidents as a priority since they also inflict significantly greater financial losses on the economies of countries in addition to the pain and grief resulting.

Accident location sites will have different numbers of accidents, with different severity profiles. These differences in site characteristics can be used to sort them into prioritised lists for investigation and analyses. To help focus actions and resources on the locations which have more fatalities or FSI accidents a severity-linked weighting scheme can be used to give an initial rank to the identified cluster sites. If no severity weighting is used, sites are ranked simply by listing them in order of the number of accidents which occur at them. What this means is that a site with 20 accidents which are all slight in severity would rank higher than a site with 10 accidents of which 5 are fatal and 5 serious. For this reason, a method of severity linked weightings is useful to produce the initial site priority order. If the same two sites were re-ranked with a severity weighting applied of 10 for a fatal accident, 5 for a serious accident and 1 for a slight accident, the first site will 'score' 20 (20 slight accidents times a weight of 1) and the second site would 'score' 75 (5 fatal accidents times the weighting of 10, and 5 serious accidents times the weighting of 5).

There is merit in using severity weightings when initially screening and ranking accident locations. If the sites are identified based on the count of all accidents irrespective of severity, some very severe accident locations with fewer accidents may be missed from the initial site listing.

In many road authorities, it is the endeavour to try to ensure that the most severe accident locations are tackled as a priority. However, there are practices (more prevalent in some African countries) to still treat all (injury) accidents with the same level of priority. Circumstances, politically, financially or operationally, will to a large extent dictate how road safety programmes are motivated and initiated. It has become clearer that certain accident types correlate strongly to higher severity outcomes; this is another reason for taking severities into account. Four main methods are used to take severity into account, these are:

1. Engineering expertise and judgement applied. The disadvantages are that it is biased towards treating the more severe sites and it is applied in an ad-hoc manner. In the absence of detailed and georeferenced accident data, however, this will be the default method to be relied on to initiate an accident location treatment programme.

2. Weighting according to accident costs for different severity accidents (the weights are the unit costs of each severity proportional to the unit cost of damage-only accidents).

   Fatal=112, Serious=16, Slight=3, Damage-only=1 (based on RTMC Cost of Crashes 2016), multiplied by the number of accidents of a given severity at a site to give a score.

3. Weighting in line with international practice

   Fatal=10, Serious=5, Slight=2, Damage-only=1 multiplied by the number of accidents of a given severity at a site to give a score

4. Weighted index

An example of a weighted index method is a Safety Priority Index System (SPIS) score (Dixon, 2011). It is based on maximum accident casualty rates over a moving 0.1-mile road section length. Metrically adapted (further adaptations will be required for local applications with respect to casualty rates and section length), the SPIS is calculated for qualifying 160 m (0.1 mile) segments of roads based on the frequency, rate and severity of accidents occurring within each segment over a three-year period. Damage only accidents are not used in the SPIS calculation. The SPIS score is the sum of three indicator values (IV Frequency + IV Rate + IV Severity), where:

- $IV_F$ (Accident Frequency Indicator Value) equals 25 percent of the SPIS score

$$IV_F = \frac{\log(Total\ injury\ accidents + 1)}{\log(150 + 1)} * 25 \qquad (6\text{-}1)$$

The maximum Accident Frequency Indicator Value of 25 is obtained when the total number of accidents reaches 150 accidents on the same 160 m segment over a three-year period. (Adapted from Dixon, 2011)

- $IV_R$ (Accident Rate Indicator Value) equals 25 percent of the SPIS score

$$IV_R = \frac{\log(\frac{(Total\ injury\ accidents * 1{,}000{,}000)}{(no\ of\ years) * (365 days) * ADT} + 1)}{\log(7 + 1)} * 25 \qquad (6\text{-}2)$$

The maximum Accident Rate Indicator Value of 25 is obtained when the accident rate reaches seven accidents per million entering vehicles in the same 160 m (0.10-mile) segment over a three-year period. (Adapted from Dixon, 2011)

- $IV_S$ (Accident Severity Indicator Value) equals 50 percent of the SPIS score

$$IV_S = \frac{100(Fatal\ accidents + Injury_{Serious}) + 10(Injury_{Slight})}{300} * 50 \qquad (6\text{-}3)$$

The maximum Accident Severity Indicator Value of 50 is obtained when the accident severity component [100(Fatal accidents + $Injury_{Serious}$) + 10($Injury_{Slight}$)] is equal to or greater than 300 for the same 160 m segment over a three-year period. (Adapted from Dixon, 2011)

$$\text{SPIS Score} = \boldsymbol{IV_F} + \boldsymbol{IV_R} + \boldsymbol{IV_S} \tag{6-4}$$

The higher a SPIS score, the higher the potential safety needs for the identified roadway segment. The highest SPIS score possible is 100. This is reached when a 160 m segment over three calendar years has:

- 150 or more total accidents,
- Seven or more accidents per million entering vehicles, and
- A combined severity rating equal to or greater than 300.

There is no clear right and wrong practice for using any of these methods, however, an approach which favours more severe accidents, but which does not weigh as heavily as a system based on accident costings is recommended. There are pros and cons for all these methods and traffic and road departments need to employ the best practicable methods to achieve their objectives to reduce road traffic casualties in the most cost-effective manner.

Practitioners should test different weighting schemes to check that they are performing in a desired way. Ideally sites should also be filtered and prioritised by comparing the accident occurrence at identified potential accident locations to the average occurrence for similar road sections which have similar flow levels. There may be more prescriptive requirements from treasury departments that may be relevant for grant funding protocols that should be recognised before deciding in a particular method.

#### 6.3.2.4 Step 4: Analyse accident types and patterns

The accident characteristics from identified accident locations should be investigated to identify patterns in the occurrences of the accidents. Identified patterns and commonalities should provide clues which help to diagnose the underlying problem at the site and will inform the development of a treatment plan targeted at solving the underlying issue. For example:

- If a high proportion of accidents in the cluster involved pedestrians it could be due to a lack of appropriate provision for the non-motorised demand
- If a large number of accidents are shunts (nose to tail) it could be a traffic signal phasing issue, a surface friction problem, or a general speed related problem
- If there is a high proportion of turning/or emerging vehicle accidents it could that there is a lack of adequate visibility, or excessive speed

There are a number of key information types that can help diagnose the most common issues at a range of sites. So, a summary report which shows a range of the key information on a single report is extremely useful. The typical information included is as follows:

- Accident types (with time trends)
- Accident numbers by severity (with time trends)

- Casualty numbers by severity
- Wet/dry break down of accidents
- Light/dark breakdown of accidents
- Severity indication (proportion of FSI accidents)

Ideally these data should be displayed efficiently and in a standard format so that a large amount of information can be quickly assessed to identify any clear patterns and trends. These reports can be produced semi-manually by performing the appropriate cross-tabulations and filling in a form in MS Excel or similar, or they can be generated automatically by dedicated accident data system software.

#### Cross-tabulation

Summarising and presenting information relating to subsets of the accident data can be achieved through cross-tabulation – it is the same as the 'pivot table' function in spreadsheet programmes. It is a way to reveal (or looking for) patterns in the different relationships among the various fields that are recorded in the AR form. This analysis method allows the investigator to look for less obvious patterns across all the coded fields in the data from a cluster of accidents for example. It can be used to supplement the information that is set out in the standard accident report.

The cross-tabulation exercise on the accidents data for a single accident location is generally the easiest to perform. Looking for patterns of accidents among a range of accident locations with variable traffic and road conditions is expectedly more complicated. Some typical cross-tabulations that might be done are 'day of the 'week against 'time of day' and 'accident type' against 'casualty class' for example.

Cross-tabulation results can indicate that there are likely to be significant issues with provision of facilities for pedestrians crossing and moving along the road. The site visit should therefore concentrate on these issues and particular attention should be given to observing pedestrian behaviours.

#### Accident diagrams

The construction of 'accident diagrams' is used as a further way to identify potential sources of conflict between road users at accident locations. Accident diagrams give an indication of the types of accident that are occurring at specific locations – this is typically, but not exclusively, used at junctions. The methodology is used to identify more clearly the types of accidents that are occurring and therefore help the engineer identify better the possible countermeasures which may be appropriate. The method requires that individual accidents have been given precise accident coordinate locations (ideally within 3m accuracy) and that all of the appropriate fields are filled in on the reporting form. Most importantly, it requires that the manoeuvres (as compass directions, for movement from and to) are listed for individual vehicles and road users.

In addition to an indication of the accident types, other important information can be indicated, such as the severity of the individual accidents and also the date when they occurred. In addition, indications of whether the accidents occurred under daylight or darkness and in wet or dry conditions are also indicated in the simple symbols for each accident.

#### Stick analysis

Another useful and established method to analyse the accidents at accident locations is 'Stick Diagram Analysis'. This method allows the safety engineer to view groups of accidents with each individual record being represented by a column or 'stick' of information. By moving these 'sticks' of information around, or highlighting similar factors, the safety engineer can often discover patterns in the accidents at a particular location, and this can help them to identify some underlying causes.

### 6.3.2.5 Step 5: Investigate sites

Once the pattern of accidents has been identified, the sites need to be physically examined.

#### Aim of the site visit

The aim of the site visit is to establish the underlying factors that are contributing to the dominant accident types identified from the analysis. For instance, there may be many pedestrian casualties even though a crossing is provided. During the site visit the investigation team may find that the pedestrian crossing is not co-located with desire lines or public transport facilities. Simply relocating a bus stop may encourage pedestrians to use the facilities. Similarly, a high incidence of turning vehicle accidents may require a minor modification to the junction layout. The reminders included in Appendix B may be useful in conducting a site investigation but should be used considering the accident data analyses to direct the investigation.

#### Planning site visits

Site visits:

- Should be conducted at times when accidents are occurring. The accident patterns may indicate that it is important to visit the site during darkness, during rush hour or when it is raining for example.
- Need to allow the investigation team to take the perspective of road users represented in the accident data.
- Must be conducted safely. The safety of the investigation team, other road users and construction or other personnel must not be compromised by the site visit.

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

#### Different viewpoints

The site visit should allow the investigators to take the perspective of different road users, particularly those over-represented in the accident data. Note that this should not put the investigation team at risk – for example if motorcyclists are over-represented in the accident data the investigation team should not ride the route on a motorcycle if they are unfamiliar with this mode of transport.

### Recording findings

Video cameras, or digital cameras and voice recorders, enable images of the site to be recorded along with a spoken commentary of issues. This is extremely useful when later collating the observations and the images can also form an informative part of the report. It is recommended that a full video of the site/road is recorded and that many photographs are taken during the site visit. These are important to provide a reminder of key issues when writing the report and provide a record of the conditions during the site visit.

Taking videos and photographs in a systematic manner will help when reviewing them later. Always start a video sequence speaking to the camera and naming the site, identifying the personnel involved, stating the date and time and by specifying direction of travel. It can also be helpful to provide a video commentary. Photographs should also be taken in a systematic manner so as to assist with subsequently identifying features and locations. For example, ensure that landmarks are included and always progress around an intersection in a clockwise direction. It may also be helpful to photograph a written card which describes the location prior to taking a sequence of photographs. Copies of plans should also be used to record any specific features seen during the visit for later reference.

### Community intelligence and consultation

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

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

### Conflict studies

A conflict study can provide useful information that is complementary to accident data. A conflict or encounter often involves a road user (a pedestrian, a pedal cyclist or the driver of a motorised vehicle) taking some form of evasive action. One definition of a conflict is: two traffic participants maintain such a course and speed that a sudden evasive manoeuvre of one of the two participants is required to avoid an accident.

Conflict studies can be conducted by making, and recording, observations from the road-side or by observing interactions on video. It should be noted that whilst the most common conflicts are often similar to the most common manoeuvres, this is not always the case. In some instances, movements which are less common can be disproportionately over-represented in conflicts. Therefore, as well as identifying information about conflicts, it is also necessary to record some indicative traffic counts so as to help to understand the rate of risk exposure associated with any particular conflict.

The assessment of conflicts involves an element of subjective judgement, and it is therefore important to ensure that suitably skilled personnel conduct the analysis and that it is conducted in a consistent manner.

Figure 6-1 shows a five-level conflict classification structure that can be used in conflict measuring studies (African Development Bank (b), 2014).

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

*Figure 6-1: Example of conflict classification*

In addition to identifying the manoeuvres and the types of traffic involved in a conflict, it is also necessary to consider the severities of conflicts along with the rate of exposure to risk. The study will therefore include representative traffic counts and a categorisation of each observed conflict. Conflicts can be recorded on site using very simple sketches. These sketches record the manoeuvres and the road user types involved in each conflict, along with the frequency and the severity.

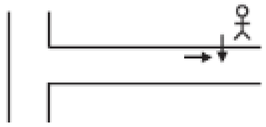
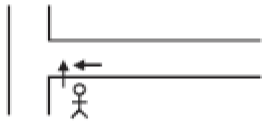
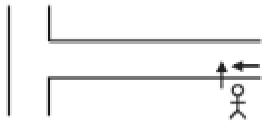
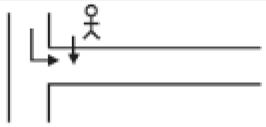
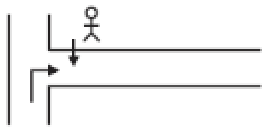
| | Conflict Severity | | | | |
|---|---|---|---|---|---|
| Sketch of conflict | 1 | 2 | 3 | 4 | 5 |
|  | III | III | I | | |
|  | IIII | II | | | |
|  | III | III | | | |
|  | ~~IIII~~ III | III | II | | |
|  | ~~IIII~~ | II | II | | |

*Figure 6-2: Example of a conflict measuring study sheet for pedestrian-vehicle conflicts at a T-junction*

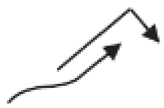
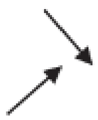
| | Conflict Severity | | | | |
|---|---|---|---|---|---|
| Sketch of conflict | 1 | 2 | 3 | 4 | 5 |
|  | ~~IIII~~ | IIII | | I | |
|  | | | II | | |
|  | ~~IIII~~ II | II | III | I | |
|  | ~~IIII~~ I | IIII | II | II | |

*Figure 6-3: Example of a conflict measuring study sheet for vehicle-vehicle conflicts at an intersection*

### Safety considerations

Throughout any site visit it is important to maintain the safety of the investigation team. The investigation team should be aware that the sites they are investigating are high risk (otherwise they would not be investigating them) and so extra care and caution should be exercised.

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

- Planning and administration
- A manager should be notified of any deviations from planned schedules
- A mobile telephone should be provided for emergencies and for checking in with the line manager at the start and end of each day.
- The investigation team must be equipped with sufficient supplies of drinking water and food.
- Vehicle safety
- Vehicles must be roadworthy and properly equipped with suitable reflective materials and lighting bars. They should generally travel at the prevailing traffic speed.
- Site/operational issues:
- Site visits must always involve at least two personnel - one should act as a look out when the other is preoccupied (e.g., taking photographs).
- Appropriate traffic management should be requested if it is otherwise unsafe to inspect the site.
- The investigation team should park safely to not obstruct traffic flow or obscure sightlines.
- The investigation team must be aware of risks from beyond the road. For example, the risks of sunstroke, personal attack, or animal bites (including insect or snake) should be evaluated.
- Appropriate Personal Protective Equipment (PPE) must always be worn. Different PPE will be appropriate for different situations, but it is likely to include reflectorized vests or jackets and trousers and sunshades. Suitable footwear is essential and might include steel toe cap boots. Hard hats or eye goggles will be necessary in some situations.
- The investigation team must never use video cameras, cameras, mobile phones or other equipment while they are driving.
- Investigations must be made from safe locations such as footways, hardened verges or overbridges.

Investigators should not stand in the road and they should only cross the road in suitable locations and with care.

- The investigation team should avoid walking with their backs to traffic where possible.
- The investigation team must not expose themselves or other road users to risks during adverse weather conditions such as high winds or heavy

rainfall. It is possible however to conduct some observations from a safe place (e.g., pedestrian behaviour in the rain).

- The investigation team should not intervene in incidents or direct traffic unless they are specifically trained and equipped to do so. Well-intentioned intervention of this type can make matters worse and it is better to call the Police or other emergency services in such situations.

The investigation team should stop work and leave the site if unforeseen risks are identified. They should consult with a manager to determine a way forward.

#### 6.3.2.6 Step 6: Identify solutions

For each site, countermeasure options are 'tested' for their potential to reduce the occurrence of fatal or serious accidents that have occurred at the location. For example, if there are many serious pedestrian accidents, and pedestrians are observed crossing the road away from crossing facilities then provision of pedestrian crossings and guard rail may be appropriate. Similarly, if there are substantial numbers of accidents occurring at night at an intersection, it may be appropriate to provide lighting or improved warning signs/delineation.

Volume 2, Appendix B can be perused to provide a sense of potential treatments/solutions relevant to different accidents. It is only a high-level indication to the type of safety improvement measures that can be effective to counter specific accident types - the appropriateness of which for different circumstances need to be carefully considered.

#### 6.3.2.7 Step 7: Report

Once the analysis and preferred solution(s) have been identified the whole investigation needs to be summarised in a report to management for appropriate action. The report will review the process that has been followed, starting with the initial identification of the problem through data analysis. This will be followed by a description of the findings of the site visit that identify the factors contributing to the accident problem and the reasoning behind the identification of proposed solutions.

This will then be taken forward to the development of a treatment plan described in Section 6.8.

## 6.4 Route/corridor analysis and investigation

Route/corridor analysis aims to identify road sections that are performing badly from a road safety point of view in comparison to the average for other similar roads. In this technique roads with a high potential for accident reduction are those where the accident density is much worse than the average for that road type. Once road sections that have a high potential for accident reduction have been identified, they should be investigated through a site visit to see if there are treatments that will raise the standard of that road to at least average for the road type. The person conducting the site review will need to consider the type of accidents occurring on the section to determine whether any treatments are likely to rectify the underlying accident problem.

### 6.4.1 When to conduct route/corridor analysis

Route/corridor analysis should be conducted on an annual basis. These analyses will require a minimum of three years of accident data. In some countries with high rates of under reporting it may be necessary to use up to five years of data. As with accident location analysis there is a balance to be reached between having sufficient data for the analyses to be robust and having data that reflects the current road network. As an approach, route/corridor analysis is particularly useful since it does not necessitate the precise accident coordinates necessary for accident location analysis. Route/corridor analysis should be conducted alongside accident location analysis since the two approaches will highlight different issues; route/corridor analysis may uncover issues that pertain to longer sections but are not concentrated enough to appear as localised accident locations.

Whilst route/corridor analysis does not require precise accident coordinates, some information about accident locations is necessary to attribute accidents to road sections. This information can be in the form of accident coordinates, or it can be the road number, road section, link node location, or chainage along a road (see Section 4 for more information on these types of accident locators). For the results to be the most use this would be recorded and available for all accidents over the whole road network.

### 6.4.2 Methodology

A step-by-step procedure for conducting route/corridor analysis and investigation is outlined in Figure 6-4 below.

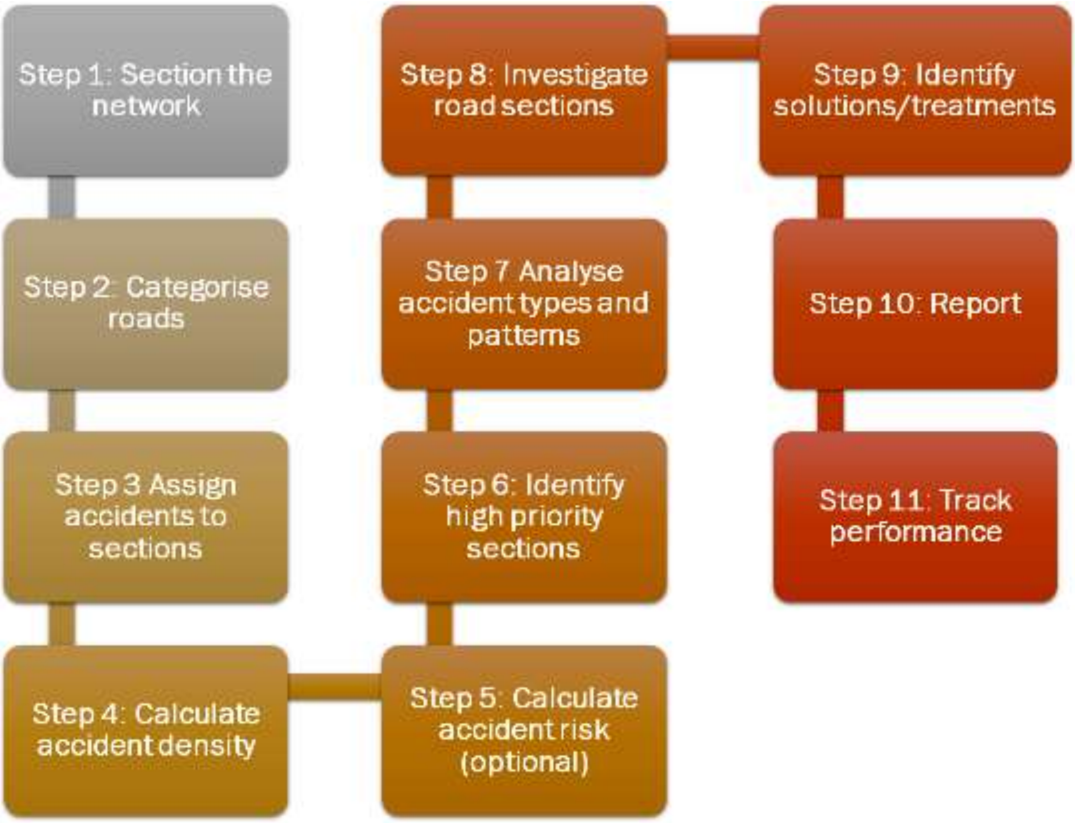



*Figure 6-4: Route/corridor analysis and treatment steps*

6.4.2.1 <u>Step 1: Section the road network</u>

This first task should only be conducted once so that, as much as possible, consistent road sections are used every year (substantial changes to the road network including new roads will of course need to be reflected in the dataset). This will allow the monitoring of high-risk sections year by year. Ideally road sections should be:

- Homogenous in character (the section should have similar design features and similar traffic flows)
- Between 10 km and 150 km in length (and ideally as similar in length as possible)
- Meaningful, e.g., road x between junction y and junction z or between two towns or settlements

Network Level Assessment (NLA) as described in Volume 2 requires a similar process to be conducted. It would be advantageous and efficient to use the same road sections for both route/corridor analysis and NLAs.

The way in which the network is sectioned will need to reflect the way in which accident locations are recorded by the police. It will be necessary in Step 3 to assign accidents to each length. This means that it must be possible to determine which accidents were on each length. In the worst case, this may restrict network sectioning to road names (preferably by jurisdiction). This may impact upon the quality of the results and the ability to be precise about priorities across the network since most roads will be much longer than the ideal road section length.

If police accident data are already recorded using a link-node system, then it may be best to use this as a basis for sectioning the network. Each section should be given a unique identifier and sufficient location details recorded such that the section is identifiable on the network (i.e., latitude and longitude, road numbers or settlement names at the start and end points).

Some free-source web-based mapping (Google Maps) provides a latitude and longitude information if the location is clicked upon and selected.

#### 6.4.2.2 Step 2: Categorise roads

The next step is to categorise each road section using TRH 26. This is normally already done as part of Road Asset Management Systems (RAMSs).

Ideally, traffic flow data should be collected in a robust and reliable manner. This would involve conducting detailed traffic surveys across the road network (again already systematically done for the RAMSs by some road authorities). Often these will be done by different departments in the road authority (for projects concerning planning or environmental impact, etc.). If traffic flow data are not available, these can be conducted based on considered estimates, though the results may not be as robust.

#### 6.4.2.3 Step 3: Assign Accidents to Sections

The process for assigning accidents to sections will depend on the detail of data available. If the network sectioning has been conducted to fit precisely with police accident data link-node locations, or if the police are able to add the 'route/corridor analysis section' to the list of fields they record, then this process has already been completed.

If accident coordinates are available in a database, then these will need to be assigned to the road sections. This can be done using a GIS mapping program or website, or by comparing the accident coordinates with the latitudes and longitudes of the end points of the road sections with the same road number. Note that it is more reliable to use accidents rather than casualties for this kind of analysis since counting casualties can skew data due to accidents involving many casualties (e.g., mini-bus accident). If severity information on accidents is available and reliable, weightings can be applied to the number of accidents in a comparable manner to that conducted in accident location analysis (see Section 5.2.2.3).

#### 6.4.2.4 Step 4: Calculate Accident Density

Accident density is a measure of the concentration of accidents along a section; it is defined as the number of accidents on the road section (in a chosen time period) divided by the length of the road section. The time period chosen will depend on the number of accidents recorded (the higher the number of accidents per road section the shorter the amount of time required), however, it is suggested that a period of three years would be a good starting point.

Accident densities show where most accidents are occurring across the network. Accident density is highly influenced by traffic flow and so it is often the case that such analyses just show where the greatest traffic flows are across the network. Therefore ideally, accident risks are also computed, however these require accurate traffic flows to be recorded for each of the road sections used in the route analysis.

#### 6.4.2.5 Step 5: Calculate accident risk (optional)

Accident risk is the risk to an individual per billion vehicle kilometres driven. Accurate traffic flow data are required for each road section to calculate accident risk. This measure effectively controls for traffic flows to find intrinsically high-risk sections. Care should be taken with the results of risk analysis since high-risk sections may not have the greatest treatment priority. Simply focussing on high-risk sections alone may mean investment is made on roads with low traffic volumes so the casualty reduction potential may not be at its greatest. The routes most suitable for treatment are likely to be those with a moderate to high accident risk and a moderate to high accident density.

#### 6.4.2.6 Step 6: Identify high priority sections

It is unlikely to be possible to investigate all routes/corridors in detail; therefore, it is necessary to prioritise further review and treatment. Road authorities may wish to focus their efforts on strategic/important roads that have higher traffic flows or those locations that have a greater number of higher severity accidents. In this step, the highest priority sections for treatment need to be identified. In terms of risk and potential for accident reduction, three sub-steps are needed:

- Step 6a: Calculate the average accident density for each road category. It is important to ensure that this is calculated as the total number of accidents on the road category divided by the total length for the road category (rather than averaging the calculated densities).
- Step 6b: Calculate the difference between the accident density for each section and the average for its road category and rank the sections on this basis.
- Step 6c: Calculate the potential for accident savings by multiplying the potential accident savings per km per year by the length of the road section.

*Table 6-2: Example of route/corridor analysis results:*

| Section ID | Road category | No of accidents | Road length (km) | Accident density (per km per year) | Average accident density for road type (per km per year) | Potential accident savings per km per year* | Potential accident savings per year |
|---|---|---|---|---|---|---|---|
| P402/1 | Class 3 Divided 4-lane | 17 | 7.3 | 2.33 | 1.95 | 0.38 | 2.77 |
| P402/1 | Class 4 Undivided 4-lane | 31 | 9.5 | 3.26 | 2.17 | 1.09 | 10.36 |

*Rank for further review based on potential accident savings per km per year.

A typical target for route/corridor analysis would be to at least investigate the top 10% of sections (more if possible or as may be directed by targets as per policy or other) through the analysis of accident types and patterns and the conducting of site reviews. It is possible to calculate the potential casualty savings by multiplying the potential accident savings per km per year by the average number of casualties per accident. Although this will not further aid prioritisation, it may be a useful calculation to make the case for investment.

6.4.2.7 Step 7: Analyse accident types and patterns

Once high priority sections have been identified, the character of the accidents that have occurred needs to be analysed. This can be conducted similarly to that described in Section 5.2.2.4.

6.4.2.8 Step 8: Investigate Road sections

In this step an investigation team will visit the road section and, equipped with knowledge of the type of accidents occurring, will investigate the section to determine if any treatments might reduce risk. A route/corridor visit is like those conducted for accident location sites in that:

- The aim is to identify the underlying factors contributing to the dominant accident types identified in the analysis
- Visits need to be planned so that timings are in accordance with accident patterns (e.g., conduct visits in the night as well as during the day if a large proportion of accidents occur at night)
- The investigators must adopt the viewpoint of different road users (particularly those represented in the accident data analysis)
- The safety of the investigation team must be taken into consideration and equipment provided n Findings should be recorded and documented using videos and photographs
- Community intelligence and consultation can provide useful additional information

A route or corridor visit differs from an accident location site visit since the same level of detail is not required. Moreover, conflict studies are not relevant.

Investigators need to examine the road characteristics and features of the road that appear to be causing road users a problem. During the visit, there may be clues regarding the location of accidents (e.g., damaged or missing roadside furniture or vegetation, or even vehicle debris or tyre marks on the road surface) that will allow more targeted treatment.

Note that it can be beneficial to investigate the best performing roads to understand why they are performing so well, and whether any lessons can be learned for application of those features across the road network.

#### 6.4.2.9 Step 9: Identify solutions

For each section, countermeasure options are 'tested' for their potential to reduce the types of accidents known to occur on the section. Emphasis should be given to the reduction of serious or fatal accidents. For example, if there are many pedestrian accidents, and pedestrians are observed crossing the road away from crossing facilities then provision of pedestrian crossings and guardrail may be appropriate. Similarly, if there are many run-off road accidents occurring at night then it may be appropriate to provide improved warning signs and delineation along the section. In addition, it may be necessary to remove any roadside obstacles or provide a vehicle restraint system.

In route/corridor studies it is possible to develop a treatment plan that provides consistency of treatment along an entire route or corridor. Although treatments will need to be more extensively applied, there may be cost savings associated with treating longer stretches of road at once and consistency will improve road user experience. A list of potential treatments/solutions relevant to different accidents is given in Appendix E. It provides high-level, indicative, guidance as to the type of safety improvement measures which might be appropriate under different circumstances.

#### 6.4.2.10 Step 10: Report

A route/corridor analysis report should contain:

- A description of the methodology used (corresponding to those applicable steps described in Section 5.3.2)
- A summary of the results showing:
  - 10% best road sections for each road category
  - 10% worst road sections for each road category

This may take a format with the sections ranked by accident density.

- The full database showing the results for all road sections should be appended to the report
- Results of the site review
  - List of proposed treatments for further review and prioritisation (see Section 5.5)
  - Once several years of data have been analysed, it will also be possible to include a performance tracking section

If Network Level Assessments (NLA)are also being conducted (see Volume 2), it would be advantageous to share the results of the route/corridor analysis with the NLA project manager and, if possible, combine the resultant data sets. This would mean that the Road Safety Assessor would be able to interrogate the performance of a road section alongside the characteristics of the section.

**Accident maps (optional)**

Should a GIS map of the road sections be available, maps showing the accident densities and accident risks along sections can be produced. The road sections can be grouped into bands according to their accident densities (and then accident risks) and then the map coloured according to this bands so that low density (or rate) sections are coloured a different colour to higher density (or rate) sections. Maps similar to those produced using the iRAP Risk Mapping Protocol can be developed (see https://irap.org/).

6.4.2.11 Step 11: Track performance

Each year the process should be repeated with the most up to date data available. Since these analyses often warrant around 3 years of data, this would mean comparing, for example, the dataset from 2013, 2014 and 2015 with the dataset from 2016, 2017 and 2018. The performance of sections previously identified as high risk should be reviewed, particularly those sections that have been treated. This step should also include the identification of any sections where the accident density and/or risk has changed a lot from year to year – even if this is a reduction it needs to be understood.

## 6.5 Area analysis and investigation

As discussed in previous sections, there are varying degrees of road safety data available in countries across Africa. Detailed accident location and route/corridor analyses can only be conducted effectively where there are accurate and consistent data available. Both approaches require some information about the location of accidents. If accident locations are not recorded, the police may still record information on the area in which the accident took place. This may take the form of a police area code or similar.

Area analysis seeks to identify types of treatment that will be effective in areas experiencing higher than expected accidents of certain types. It is therefore important to be confident that the treatment being considered will be effective for particular types of accident.

### 6.5.1 When to conduct area analysis

Area analysis should be conducted on an annual basis. These analyses will require a minimum of three years of accident data. In some countries with high rates of under reporting it may be necessary to use up to five years of data. As with accident location analysis there is a balance to be reached between having sufficient data for the analyses to be robust and having data that reflects the current road network.

### 6.5.2 Methodology

A step-by-step procedure for conducting area analysis and investigation is outlined in Figure 6-5 below.


*Figure 6-5 Area analysis and treatment steps*

#### 6.5.2.1 Step 1: Analyse network-wide accidents

The initial step is to assess the available data for the whole country, network or jurisdiction to gain a broad understanding of the current situation and overall trends. This will require a comparison of several years of data in a consistent format.

Possible analyses will depend on the accident characteristics recorded by the police. The ideal analyses are as follows (it is likely many of these will not be possible):

- Fatalities by year (to be able to identify overall trends)
- Fatality rate per 100,000 population per year (number of fatalities divided by the population of the country, then multiplied by 100,000)
- Distribution (%) of accidents by:
  - Road type (single carriageway, dual carriageway; paved, unpaved)
  - Time of day (day versus night)
  - Accident type (ideally head-on, run-off, side swipe, vulnerable road user etc.)
  - Location type (rural, urban, semi-urban)
  - Road character (straight and flat, bend, slope, bend and slope, narrow, bridge, rail crossing)
  - Median presence (divided, undivided)
  - Junction type
  - Number of lanes

- Road user type (pedestrians, motorcyclists, pedal cyclists, light vehicle occupants, trucks, minibus, buses, agricultural etc.)
- Manoeuvre (turning, changing lanes, reversing, parking, overtaking etc.)
- Road condition (good, poor)
- Weather conditions (dry, wet, snow/ice)
- Road works (present, not present)

6.5.2.2 Step 2: Conduct area analysis to identify common accident themes

The next step is to conduct the same analyses that were possible under Step 1 but this time for each area of interest. The way in which areas are allocated may vary. As a rule, the smaller the area, the better to allow a more targeted approach in the completion of the site visit in Step 4.

6.5.2.3 Step 3: Compare area results to national trends

Initially the number of fatalities by area should be reviewed. This can be used to see if any trends are emerging where there are steeper than expected increases in fatality numbers in a particular area. If population data are available by area, then it may be possible to calculate the fatality rate per 100,000 population per year by area. This may identify poor performing areas (though it should be noted that not all road users will stay within their home area, so this analysis is not without fault).

- Fatalities by year (to be able to identify overall trends)
- Fatality rate per 100,000 population per year

Comparisons of pure counts (not rates) between individual areas and the whole network can be made statistically using a chi-squared goodness of fit test. This will test to see if the distribution of accidents or fatalities is the same in each area as the national (or regional) figures. For example, if comparing the distribution of males and females killed in road accidents in one area compared to the national figures (using hypothetical figures).

**Step 1:** Factor the national figures so that the total national figure is the same as the area total.

**Step 2:** Compare the factored national figure with the area figures using a chi-squared statistic: (observed expected) 2/expected.

**Step 3:** Identify the number of degrees of freedom: this is the number of rows (number of categories) – 1. In this case this is 2 (males and females) – 1 = 1.

**Step 4:** Sum the chi-squared statistics and compare them to the chi-squared standard distribution with the appropriate degrees of freedom (this can be done automatically using Excel or can be looked up in statistical tables). Excel will do this with the function ‘chidist’. This is the p-value.

**Step 5:** Interpret the p-value: if this value is smaller than 0.05, then the distribution of males to females in area 1 is statistically significant different (at the 95% level) to that across the whole network. In other words, the spread of male and female fatalities is not the same in area 1 as it is across the whole network. In the example, the p-value is greater than 0.05 and therefore there is no significant difference between the spread of female and male fatalities in area 1 compared to the national figures.

Comparisons of counts between areas can be made using a chi-squared test of independence, note that this is different to the chi-squared goodness of fit test shown above. Comparisons of rates between areas can be computed using a Mann-Whitney U-test or a normal t-test if the parametric assumptions have been achieved

The results should indicate characteristics of accidents that differ from those observed across the whole road network.

#### 6.5.2.4 Step 4: Area visits

In this step, an investigation team will visit the area and, equipped with knowledge of the type of accidents occurring in the area, determine if any treatments might improve the situation. These area visits are conducted using similar principles to those adopted for route/corridor investigations.

#### 6.5.2.5 Step 5: Identify solutions

Solutions should be identified in the same way as for route/corridor analysis (See 5.3.2.9).

#### 6.5.2.6 Step 6: Report

A route/corridor analysis report should contain:

- A description of the methodology used corresponding to the steps taken
- A summary of the results for Steps 1, 2 and 3
- The full database should be appended to the report
- Results of the site review
- List of proposed treatments for further review and prioritisation (see Section 5.5)
- Once several years of data have been analysed, it will also be possible to include a performance tracking section

#### 6.5.2.7 Step 7: Track performance

Once several years of data have been compiled it will be possible to conduct performance tracking for each area. This will allow the identification of any emerging trends by area. Once again, the granularity of performance tracking by area will depend on the data recorded by the police.

## 6.6 Identification of accident causation and accident severity factors

Before completing the analysis and preparing a summary report, consider what other data is required but not yet provided. For example, does the accident information or the site inspection indicate that skid resistance testing should be conducted? Do sight distances need to be measured?

### Draw conclusions

With all the information available from the analysis and the field inspection, conclusions can be made about the underlying factors contributing to the accidents. An assessment should be made of what it is about the road or traffic environment which is leading to accident occurrence and/or accident severity.

### Write an accident summary report

An accident summary report can then be prepared. This summarises the information available about the site and incorporates the introduction and data analysis. This summary report can form the first part of the final accident location treatment report which will include consideration of countermeasures and an economic appraisal of the proposed treatment.

At this stage, the accident summary report would typically include the following sections of the report framework:

- introduction
- data analysis, as well as the information, an accident histogram by accident type column sub-groups may optionally be included in the preliminary report or the accident summary report
- contributing accident factors
- appendices.

Note how the identification of common factors leads to the description of the site's problems. Also in this example, there are descriptions of possible remedial measures (which address these identified problems. Another alternative is to structure the report according to the Safe System pillars.

### Applying the process to area studies

The usual context for accident diagnosis on an area-wide basis is that a particular area (say a residential precinct up to 5 $km^2$ or a shopping/commercial district) has been identified as having a safety problem. In diagnosing that problem, the task is to plot the location of all recorded accidents, together with a code indicating the road user movement or accident type. Since a focus of such studies may be vulnerable road users, an analysis and presentation like that described for site analysis is useful.

An explicit functional road classification scheme is important in this instance, since often in these types of study a solution involves adaptation of the road and street network to ensure that extraneous traffic is excluded or discouraged. This cannot be done until all the legitimate (and necessary) traffic routes have been determined.

Area studies will incorporate aspects of both site and route studies, to the extent that accidents cluster at these locations. However, one important objective of an area study is to consider all the accident problems of the area together, in a consistent manner. This may include road network problems which are contributing to the accident experience of the area (e.g., traffic using residential streets as a 'rat run'). Solutions resulting from area-wide studies should be integrated into a total scheme to ensure that new safety problems are not created elsewhere, either in a nearby street or a nearby area. Implementation will often require community consultation.

**Applying the process to mass action programs**

The approach to the diagnosis of accident patterns for mass action programs is a little different because the focus is not a particular site. Nevertheless, the basis of the investigation is again an interrogation of the mass accident data base. Accidents may be sorted by accident type (as described above) to identify the locations where a particular type of accident, amenable to a standard treatment, is occurring. Examples, with possible countermeasures, might include:

- accidents involving accidents with a bridge or structure (guard fencing and delineation)
- rural single vehicle run-off-the-road accidents (sealed shoulders)
- accidents with utility poles on bends (removal of poles, shielding them, making them frangible or improving skid resistance).

Alternatively, accidents may be sorted by the road user to identify where accidents involving those users are occurring. Examples might include:

- accidents involving older or child pedestrians
- accidents involving cyclists or heavy vehicles.

Under mass action programs, many sites are often treated, irrespective of whether accidents have occurred at all of them. Care therefore needs to be taken when conducting economic appraisals for mass action, as the accident modification factors (AMFs) applicable at such sites may differ to those from where clusters of similar accident types occur (they may be lower). Similarly, there may be economies of scale when installing treatments that make the cost per unit installed less.

To the extent that there is a significant occurrence of accidents of a particular type or accidents with a common contributing factor revealed by such a study, the analysis could form the basis of a mass action program. If there is no significant occurrence by accident type, it is unlikely that a mass action program of engineering countermeasures is appropriate.

## 6.7 Countermeasure selection and design

Having identified the elements of the road and traffic environment which contributed to the accidents and their severity, the next step involves consideration of countermeasures. For a solution to be effective, it must be applied to a particular problem which it is known to affect. It must be an effective countermeasure.

The aim of countermeasure development is to:

- select countermeasures which have been demonstrated to be effective in reducing the incidence and/or severity of target accident types

- check that adopted countermeasures do not have undesirable consequences, either in safety terms (e.g., lead to an increase in the number or severity of another accident type, or accident migration) or in traffic efficiency or environmental terms
- be cost-effective, i.e., maximise the benefits from the whole program of expenditure over a number of sites
- be efficient, i.e., produce benefits which outweigh the costs.

There are several criteria for countermeasure selection, including (Ogden 1996):

- Technical feasibility: can the countermeasure provide an answer to the safety problems which have been diagnosed and does it have a technical basis for success?
- Economic efficiency: is the countermeasure likely to be cost-effective and will it produce benefits to exceed its costs?
- Affordability: can it be accommodated within the program budget; if not, should it be deferred, or should a cheaper, interim solution be adopted?
- Acceptability: does the countermeasure clearly target the identified problem, and will it be readily understandable by the community?
- Practicability: is there likely to be a problem of non-compliance, or can the measure work without unreasonable enforcement effort?
- Political and institutional acceptability: is the countermeasure likely to attract political support and will it be supported by the organisation responsible for its installation and ongoing management?
- Legal conformity: is the countermeasure a legal device, or will users be breaking any law by using it in the way intended?
- Compatibility: is the countermeasure compatible and consistent with other strategies, either in the same locality or which have been applied in similar situations elsewhere?

The decision to adopt a particular countermeasure may involve more than a simple matching of a solution to a problem.

### Safe System treatments

A challenge under a Safe System approach is to ensure greater usage of treatments that will provide Safe System outcomes (i.e., the elimination of death and serious injury). Due to cost considerations, safety improvements that have only moderate effects on fatal and serious accident outcomes are often used as these often produce a greater benefit-cost ratio (see Section 5). Although there is a place for such treatments in reducing accident risk, other treatments that produce greater benefits in terms of fatal and serious injury per dollar spent should be explored as first options where possible. Further discussion on this issue can be found in Turner et al. (2009).

### Speed management

Speed is known to have a significant impact on the likelihood and severity of accidents. A good evidence base now exists regarding the survivability of road users for different accident types based on impact speed. This knowledge needs to guide the approach that is taken to the management of speed.

Where speed has been identified as a contributory factor to accident severity and/or causation, appropriate management of speed should be investigated as a countermeasure. At intersections, techniques include the installation of channelisation, roundabouts or threshold treatments. At mid-block locations, appropriately designed traffic calming can be used.

### Match the solutions to the problems

Often there will be a number of alternative countermeasures which could be applied, either individually or in combination. The final choice about which countermeasure(s) to select requires road safety engineering experience and judgement about the factors which have led to the accidents.

There is extensive literature, particularly from the USA and Australia, that can be consulted for more information on the accident modification factors (AMFs) (or Crash Modification Factors) for various countermeasures to common types of accidents. These should be used for indicative purposes only to get guidance on the potential of a solution to accident locations. Every opportunity to treat an accident location is an opportunity to contribute to research and development to develop locally based AMFs. It is important to note that any countermeasures will only be effective if they really are a countermeasure for the type of accidents (and the particular causes identified) at the location in question. This underlines the point that the process must firstly identify whether the safety problem at a location is amenable to treatment, then determine what (if anything) that treatment should be.

The countermeasure for one accident problem is likely to be different from the countermeasure for another problem. In some cases, the countermeasures may possibly even be in conflict. For example, if there is a signalised intersection with a history of both pedestrian accidents and accidents between turning and oncoming vehicles, the latter can be tackled with fully controlled turn phasing of the signals, but this may make the pedestrian situation more complex, and perhaps even exacerbate it if the pedestrians do not obey the pedestrian signals. In such cases road safety engineering knowledge and judgement is required to assess all possible positive and negative effects, including possible further countermeasures to address the negative effects.

### Select the solutions

With some accident locations there may be a clearly defined accident pattern and an obvious countermeasure which can be confidently applied. In other cases, the accident pattern is unclear and/or the solution is not evident. It may be that two solutions are relevant, one being a relatively expensive one which overcomes a large percentage of the accident problems and the other being a lower cost solution which reduces the accident problem to a smaller degree. Until the stage of analysing the benefits and costs it may be a good idea to keep both treatment options under consideration.

## 6.8 Development of a treatment plan

Treatment plans are a prioritised list of countermeasures that are estimated to offer cost effective improvements to reduce risk. The site investigations conducted in response to the analyses described in Sections 6.3, 6.4 and 6.5 will allow the identification of potential treatments for application across the network. Before conducting the curative techniques described in this TRH 29 it is necessary to ensure that a budget is in place to implement recommended treatments.

It will rarely be possible to implement all possible treatments and so it will be necessary for the treatments to be prioritised. Since it is public funds that are to be used accountably, Economic Appraisal (Section 7) will be an appropriate instrument to ensure that any planned investment will be commensurate with the achievement of the desired results and impact. Some recommendations on treatments can specifically dedicated to road safety improvements that can scheduled as part of a rolling action plan. Some problems identified will be of an urgent nature for which an immediate action will have to be devised and funded from discretionary or the like mechanisms. Some treatments may be of the type and extent that, with some careful planning, can be incorporated into maintenance programs at little, or no, additional cost.

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

### 6.8.1 Role of economic appraisal

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

There are several techniques that can be used, from the more complex Benefit Cost Analysis (BCA) which requires an extensive set of supporting information and parameters, to more straightforward techniques that include First-Year-Rate-of-Returns (FYRR) and Cost-Effectiveness Analysis (CEA). It should be noted that EA is an approximate method with the main aim to conduct it as consistently and practically as possible. Also, EA results are seldom used as the sole justification for decision making on whether to fund a scheme or not.

For all the methods, it is necessary to determine the number of relevant accidents that will be saved and thereon estimate the potential effectiveness of treatments. These aspects are described briefly below. Conducting economic appraisal is dealt with in detail in Section 7.

#### 6.8.1.1 Identify relevant accidents

The first step is to identify the number of accidents that are relevant to a particular treatment. So, for example, if the treatment is to install a vehicle restraint system, relevant accidents would be ones involving a vehicle running off the road. For the installation of a pedestrian crossing, relevant accidents would be those where pedestrians were crossing (rather than walking along) the road.

#### 6.8.1.2 Effectiveness of treatments

There are countries that have been performing road safety management and evaluation purposefully for many years and have gathered reliable evidence on the effectiveness of treatments. However, the availability of such information is currently in a development stage and likely limited. Thus, instead, it is necessary to use information about the effectiveness of treatments from other regions of the world and apply road safety engineering judgement and experience when considering the likely impact in the relevant context.

One significant benefit to improving the quality and analysis of accident data is that it will become possible to evaluate the impact of treatments more confidently. Building a regional resource containing evidence on the impact of treatments should be considered a priority. Sharing such results will allow significant evidence to base to be built relatively quickly. Section 6.2 provides guidance on simple approaches to evaluation that can be used to start to build an evidence base. There are several international sources on the likely effectiveness of treatments. The first source that can be consulted is the iRAP Road Safety Toolkit (toolkit.irap.org).

The iRAP Toolkit compiles best practice information on road safety treatments from across the world. In the toolkit there is information about the effectiveness of a treatment, relative cost, implementation issues and references to sources that provide more detail. Exhaustive information on the iRAP Toolkit is accessible at https://toolkit.irap.org/. A further source that can be consulted is 'The Handbook of Road Safety Measures' (second edition) (Elvik et al., 2009). This source compiles similar information in greater detail. According to the iRAP toolkit, installation of a vehicle restraint system has an effectiveness of 40-60% in reducing run-off-the-road accidents. If an average over 3 years of 10.5 run-off-the-road accidents occur on a road section each year, and a conservative estimate of effectiveness of 40% is taken, then 4.2 accidents per year may be saved through the installation of a vehicle restraint system.

#### 6.8.1.3 Economic appraisal methods

**Benefit cost analysis**

BCA is a demanding task to perform properly. It requires all significant monetised costs and benefits to be assessed typically over a scheme's lifetime. It should include annual maintenance costs, all environmental and social impacts; all costs need to be moved into a single base year value and GDP growth across the assessment period needs to be considered. It is an in-depth process that can require significant effort and so it is not suited on smaller schemes. To conduct a BCA, the following information is generally required:

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

These items are then used to calculate a Net Present Value (NPV). ROSPA (1995) suggests that in some cases it may be advisable to carry out an evaluation which expresses the difference between costs and benefits that may accrue over several years (e.g., if the installation covers more than one year and there are known to be inevitable new maintenance costs in future years. The accrual needs to be against a common year price base. In the NPV approach there is a need to take account of money having a changing value over time because of the opportunity to earn interest or the cost of paying interest on borrowed capital.

The major factors determining present value are the timing of the expenditure and the discount rate (interest rate). The higher the discount rate, the lower the present value of expenditure at a specified time in the future. If the discount rate for roads is 6%, then R100 of value this year, if it accrues next year would be valued at 6% less (i.e., R94 and the following year R88, etc.). The overall economic effectiveness of a scheme is indicated by the NPV, which is obtained by subtracting the Present Value of Costs (PVC, which must also be discounted if spread over more than one year) from the Present Value of Benefits (PVB).

### First-year-rate-of-returns

First-Year-Rate-of-Returns (FYRR) is commonly used for appraising low-cost schemes. In this method accident costings are required along with estimated treatment costs and accident savings. The simplest FYRR will be estimated as the number of accidents in the 12 months before installation minus the predicted number of accidents in the 12 months after installation multiplied by the average cost of an accident. The formula is:

$$\frac{100 * ((accidents\ in\ year\ before\ -\ accidents\ in\ year\ after)\ *\ average\ cost\ per\ accident)}{Total\ cost\ of\ scheme}$$

### Cost effectiveness

The simplest method for carrying out EA is called 'Cost Effectiveness Analysis' (CEA). In CEA the cost that needs to be expended for each accident saved in alternative and competing schemes is estimated to help with the prioritisation of investments. Care must be taken when assessing the likely effectiveness of treatments since these are unlikely to be additive. In some cases, calculations have been seen where the estimated effectiveness of several treatments is greater than 100%. This is clearly not possible. Road safety engineering judgement needs to be applied in combining the likely effectiveness of treatments. The main parameters required are:

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

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

Using the same example as described earlier the following calculation can be performed.

- Number of relevant accidents per year 10.5
- Expected reduction or measure effectiveness 40%
- Expected saved accidents per year 4.2
- Cost of measure R400,000
- Cost Effectiveness is R9,524 (400,000/4.2)

This gives a value which represents the cost required to save a single accident for each proposed scheme. The potential schemes can be ranked by the calculated CEs in descending order and those schemes with the smallest values should be implemented preferentially. This method does not require accident cost estimates, although estimates of the effectiveness of treatments are required. Disadvantages include that the approach does not consider accident severity. Clearly this does require an estimate of the number of accidents, and in our current context, this can be difficult to achieve.

#### 6.8.2 Implementing a treatment plan

Once a treatment plan has been devised and prioritised, implementation should follow. Where there are major changes to a site, road section or area, these should be subjected to Road Safety Audit (see TRH 29, Volume 3).

# 7 Conducting economic appraisal

## 7.1 Objectives

The key objectives of economic appraisal are to ensure that treatments are cost-effective, and that they optimise road safety benefits producing the greatest reduction in fatal and serious injury based on available budgets. The term appraisal is used here to refer to the analysis of measures before they have been conducted. By contrast, the word evaluation is used to refer to the analysis of measures after implementation.

Economic appraisal approaches include CEA and BCA. BCA uses monetary values to compare total benefits with total costs of any given countermeasure indicating whether a project is worthwhile and to determine the applicability of an investment based on the total benefits and costs of the investment. It is also used to compare a project with any alternative projects, isolating and measuring the benefits and costs of each project.

The steps for conducting BCAs are outlined below.

- Project definition: identify the accident problem, define the target and outline treatment options.
- Define base case and project options.
- Determine parameters (e.g., treatment life, discount rate, time frame etc.).
- Identify and quantify all impacts (benefits and costs, in terms of treatment effectiveness i.e., the target number of accident reductions; implementation, maintenance and operation costs, social cost of accidents etc.).
- Convert all benefits and costs to present values (discounting).
- Calculate the benefit cost ratio and net present value.
- Sensitivity analysis.
- Report and present results.

## 7.2 Cost of accidents and remedial treatment options

### 7.2.1 Treatment options

The first step in the analysis is to identify the scale and nature of the road safety problem. This entails obtaining the number of observed accidents and injury types (e.g., fatal, serious, minor) over a specific period. The data forms the basis from which reductions in accident occurrence and severity, and thus benefits are estimated.

Countermeasure options generally differ in levels of expenditure and maintenance costs. Treatment options selected will depend on the direct impact on the identified accident problem. This involves selecting targeted remedial treatments that have been demonstrated to reduce the likelihood and/or severity of these accidents.

An assessment of the safety problems at a site may lead to recommendations for very low-cost engineering treatments, such as a few signs, or some added line marking, or chevron alignment markers around a curve.

If a very low-cost treatment is judged to be an effective course of action, there is little point conducting a full economic appraisal of it. It may well cost more in time and effort to justify the expenditure than to implement the treatment. It should simply be implemented as soon as possible, e.g., using a budget allocation for minor safety works or for maintenance. But keep in mind:

- Any very low-cost treatment must reduce the identified accident type(s).
- There is a limit to how effective very low-cost treatments can be; to treat most accident locations a significant expenditure of money will be required.
- The temptation to solve every problem by putting up a sign should be avoided (although it is also important to check existing signs are appropriate and well maintained).

### 7.2.2 Cost of Accidents

A key component of benefit cost analysis is the cost of accidents. The benefits from safety countermeasures over time are estimated by placing an economic value on accidents and applying this to the expected reduction in accidents (by injury or accident severity). This economic value, referred to as the social cost of accidents, is the value of property damage caused by vehicle accidents, medical and ambulance costs, insurance and administration costs, loss of output costs, police costs and human costs associated with the pain and suffering caused by death and injury.

For prioritising actions aimed at reducing accident frequency, a single average cost for all injury accidents is generally considered sufficient, particularly in view of the difficulty in predicting the specific severities of accidents that might be prevented.

The value of the accident reduction benefits is calculated using the standardised costs of the particular accident types.

## 7.3 Calculating the costs and benefits

### 7.3.1 Key parameters

The key parameters for estimating countermeasure benefits and costs include the countermeasure's treatment life, costs, benefits and the discount rate.

#### Treatment life

Project or treatment life refers to the period over which a treatment will deliver safety benefits before major rehabilitation or replacement is required. The treatment life varies with type and scope of project, climate causing infrastructure to deteriorate, traffic volume either causing infrastructure to deteriorate or growth causing congestion requiring changes to infrastructure, local standards and resource availability affecting ability to replace infrastructure when due and level and regularity of maintenance.

For projects involving multiple treatments e.g., network or national accident location programs, the service life applied is that of the longest-lived component. Accurate information on a countermeasure's life helps determine the allocation of funds to achieve the most cost-effective returns in terms of injury and accident reductions.

#### Costs

Total countermeasure costs include implementation (installation, material and labour costs), routine and periodic maintenance, and any operating costs (e.g., electricity supply).

There are different definitions of treatment costs with some texts defining costs as initial or upfront costs only and others treating costs as both initial and operating/maintenance costs. It is customary practice to include changes in maintenance expenditure on the costs side of the equation, as these are a cost (or saving) to the road agency. This section will treat ongoing/operating costs as negative entries in the benefits balance sheet. Whichever definition is chosen, it is important that it be applied consistently, because criteria based upon dividing one number (e.g., costs) into another (e.g., benefits) will produce different values depending upon the definition of costs and benefits. Funding programs or government agencies (e.g., treasury) often specify what must be included in costs.

#### Initial cost (e.g., engineering and capital)

Initial costs refer to the costs incurred up-front, as the project is designed and built (implementation costs) e.g., installation, material and labour costs for each countermeasure. The costs differ by road environment type, traffic volumes, local environment, local labour costs and availability of materials).

#### Annual maintenance and operating costs

These costs refer to routine and periodic maintenance costs and running costs. The level and regularity of maintenance and associated running costs depend on the countermeasure or in the case of multiple treatments, countermeasures.

#### Benefits

The benefits of a safety countermeasure principally comprise savings in road accident costs which are estimated to result from its implementation. They are due either to a reduction in the number or the severity of accidents. Other significant cost reductions or increases resulting from the treatment should also be included. Unlike the cost, which is usually incurred in one (or possibly two) years when the project is designed and built, the benefits are gained over the life of the project.

Benefits are expressed in terms of monetary savings from accident reductions or prevention of casualties (fatalities and injuries) over a given number of years. For example, in the case of accident location treatments, the estimate of resulting accident changes reflects the changes in target accidents (i.e., accident types of the treatment is aiming to prevent).

The accident changes can be presented as accident rates (e.g., per 100 million vehicle-kilometres of travel) or as changes in the number of casualty accidents. The use of accident rates as an estimate of accident changes depends on whether they reflect the number of accidents and accident severity and how they are measured. In some cases, the accident rate may not fully reflect the changes in accident severity. The effectiveness and magnitude of accident changes vary, for example by road environments, i.e., built-up (urban) and non-built-up (rural), and the existing accident severity and type.

Treatment effectiveness is measured by accident modification factors (AMFs). Different methods are used to obtain the numbers of accidents avoided and to estimate the treatment effectiveness. The estimate of treatment effectiveness depends on varied factors including data availability related to the past performance of the treatment, estimation method (i.e., whether confounding factors are taken into account), local conditions and changes in traffic volumes over time. In the case of multiple treatments, evaluation studies traditionally identify and measure the effectiveness of the primary or main treatment.

### 7.3.2 Discounting

In any economic appraisal, it is important to identify a given base year from which all future costs and benefits can be assessed. This is because the value of a dollar received in the future is less than the value of a dollar now (also referred to as the time value of money). Crucial to this process is the appraisal period, base year and discount rate.

### Appraisal period

The selection of an appraisal period has a critical impact on the value of benefits and costs. The potential economic/treatment life of the project should only be used as the appraisal period after careful consideration because traffic patterns, traffic management objectives, technology, etc. may all change over the whole economic life of the works.

For example, the period used for appraisal for road marking projects will usually be no greater than five years, while those for signing and road surface improvements will not exceed 10-years. For construction of new works, the appraisal period will generally be up to around 20-years, although in some circumstances (e.g., grade separation or curve realignment), the appraisal period may be far greater. Specialists in individual jurisdictions should be consulted regarding appraisal periods.

### Base year

The base year is the year to which all monetary values for the impacts (benefits and costs) of a treatment are discounted. The base year for small projects is usually the first year of implementation but varies from the year preceding construction to the year preceding operation or the last year of construction.

### Discount rate

The discount rate is used to convert future benefits and costs to present values. The appropriate discount rate for this form of economic appraisal is often a matter of some disagreement. Often, it is prescribed by another arm of government (a treasury or department of finance) in order to maintain consistency across different agencies.

The choice of discount rate can have significant effects on the desirability and selection of projects, especially where benefits and costs accrue later in the treatment's life. A higher discount rate reduces the value of benefits and costs occurring later in the treatment's life, favouring projects where benefits occur early in the project.

To calculate the present value, first compute the discount factor as in Equation 7-1.

$$\text{discount factor} = \frac{1}{(1+r)^t} \qquad (7\text{-}1)$$

where

r = discount rate

t = number of years from base year

The present value is therefore computed as the benefit or cost multiplied by the discount factor. The values are used to calculate an index which is used to assess the worth of the treatment, and later to rank it against other candidate projects for a works program.

### 7.3.3 Calculating costs and benefits

Selection criteria in benefit cost analysis include the first-year rate of return (FYRR), the internal rate of return (IRR), benefit cost ratio (BCR) and incremental benefit cost ratio (IBCR) as well as net present value (NPV). However, the two main indicators in assessing a project or treatment are the BCR and the NPV. They indicate whether the benefits of the proposed treatment outweigh the costs and if the preferred treatment has the greatest net social benefit.

#### Benefit cost ratio

Benefit cost ratio (BCR) is defined as the present value of benefits (net operating and maintenance costs) divided by the present value of implementation costs. It is used to rank projects where there is a budget constraint and serves as an indicator of a project's economic efficiency (Equation 7-2).

$$\text{BCR} = \frac{PV(B - OC)}{PV(IC)} \qquad (7\text{-}2)$$

where

$PV$ = present value
$B$ = all benefits
$OC$ = treatment operation and maintenance costs
$IC$ = treatment implementation costs

Source: ATC (2006).

A BCR greater than 1.0 indicates that the alternative is worthwhile, and the greater the BCR, the higher the benefits are. However, this says nothing about whether a project should be conducted. Although the approach can determine whether a project is worthwhile, ranking according to BCR will not necessarily maximise reduction in fatal and serous accident outcomes. BCR tends to provide more favourable outcomes to low-cost treatments, which may be less effective in terms of fatal and serious casualty reduction. For example, installation of warning signs, although providing a high BCR tend to reduce fatal and serious accident outcomes only marginally. For this reason, it is recommended that BCR not be used on its own when prioritising options, but rather NPV also be used.

#### Net present value

Net present value (NPV) is the difference between the discounted (present value) monetary value of all the benefits and costs of a particular project or measure. A treatment with a positive NPV can be regarded as economically worthwhile, i.e., the community is better off to undertake it than not. A positive NPV therefore indicates an improvement in economic efficiency compared with the base case.

The NPV is expressed as (Equation 7-3).

$$NPV = \sum_{t=0}^{n} \frac{(B_t - OC_t - IC_t)}{(1+r)^t} \quad (7\text{-}3)$$

where

r = discount rate
t = time in years
$n$ = number of years during which benefits and costs occur
$B_t$ = benefits in year $t$
$OC_t$ = operating and maintenance costs in year $t$
$IC_t$ = implementation costs in year $t$

Source: ATC 2006.

The major methodological advantage of the NPV method compared with the BCR method is that it provides a consistent, simple comparison of alternatives and is unaffected by interpretations or errors in deciding what is a cost or a benefit. Moreover, the NPV method is applicable where there is a budget constraint.

### Conduct sensitivity tests

An economic appraisal should always be subjected to a sensitivity test. This is a test to determine how sensitive the results are to changes in the assumptions made about the values of variables.

In particular, a range of expected accident reduction percentages should be assessed, since one can never be certain about what the actual outcome will be (see Section 6.6 and 6.7). Using a low and a high estimate of possible and realistic outcomes is always good practice. If the outcome is favourable, even when a pessimistic forecast of accident reduction is used, one can be confident that the project is worthwhile. Conversely, if the outcome is unfavourable even with optimistic assumptions, one can be confident that the project is unlikely to be worthwhile.

It is in the middle ground (favourable under optimistic assumptions and unfavourable under pessimistic assumptions) where effort should be put into refining the estimates of assumed values to get a better forecast of benefits and costs.

## 7.4 Ranking the treatment of accident locations

Once each countermeasure has been subjected to an economic appraisal, all the candidate projects need to be ranked to decide which one to implement. Usually this means comparing all projects' NPVs or BCRs. The key objective is to provide the greatest benefit (reduction in fatal and serious accident outcomes) for the available budget. The economic appraisal is an aid to decision making. If all decisions are based on benefit/cost ratios alone, a situation can arise where, for example:

- a project is delayed until the number (cost) of accidents is sufficient to justify the project, even though at the time it is delayed it can be reasonably predicted that the rate of accidents will continue unabated
- the cost of a treatment is artificially restricted, and it does not include sufficient improvements to address the accident problems.

Consequently, the ranking procedures described in this section should not preclude decision makers from applying sound judgement to approve projects which need to be advanced, or which need adequate funding to achieve project objectives.

The choice of selection/ranking criteria depends primarily on available data as well as the scope of the treatment. The NPV provides information on the total welfare gain over a project's treatment life while the BCR highlights the relationship between the present value benefits and implementation costs of a project.

The NPV method is applicable where there is a budget constraint, and the aim is to select the most worthwhile set of projects. In this case, the solution is to 'combine those projects whose total initial costs are less than or equal to the budget constraint but whose combined total net value is the largest'.

**The benefit/cost ratio itself must not be used to rank alternatives.** Rather, ranking involves a comparison of all alternatives with a BCR > 1. Generally, the NPV is the preferred criterion as it provides an estimate of the absolute size of the treatment's net social benefit.

An alternative approach is to apply the goals achievement approach, whereby projects are ranked but no attempt is made to assess their economic benefits against their costs.

**A useful checklist**

With economic appraisal of proposals increasingly required for road safety engineering projects, here is a useful checklist, particularly in conjunction with sensitivity testing:

- identify the project costs in terms of capital, maintenance and operating costs
- select an appraisal period
- choose a discount rate
- define the effects on various accident types

- differentiate between the effects of this treatment on (i) accident frequency (numbers) and (ii) casualty outcomes (severities)
- use robust data to estimate the effects of this treatment on the frequency of accident types
- identify the accident type or types in which this treatment is likely to have its greatest effect on the casualty outcome
- identify other accident types in which this treatment may have some effect on the casualty outcome.

## 7.5 Presenting the results

Having conducted the economic appraisal, present the results in a form which allows the decision maker to review the values for net present worth of benefits and costs and the values of the selected relevant variables. Tabular or graphical presentations, highlighting the economic benefits, the accident savings and the expected performance against accident reduction targets can be helpful in explaining the results of the appraisal.

## 7.6 Applying to routes, areas and mass actions

### Routes and areas

Where a route or area-wide action is being considered, the route or area should be divided into individual components (usually by individual devices) and the benefits and costs calculated separately. The costs and benefits can then be aggregated over the entire scheme to arrive at the net present value or benefit/cost ratio. In some instances, separate NPVs or BCRs can be calculated for individual components of the scheme where it is considered that these components could be installed as stand-alone treatments. Care needs to be taken that this does not result in a route or area having a series of inconsistent layouts or treatments after only the high BCR sites are treated.

### Mass actions

For a mass action scheme, the NPV or BCR should be calculated for the scheme. Mass actions are implemented on the basis that individual sites may not have an accident problem, but collectively the type of road feature is known to have a worrying incidence of accidents. It is thus not correct to calculate the BCRs separately for each site or for those sites having the greatest numbers of accidents.

## 7.7 Post-completion evaluation

Post-completion evaluations are carried out after the project has been implemented. They assess the project's performance against the stated objectives and identify future improvements. They also provide feedback on the efficiency of implementation, the effectiveness of the measure, feedback on the project evaluation process, lessons learnt and indicate whether the investment was worthwhile.

The timing of post-completion evaluations should allow for the project effects to settle, meaning they should not be in the preliminary stages of project implementation. The main component of post completion evaluations involves comparing the observed before and after accident rates and comparing these to the forecast preventable accidents (or accident modification factors where these were available) to determine if the forecast effectiveness was realised.

## 7.8 Alternatives to benefit cost approach

### The goals achievement approach to project appraisal

The ‘goals achievement’ approach is an alternative to the economic appraisal method discussed above. It aims to show the extent to which alternative proposals achieve a range of pre-set goals. The goals may be both quantifiable (e.g., economic) and non-quantifiable (e.g., social and environmental). The purpose of this evaluation is to present the decision maker with information about the consequences of alternative courses of action.

The approach involves the development of a table which shows the extent to which each alternative achieves the prescribed goals or objectives. Typically, the presentation is in the form of a table where measures which are to be used to assess the various goals are provided as rows. These measures (called criteria, or measures of effectiveness) may include safety related factors, economic factors, accessibility issues, environmental factors, or other issues of interest. The values for each of these measures are presented as columns of values for alternative project options. Alternatively, a matrix approach can be used with the purpose of determining the extent to which each alternative will meet objectives. A simple assessment scale can be used to determine whether the alternative contributes towards goal achievement (+), whether it detracts from it (–) or has no effect (0).

### Cost-effectiveness analysis

Cost effectiveness analysis (CEA) involves comparing the cost of a proposed countermeasure with the effect it produces (see Equation 7-4). Within CEA, projects are ranked and screened according to their cost and effectiveness in improving road safety or achieving policy objectives. Effects are expressed in non-monetised units, e.g., the change in the number of fatal and serious injuries. CEA is mainly applied when comparing alternative projects, programs and policies with a similar outcome. The cost-effectiveness is expressed as the cost-effectiveness ratio (CER).

$$\text{Cost-effectiveness ratio} = \frac{number\ of\ crashes\ prevented}{cost\ of\ measure} \qquad (7\text{-}4)$$

The cost-effectiveness approach to decision making is concerned with determining the extent to which each of a number of alternatives contributes to the attainment of prescribed objectives. It is most applicable where there is a fixed budget, and the aim is to achieve maximum results from that expenditure and where there is a specified objective, and the aim is to determine the cheapest way of achieving it.

This approach and all other goals assessment techniques differ from other economic appraisal techniques in that they say nothing about how worthwhile the objective is: there is no measure of worth or value about the objectives or the results of the analysis. Therefore, the cost-effectiveness approach has relevance to road safety project appraisal only to the extent that it assists in screening and ranking alternatives which are essentially similar in nature, and which can be assessed with respect to a single objective, such as reduction in the number of fatal and serious casualties.

For example, if a road authority has a simply expressed goal of reducing the number of fatal and serious casualties in total, then the economic benefits or other impacts of remedial schemes are essentially irrelevant to that goal. A cost-effectiveness approach which simply lists the expected accident reduction from each of various competing schemes would therefore be appropriate to that goal, as it would indicate to the decision maker the set of treatments which are expected to have the maximum potential to reduce accident frequency.

#### FSI casualty equivalents approach

An approach used in some other countries is the cost per FSI saved. Further development on this is ‘FSI casualty equivalents’ representing the average number of people that are killed or seriously injured for every reported injury accident. FSI factors are calculated for intersections and midblock locations for a range of different accident types. The FSI-factors take into account the relationships between speed environment, road- and accident type and are founded on knowledge that the change in these factors affects the severity of accident outcomes.

The FSI casualty equivalents are applied to each reported injury accident to estimate the number of people that can be expected to be killed or seriously injured if current accident trends continue. The FSI casualty equivalents method acknowledges that actual fatal and serious accident data alone is not a good indicator of the underlying risk of a high-severity accident at many locations. The FSI casualty equivalents method allows parts of the road network with moderate accident numbers to be identified as high-risk if the type of accidents occurring are indicative of a high probability that the next occurrence will be of high severity.

This approach is very consistent with the key Safe System focus of maximising the reduction in these severe accident types. A quick guide to conducting such an evaluation suggests the following steps:

- identify treatment options
- calculate treatment costs for each of these options

- determine the value of each FSI saved[4]
- convert the annual savings to present value of the whole-of-life of a project with long-term benefits[5]
- use this value to calculate FSI saved per amount (say R100 million) invested
- projects with the highest FSI saved per R100 million spent would produce the best Safe System outcomes.

This approach, however, is very dependent on reliable data on casualty accidents.

# 8 Monitoring and evaluation

## 8.1 Purpose

Monitoring is the systematic collection of data about the performance of road safety treatments after their implementation. Evaluation is the statistical analysis of that data to assess the extent to which the treatment (or a wider treatment program) has met accident reduction objectives.

Post-implementation monitoring is essential to ascertain the positive and negative effects of a treatment and thus improve the accuracy and confidence of predictions of that treatment's effectiveness in subsequent applications. There is a duty to ensure that the public does not experience additional hazards because of treatments and this duty carries with it an implied need to monitor what happens when a scheme is introduced.

The purposes of monitoring a treatment are to:

- assess what changes have occurred in accident occurrence and whether safety objectives have been met
- assess the treatment's impact on the distribution of traffic and the speeds of motor vehicles
- call attention to any unintended effects on traffic movements or accident occurrence
- assess the effects of the treatment on the local environment

[4] This 'FSI saved' value will be different for different projects, e.g., intersection projects, road mid-block projects, etc. However, such a value determination is dependent on whether the differentiation among these various project types would be possible in the available accident and accident cost data. Currently, it is not and an average cost per FSI of approximately R2.2 million, based on the RTMC unit costs of accidents (RTMC, 2016), CPI adjusted for 2018, could be applied across all types of projects as an interim measure.

[5] A rough calculation is to multiply the annual savings by 11 for a project whole-of-life of 20 years at a discount rate of 6 per cent.

- learn of the public's response to the treatment: its acceptability in general and any concerns about safety.

There are three important tasks to monitoring and evaluation:

1. Pay careful attention to a site immediately after treatment in case things go terribly wrong.
2. Assess the effects over a longer time period, say three years, to attempt to determine the influence of the treatment on accidents or other performance measures. This requires careful statistical analysis, correcting for external factors (Section 8.2.1) and bearing in mind that accident frequencies may be so low that any observed changes in accidents may not be statistically significant.
3. Focus, over this longer time period, upon the accident types which the treatment was intended to correct and assess whether these have declined.

Monitoring and evaluation are only meaningful if there has been a clear statement of the objectives of the treatment, a prediction of its effects and a logical link between the treatment and its effects. Monitoring reinforces the rigour that should apply to all accident investigation and prevention work. It is important to plan for monitoring and evaluation before a treatment is implemented, to ensure that adequate data is collected, and objectives are set.

Performance indicators may relate not only to accidents, but also to other changes which may follow the treatment. There are suggestions that road safety schemes potentially affect the following parameters and so some or all of them may need to be monitored:

- the number and type of accidents
- the severity of accidents
- the distribution of accidents over the road network
- traffic flows and travel times
- turning movements and delays at intersections
- access times and distances within residential areas
- routes taken by motorists, cyclists and pedestrians
- operations of buses and heavy vehicles.

A comprehensive monitoring exercise should ideally include all these effects, since without a knowledge of what has happened to (say) traffic volumes, information about what has happened to accidents may be misleading or meaningless. Consideration should also be given to changing road environments (e.g., new commercial activity) and accident migration, particularly where there have been changes in traffic flows.

Because accidents are comparatively rare events, it may take an exceptionally long time for a statistically reliable sample to accrue. This can be partially overcome using proxy measures such as traffic conflicts or indirect measures such as media monitoring, insurance company claims records, emergency service records (e.g., ambulance, hospital admissions) or tow truck records if they are available for before and after periods.

Historically, resources devoted to monitoring in most road authorities are limited. The inclination is to direct resources into the development and implementation of schemes which have been prioritised and shown to have a potential for accident reduction, rather than into monitoring exercises. Therefore, it needs to be acknowledged that, without widespread evaluation, understanding of the safety effectiveness of road safety engineering treatments (and other road safety measures for that matter) will remain limited. Hauer (1988) emphasised that 'The level of safety built into roads is largely unpremeditated. Standards and practices have evolved without a foundation of knowledge. At times, the safety consequences of engineering decisions are not known, at others some knowledge exists but is not used.'

## 8.2 Monitoring and evaluation methods

The essence of monitoring is to measure what is happening in the real world and then, in an evaluation phase, to attempt to compare that with what is expected would have happened if the treatment had not been introduced. There are several experimental design challenges when this is attempted[6]. It is necessary to take the numerous factors explicitly into account in the evaluation of road safety treatments or programs. This can be done by:

- before and after studies, and
- comparisons using control sites.

### 8.2.1 Statistical analysis

Statistical analysis is required to evaluate the effectiveness of accident location treatments. These guidelines commenced by defining an accident location (or accident location) as a location where a limited range of accident types occurs repeatedly, suggesting that there are common causes, rather than the accidents being the result of mere chance. In evaluating the effectiveness of an individual accident location treatment or a treatment program, the aim is to establish whether a drop in the number of accidents should be attributed to the treatment or to chance alone.

Statistical analysis is a complex though important subject. It is beyond the scope of this TRH 29. The best available reference is Council et al. (1980). Others are OECD (1981) and Miller (1983). The topic is also discussed in Ogden (1996) and RoSPA (2002) which both include worked examples. Bear in mind that the extent and

[6] The Austroads Guide to Road Safety, Part 2: Safe Roads is a good resource to consult (Austroads, 2021).

accuracy of data which are available to the practitioner are such that sophisticated analyses are not possible.

The three main applications of statistical testing in the road safety engineering area are:

- comparison of accident frequencies, for which a chi-squared test is suitable, or a paired t-test if the distribution of accidents can be assumed to follow a normal distribution
- comparison of accident rates, for which a paired t-test is suitable
- comparison of proportions, for which a z-test is suitable.

In all statistical analysis of accident reductions, the 95% confidence level should be applied (i.e., an effect should not be claimed as statistically significant unless it is achieved at this confidence level).

If a more comprehensive analysis is to be conducted and the data exist to support it, there is a wide range of statistical techniques which can be brought to bear.

## 8.3 Issues for consideration

### 8.3.1 Planning before treatment for monitoring afterwards

Monitoring and evaluation are tasks which typically occur after a remedial treatment is implemented. As they involve a comparison of circumstances before and after treatment, it is essential that monitoring is considered at this early stage. What data should be collected now (before) and over what period about the performance of the particular road location so that meaningful and valid comparisons may be made with data collected after treatment has occurred? The period of review is important to ensure that the data considered is representative.

Performance indicators which will need to be monitored and measured may relate not only to accidents, but also to other changes which may follow the treatment.

A comprehensive monitoring exercise should ideally include all these effects, since without a knowledge of what has happened to (say) traffic volumes, information about what has happened to accidents may be misleading or meaningless.

### 8.3.2 Threats to the validity of evaluation

There are some factors outside the time period or location being assessed which may affect the calculations of treatment effectiveness at the location. To ensure that the findings of an evaluation are valid, these effects need to be accounted for. Not accounting for each of these factors will have the effect of increasing the calculated value of gains from an accident location treatment program, with the consequence that invalid conclusions may be drawn.

#### Changes in traffic flows

Accident rates can be affected by changes in traffic flows, with increases occurring with greater flows, and reducing with diminished flows. These changes may result directly from the treatment, or for reasons unrelated to the treatment. These increases or decreases may not happen in a linear manner.

### General trends in the number of accidents

Consideration should be given to general trends in accidents. For example, there may be a general trend of reduced numbers of accidents in the region due to general factors such as safer cars, legislative changes, general road improvements or rising fuel prices. These general changes can be accounted for by inclusion of similar 'control' sites.

### Regression-to-the-mean

Over a period of years, if there are no changes in the physical or traffic characteristics at a site, accidents at that site per unit of time (e.g., annually) will tend to fluctuate (due to the random nature of accident occurrence) about a mean value. Because sites are commonly selected for treatment based on their ranking in numbers of accidents compared with all other sites, there is a high possibility that sites will be chosen when their accident count is higher than the long-term average. In this case, even without treatment, the accident rate at these sites is likely to reduce (i.e., it will regress to the mean) in the following year.

This aspect of accident experience is a matter of concern in the post-implementation evaluation of a safety treatment because, to the extent that the phenomenon is present, the impact of the treatment will be exaggerated. This is thus a matter that will require particular attention together with issues about accounting for this random variation (the nature of the beast) as well as estimating the true underlying accident rate.

### Other possible methodological issues

There is a reasonable degree of acceptance that the above factors should be accounted for when conducting evaluations of accident location treatments. In addition, there are other factors, about which there is no conclusive evidence and for which there is no general acceptance. The effect of accounting for each of these factors (were they to be shown to be real) would be to diminish the value of gains from accident location treatment programs. The two factors are accident migration and risk compensation, and they are included here to provide an understanding of the terms.

### Accident migration

The hypothesis with accident migration is that accidents may increase at sites surrounding the treated site due to changes in trip patterns or changes in drivers' assessment of risk. There is some evidence that the phenomenon exists, but none regarding the degree to which it has an effect.

Boyle and Wright (1984) found in a sample of sites in London that accidents at the treated sites fell by 22% but accidents in the surrounding streets increased by 10%. Their work did not account for regression-to-the-mean and Maher (1987) has suggested that accident migration is generated by a combination of regression-to-the-mean downward of the high accident numbers at the treated sites and regression-to-the-mean upward of the low accident numbers at the surrounding sites. Indeed, Maher (1987) showed that using adjacent or nearby sites as control sites leads to bias in the evaluation results.

This raises the issue of driver expectation and the need to provide drivers with consistent treatment of similar situations: when treating a location, it is important to consider what drivers might expect at other similar locations further along the road. If the physical arrangement at those other locations is incapable of matching their expectations, then some form of treatment at those locations should be considered.

Not all the effects hypothesised as being due to accident migration can be explained in terms of regression-to-the-mean, but at this stage any review of accident risk migration would require significant investment. There are several treatments where accident migration may occur, particularly as a result of changes in traffic volume. It makes intuitive sense that the installation of a treatment that changes traffic flow may have an influence on safety, although this effect could be negative, neutral or positive. As an example, if traffic calming is installed on a local road, some through traffic will be deterred from using this route. If traffic is redirected to a higher quality road, the net effect on safety might be an improvement. However, if traffic now uses an alternative route that is less safe than the route originally taken, then the net effect on safety may be negative.

#### Risk compensation

Risk compensation theory postulates that at any given time there will be a level of risk that an individual will tolerate or seek. If a safety measure reduces the potential for harm in one way, a person will compensate for that by increasing risk in another way, such as:

- a motorist provided with an enhanced braking system might use the benefit to drive faster or brake later, resulting in accidents of higher severity
- a motorist wearing a seat belt might feel safer and drive in a manner which places pedestrians more in danger.

In the area of road safety, risk compensation theory postulates that safety benefits tend to be consumed as performance benefits, risk is redistributed to other locations (accident migration) and risk is redistributed to more vulnerable groups of road users.

Risk can be described as either objective risk (as measured for example in accident studies) or as perceived or subjective risk (which is what affects behaviour). It is only where a treatment results in a reduction in both objective and subjective risk that risk compensation would, logically, become a factor, since in other cases there is either no change in the subjective risk, or an increase in it (a treatment would not be implemented which lowered subjective risk without also lowering objective risk). However, provided that the reduction in objective risk is at least as great as the reduction in subjective risk, the treatment will still produce a positive outcome (Rumar, 1982). Wong and Nicholson (1992) for example, found that while vehicle speeds increased after an improvement in road alignment, the levels of side friction demanded by drivers declined significantly, indicating that the level of safety had indeed been increased by the realignment. They stated that the ultimate test of the effect of the realignment is whether the actual margin of safety has improved, and the results of this study show clearly that it has. What risk compensation, if any, has occurred has been insufficient to completely undermine the intended goal of the realignments, namely a reduction in the likelihood of accidents at the curves.

This carries with it the implication that any road design change which reduces the subjective risk should also reduce objective risk to at least the same extent, otherwise the road user will tend to respond inappropriately. In particular, care should be taken in situations where sight distance is increased, since this will possibly lead to an increase in approach speeds. If the geometry and/or traffic control at the site does not support these higher speeds, it is possible that the situation could become more, not less, hazardous. To put it in the words used above, the subjective risk has been reduced to a greater extent than the objective risk.

# 9 Structuring an accident location investigation report

The documentation prepared in earlier sections needs to be drawn together into a report which sets out the accident patterns, their causes and proposed solutions. If the documentation has not yet commenced, the following is a report structure which covers the topics to include:

**Cover**

- title such as ‘accident location investigation and treatment’ or, if it embraces a wider investigation, ‘accident location investigation and road safety audit’ or other appropriate combination
- a brief description of where the location is (e.g., street name, local authority area, kilometre marker post, GPS and map references)
- the organisation for whom the investigation is being conducted and a list of the investigation team members and affiliations
- the name of the organisation in charge of the study
- the date of the report (month and year).

**Introduction**

- the organisation for whom the investigation is being conducted and a list of the investigation team members and affiliations
- a detailed description of where the location is (e.g., street name, local authority area, kilometre post, GPS and map references)

- an aerial view of the accident location (e.g., from Google Earth), showing the location and direction of photos
- reference to any previous accident reports and their outcomes
- a description of the location (e.g., road geometry, environment, speed limit, volumes), including roadworks (if any) within the period of accidents being analysed.

Data analysis

- an accident listing (showing the basic details of each accident):
  - location, distance
  - time
  - day of week
  - date (day, month, year)
  - accident type
  - direction of approach of Vehicle 1
  - severity
  - road surface (wet/dry)
  - light condition (light/dark/dusk or dawn)
  - traffic control.
- a summary, for all accidents, of characteristics not in the factor matrix, e.g.:
  - total number of reported accidents and severities
  - year of the accident
  - period of week (i.e., weekday or weekend).
- the estimated cost of accidents for each separate accident type grouping in a table
- a factor matrix showing the number of accidents by the following factors:
  - accident type
  - direction of approach of Vehicle 1
  - vehicle types involved
  - road surface (wet/dry)
  - light condition (light/dark/dusk or dawn)
  - any other common factors identified (alcohol, fatigue, roadside objects, driver age etc.)
- an accident diagram, together with a copy of the accident type table being used
- a summary of common factors in the accidents, deduced from the above
- measures previously implemented and their effectiveness.

Contributing accident factors – deduced from the data analysis and site inspection

- conclusions about the road environment factors which have contributed to the particular accident groups for which there are common factors. These are the accident causes which are addressed in the next section.

These factors could be structured based on the Safe System pillars to focus investigation and analysis

- any identified vehicle or human behaviour factors.

Accident countermeasures

- a list of the proposed treatments which are designed to counter the identified accident causes (with mention made about which treatment is aimed at which problem). These treatments could be structured based on the Safe System pillars
- other safety problems warranting treatment: a section about minor items identified on-site which can be improved by very low-cost measures
- a plan of the preliminary design of the countermeasures
- this section may put forward two options with different costs and different effects on accident reduction.

Economic appraisal

- the cost of the accidents by accident type
- the effect on accident types expected (e.g., using AMFs) and the consequent benefits in accident reduction. This should be clearly tabulated, so that evaluation can take place at a later date
- other benefits
- the cost of design and construction of the proposed treatment
- the net present value and benefit/cost ratio.

Appendices

- photographs of the site, relevant to the accident factors.

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# Appendix V1-A: Example of accident and fatality rate by type of road

Example: Oregon State Highway System accident rates by urban and rural areas and functional classification (Dixon, 2011; updated to 2019 from https://www.oregon.gov/odot/Data/Documents/Crash_Rate_Tables_2019.pdf)

2019 Crash Rates by Jurisdiction and Functional Classification

| JURISDICTION AND FUNCTIONAL CLASSIFICATION | MILES | ANNUAL VEHICLE MILES | CRASHES | FATALITIES | CRASH RATE* | FATALITY RATE* |
|---|---|---|---|---|---|---|
| **TOTAL STATE HWY SYSTEM** | **7,373.61** | **21,862,221,048** | **20,539** | **261** | **0.94** | **1.19** |
| Interstate Freeways | 729.57 | 9,877,209,520 | 4,661 | 33 | 0.47 | 0.33 |
| Other Fwys/Expressways | 66.88 | 1,511,635,455 | 1,217 | 6 | 0.81 | 0.40 |
| Non-Freeways (combined) | 6,577.16 | 10,473,376,073 | 14,661 | 222 | 1.40 | 2.12 |
| Other Principal Arterials | 3,255.81 | 8,100,905,714 | 11,349 | 154 | 1.40 | 1.90 |
| Minor Arterials | 1,963.64 | 1,989,245,556 | 2,795 | 53 | 1.41 | 2.66 |
| Urban Collectors | 48.03 | 61,427,165 | 104 | 1 | 1.69 | 1.63 |
| Rural Major Collectors | 1,272.76 | 319,159,983 | 405 | 13 | 1.27 | 4.07 |
| Rural Minor Collectors | 34.03 | 2,521,475 | 8 | 1 | 3.17 | 39.66 |
| Rural Local | 2.89 | 116,180 | 0 | 0 | 0.00 | 0.00 |
| **URBAN HWY SYSTEM** | **1,143.23** | **11,836,280,775** | **13,663** | **102** | **1.15** | **0.86** |
| Interstate Freeways | 234.35 | 5,789,730,010 | 3,229 | 20 | 0.56 | 0.35 |
| Other Fwys/Expressways | 66.88 | 1,511,635,455 | 1,217 | 6 | 0.81 | 0.40 |
| Non-Freeways (combined) | 842.00 | 4,534,915,310 | 9,217 | 76 | 2.03 | 1.68 |
| Other Principal Arterials | 614.77 | 3,888,206,811 | 7,975 | 67 | 2.05 | 1.72 |
| Minor Arterials | 179.20 | 585,281,334 | 1,138 | 8 | 1.94 | 1.37 |
| Urban Collectors | 48.03 | 61,427,165 | 104 | 1 | 1.69 | 1.63 |
| **Urban Cities** | **628.51** | **7,785,042,552** | **10,582** | **50** | **1.36** | **0.64** |
| Interstate Freeways | 116.60 | 3,623,086,725 | 2,416 | 13 | 0.67 | 0.36 |
| Other Fwys/Expressways | 53.84 | 1,367,307,520 | 1,097 | 4 | 0.80 | 0.29 |
| Non-Freeways (combined) | 458.07 | 2,794,648,307 | 7,069 | 33 | 2.53 | 1.18 |
| Other Principal Arterials | 363.69 | 2,473,700,776 | 6,247 | 30 | 2.53 | 1.21 |
| Minor Arterials | 74.81 | 288,582,433 | 758 | 2 | 2.63 | 0.69 |
| Urban Collectors | 19.57 | 32,365,098 | 64 | 1 | 1.98 | 3.09 |
| **Urban Fringe** | **514.72** | **4,051,238,223** | **3,081** | **52** | **0.76** | **1.28** |
| Interstate Freeways | 117.75 | 2,166,643,285 | 813 | 7 | 0.38 | 0.32 |
| Other Fwys/Expressways | 13.04 | 144,327,935 | 120 | 2 | 0.83 | 1.39 |
| Non-Freeways (combined) | 383.93 | 1,740,267,003 | 2,148 | 43 | 1.23 | 2.47 |
| Other Principal Arterials | 251.08 | 1,414,506,035 | 1,728 | 37 | 1.22 | 2.62 |
| Minor Arterials | 104.39 | 296,698,901 | 380 | 6 | 1.28 | 2.02 |
| Urban Collectors | 28.46 | 29,062,067 | 40 | 0 | 1.38 | 0.00 |
| **RURAL HWY SYSTEM** | **6,230.38** | **10,025,940,273** | **6,876** | **159** | **0.69** | **1.59** |
| Interstate Freeways | 495.22 | 4,087,479,510 | 1,432 | 13 | 0.35 | 0.32 |
| Non-Freeways (combined) | 5,735.16 | 5,938,460,763 | 5,444 | 146 | 0.92 | 2.46 |
| Other Principal Arterials | 2,641.04 | 4,212,698,903 | 3,374 | 87 | 0.80 | 2.07 |
| Minor Arterials | 1,784.44 | 1,403,964,222 | 1,657 | 45 | 1.18 | 3.21 |
| Rural Major Collectors | 1,272.76 | 319,159,983 | 405 | 13 | 1.27 | 4.07 |
| Rural Minor Collectors | 34.03 | 2,521,475 | 8 | 1 | 3.17 | 39.66 |
| Rural Local | 2.89 | 116,180 | 0 | 0 | 0.00 | 0.00 |
| **Rural Cities** | **166.93** | **318,628,355** | **367** | **2** | **1.15** | **0.63** |
| Interstate Freeways | 11.63 | 83,928,830 | 23 | 0 | 0.27 | 0.00 |
| Non-Freeways (combined) | 155.30 | 234,699,525 | 344 | 2 | 1.47 | 0.85 |
| Other Principal Arterials | 89.43 | 172,135,832 | 233 | 2 | 1.35 | 1.16 |
| Minor Arterials | 39.93 | 52,893,767 | 93 | 0 | 1.76 | 0.00 |
| Rural Major Collectors | 25.65 | 9,615,541 | 18 | 0 | 1.87 | 0.00 |
| Rural Minor Collectors | 0.29 | 54,385 | 0 | 0 | 0.00 | 0.00 |
| **Rural Areas** | **6,063.45** | **9,707,311,918** | **6,509** | **157** | **0.67** | **1.62** |
| Interstate Freeways | 483.59 | 4,003,550,680 | 1,409 | 13 | 0.35 | 0.32 |
| Non-Freeways (combined) | 5,579.86 | 5,703,761,238 | 5,100 | 144 | 0.89 | 2.52 |
| Other Principal Arterials | 2,551.61 | 4,040,563,071 | 3,141 | 85 | 0.78 | 2.10 |
| Minor Arterials | 1,744.51 | 1,351,070,455 | 1,564 | 45 | 1.16 | 3.33 |
| Rural Major Collectors | 1,247.11 | 309,544,442 | 387 | 13 | 1.25 | 4.20 |
| Rural Minor Collectors | 33.74 | 2,467,090 | 8 | 1 | 3.24 | 40.53 |
| Rural Local | 2.89 | 116,180 | 0 | 0 | 0.00 | 0.00 |

**Crash Rate Formula: (crashes*1,000,000)/VMT; Fatality Rate Formula: (fatalities*100,000,000)/VMT*

2019 Fatal & Serious Injury Highway Crash Rates and Casualty Rates

| JURISDICTION AND FUNCTIONAL CLASSIFICATION | MILES* | ANNUAL VEHICLE MILES* | FATAL & SERIOUS INJURY (INJ-A) CRASHES* | DEATHS AND SERIOUS INJURIES* | FATAL& INJ-A CRASH RATE** | FATAL & INJ-A CASUALTY RATE** |
|---|---|---|---|---|---|---|
| **TOTAL STATE HWY SYSTEM** | **7,373.61** | **21,862,221,048** | **989** | **1,141** | **4.52** | **5.22** |
| Interstate Freeways | 729.57 | 9,877,209,520 | 142 | 159 | 1.44 | 1.61 |
| Other Fwys/Expressways | 66.88 | 1,511,635,455 | 26 | 30 | 1.72 | 1.98 |
| Non-Freeways (combined) | 6,577.16 | 10,473,376,073 | 821 | 952 | 7.84 | 9.09 |
| Other Principal Arterials | 3,255.81 | 8,100,905,714 | 589 | 676 | 7.27 | 8.34 |
| Minor Arterials | 1,963.64 | 1,989,245,556 | 185 | 223 | 9.30 | 11.21 |
| Urban Collectors | 48.03 | 61,427,165 | 5 | 6 | 8.14 | 9.77 |
| Rural Major Collectors | 1,272.76 | 319,159,983 | 39 | 44 | 12.22 | 13.79 |
| Rural Minor Collectors | 34.03 | 2,521,475 | 3 | 3 | 118.98 | 118.98 |
| Rural Local | 2.89 | 116,180 | 0 | 0 | 0.00 | 0.00 |
| **URBAN HWY SYSTEM** | **1,143.23** | **11,836,280,775** | **473** | **528** | **4.00** | **4.46** |
| Interstate Freeways | 234.35 | 5,789,730,010 | 82 | 91 | 1.42 | 1.57 |
| Other Fwys/Expressways | 66.88 | 1,511,635,455 | 26 | 30 | 1.72 | 1.98 |
| Non-Freeways (combined) | 842.00 | 4,534,915,310 | 365 | 407 | 8.05 | 8.97 |
| Other Principal Arterials | 614.77 | 3,888,206,811 | 311 | 342 | 8.00 | 8.80 |
| Minor Arterials | 179.20 | 585,281,334 | 49 | 59 | 8.37 | 10.08 |
| Urban Collectors | 48.03 | 61,427,165 | 5 | 6 | 8.14 | 9.77 |
| **Urban Cities** | **628.51** | **7,785,042,552** | **284** | **314** | **3.65** | **4.03** |
| Interstate Freeways | 116.60 | 3,623,086,725 | 51 | 58 | 1.41 | 1.60 |
| Other Fwys/Expressways | 53.84 | 1,367,307,520 | 23 | 26 | 1.68 | 1.90 |
| Non-Freeways (combined) | 458.07 | 2,794,648,307 | 210 | 230 | 7.51 | 8.23 |
| Other Principal Arterials | 363.69 | 2,473,700,776 | 183 | 198 | 7.40 | 8.00 |
| Minor Arterials | 74.81 | 288,582,433 | 24 | 29 | 8.32 | 10.05 |
| Urban Collectors | 19.57 | 32,365,098 | 3 | 3 | 9.27 | 9.27 |
| **Urban Fringe** | **514.72** | **4,051,238,223** | **189** | **214** | **4.67** | **5.28** |
| Interstate Freeways | 117.75 | 2,166,643,285 | 31 | 33 | 1.43 | 1.52 |
| Other Fwys/Expressways | 13.04 | 144,327,935 | 3 | 4 | 2.08 | 2.77 |
| Non-Freeways (combined) | 383.93 | 1,740,267,003 | 155 | 177 | 8.91 | 10.17 |
| Other Principal Arterials | 251.08 | 1,414,506,035 | 128 | 144 | 9.05 | 10.18 |
| Minor Arterials | 104.39 | 296,698,901 | 25 | 30 | 8.43 | 10.11 |
| Urban Collectors | 28.46 | 29,062,067 | 2 | 3 | 6.88 | 10.32 |
| **RURAL HWY SYSTEM** | **6,230.38** | **10,025,940,273** | **516** | **613** | **5.15** | **6.11** |
| Interstate Freeways | 495.22 | 4,087,479,510 | 60 | 68 | 1.47 | 1.66 |
| Non-Freeways (combined) | 5,735.16 | 5,938,460,763 | 456 | 545 | 7.68 | 9.18 |
| Other Principal Arterials | 2,641.04 | 4,212,698,903 | 278 | 334 | 6.60 | 7.93 |
| Minor Arterials | 1,784.44 | 1,403,964,222 | 136 | 164 | 9.69 | 11.68 |
| Rural Major Collectors | 1,272.76 | 319,159,983 | 39 | 44 | 12.22 | 13.79 |
| Rural Minor Collectors | 34.03 | 2,521,475 | 3 | 3 | 118.98 | 118.98 |
| Rural Local | 2.89 | 116,180 | 0 | 0 | 0.00 | 0.00 |
| **Rural Cities** | **166.93** | **318,628,355** | **23** | **24** | **7.22** | **7.53** |
| Interstate Freeways | 11.63 | 83,928,830 | 0 | 0 | 0.00 | 0.00 |
| Non-Freeways (combined) | 155.30 | 234,699,525 | 23 | 24 | 9.80 | 10.23 |
| Other Principal Arterials | 89.43 | 172,135,832 | 21 | 22 | 12.20 | 12.78 |
| Minor Arterials | 39.93 | 52,893,767 | 1 | 1 | 1.89 | 1.89 |
| Rural Major Collectors | 25.65 | 9,615,541 | 1 | 1 | 10.40 | 10.40 |
| Rural Minor Collectors | 0.29 | 54,385 | 0 | 0 | 0.00 | 0.00 |
| **Rural Areas** | **6,063.45** | **9,707,311,918** | **493** | **589** | **5.08** | **6.07** |
| Interstate Freeways | 483.59 | 4,003,550,680 | 60 | 68 | 1.50 | 1.70 |
| Non-Freeways (combined) | 5,579.86 | 5,703,761,238 | 433 | 521 | 7.59 | 9.13 |
| Other Principal Arterials | 2,551.61 | 4,040,563,071 | 257 | 312 | 6.36 | 7.72 |
| Minor Arterials | 1,744.51 | 1,351,070,455 | 135 | 163 | 9.99 | 12.06 |
| Rural Major Collectors | 1,247.11 | 309,544,442 | 38 | 43 | 12.28 | 13.89 |
| Rural Minor Collectors | 33.74 | 2,467,090 | 3 | 3 | 121.60 | 121.60 |
| Rural Local | 2.89 | 116,180 | 0 | 0 | 0.00 | 0.00 |

** Crash Rate Formula: (crashes*100 Million)/VMT;   **Casualty Rate Formula: ((fatalities+serious injuries)*100 Million)/VMT*

# Appendix V1-B: Reminder list

Experience has shown that whilst exceptionally long checklists can appear to be thorough, the use of such lists is problematic (African Development Bank (b), 2014).

- 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 reminder list).

- Some people can be over reliant on checklists

There is a risk that checking against a long list of reminders 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 reminders have been designed to be manageable lists of high-level pointers which should help guide the RS Assessment Team ensure that all the necessary general issues and aspects of a road are considered.

Two sets of reminder lists have been developed:

- The first set (B1) are high level road safety issues
- The second set (B2) is a high-level list of physical road elements that should be examined during the site visit

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

### B1 High level reminders - 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, motorcyclist, 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

### B2 High level reminder list - Physical road elements to consider during the site inspection

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

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

  - under different weather conditions (e.g., heavy rain, fog, sandstorm); 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

South Africa

COTO

Committee of Transport Officials

TRH 29: 2022

# South African Road Safety Assessment Methods (SARSAM)

## Volume 2

## Road Safety Assessment

Network Level Assessment (NLA) and Road safety inspection

Volume 1: Network Screening

**Volume 2: Road Safety Assessment**

Volume 3: Road Safety Audit Manual

Part A - RSA Management: Policy and Procedures

Part B - Conducting Road Safety Audits

Draft Standard (DS) version 1.0

March 2022

# FOREWORD

## Compiled under the auspices of the:

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## Existing publication:

This document forms part of the update of the South African Road Safety Audit Manual, 2nd Edition, May 2012 (SARSAM 2012)

## Document versions:

**Draft Standard:** This working draft document has been prepared specifically as a combined Volume 1 Network Screening guidelines and Volume 2 Road Safety Assessment guidelines for the Update of the South African Road Safety Assessment Methods manual and remains the intellectual property of the RTMC.

The contents of the report may only be used for the Update of the South African Road Safety Assessment Methods manual study for which it was commissioned under licence and shall not be reproduced or used in full or in part outside of this application without the authorisation of the RTMC.

## Comments:

Comments on this working draft should be provided in writing and e-mailed to the developers of the document, Messrs CSIR for the attention of the Project Manager, Mr Michael Roux at mproux@csir.co.za.

This document and its various parts will only be published in electronic format.

# PREFACE

TRH 29 consists of three mutually supporting volumes related to successive investigation and diagnostic practices to improve road safety on the South African road network. These volumes are:

- Volume 1: Network Screening
- Volume 2: Road Safety Assessment
- Volume 3 Road Safety Audit

The South African National Road Safety Strategy 2016-2030 (NRSS) accepted the vision of "Safe and Secure Roads". South Africa aims to contribute towards the reduction of an unacceptable global road safety problem that claims the lives of some 1,3 million people annually. NRSS aims to address this problem on a national scale across different subject areas. This document will fall under the Safer Roads and Mobility theme of the United Nations' 2$^{nd}$ Decade of Action for Road Safety, 2021–2030. One of the strategic themes adopted for achieving Safer Roads is the implementation of a Road Safety Audit Programme on new and upgrade road infrastructure projects.

Volumes 1 and 2 of TRH 29 provides guidelines on applying curative methods for the identification and improvement of hazardous locations, roads, and routes. They also provide proactive assessment methods for the identification and treatment of road safety deficiencies.

**Network Screening** (Volume 1) is a process for reviewing a transport or road traffic network with the objective of identifying and ranking sites from most likely to least likely to realise a reduction in accident frequency with the implementation of appropriate safety improvement measures.

**Road Safety Assessment** (Volume 2) is a two-tiered process, namely:

1) **Network Level Assessment (NLA)** which is a routine, programmed and systematic field survey on existing roads to identify risk factors that can be mitigated against to achieve enhanced safety, and
2) **Road Safety Inspection (RSI**) is an expert assessment of the road environment conducted in response to an identified road safety issue on a section of the road network. RSI involves an expert and in-depth review of the safety of existing roads. Apart from identifying safety problems, the assessment team should be looking out to identify and recommend viable and cost-effective measures which will improve safety.

Volume 3 provides guidelines on Road Safety Audit - a systematic assessment of plans for new road schemes (including on existing roads), intended to ensure that new roads have the lowest attainable accident potential across all kinds of road users. The audit process aims to avoid future accidents by removing unsafe features before they are constructed and to build in safety features that will limit casualty severity to the minimum feasibly possible.

Road Safety Audit is a proactive road safety engineering tool based on the philosophy that new road projects must have the highest achievable level of safety built into them and that road authorities do not have to wait for the accumulation of serious injury and fatal accidents statistics before positive steps can be taken to reduce the risks of such. It plays a significant role in ensuring that the road environment is forgiving, self-explaining and providing for the needs of all road users while being aligned with the principles of contemporary road safety management practices, e.g., the Safe System Approach.

Road safety audits may be conducted at all stages of the life cycle of a roads project (from conception to the final constructed project and post the opening to traffic, and on existing roads). Given that South Africa is currently in a process of road safety audit capacity development, road authorities should endeavour to introduce road safety audits at the earliest possible stage of specific projects - this will provide the highest road safety return on such investment.

A road safety audit is conducted by a qualified and experienced road safety audit team led by a road safety audit team leader recognised as a specialist road safety engineer and accredited as such by the Engineering Council of South Africa (ECSA). The size of the road safety audit team is determined by the size, complexity, and the stage(s) of the project to be audited. The road safety audit team will comprise a road safety audit team leader and at least one additional audit team member. The audit team leader is the lead auditor that is responsible for compiling the road safety audit report and representing the audit team in engaging with the roads' department/project owner (the client). The audit team members assist, collaborate, and contribute to the road safety audit.

The successful implementation of the entire road safety audit process and the implementation of the remedial measures recommended by the road safety audit team would make a meaningful contribution to ensure that road safety problems are not repeatedly introduced on the road network.

It is our firm belief that the South African Road Safety Assessment Methods 2022 manual, (this TRH 29) would pave the way for our real contribution to meeting the objectives of the NRSS and of the UNDoA2.

# ABBREVIATIONS

| | |
|---|---|
| AADT | Average Annual Daily Traffic |
| ABS | Anti-Lock Braking System |
| ARF | Accident Reduction Factors |
| ADT | Average Daily Traffic |
| AfDB | African Development Bank |
| AMF | Accident Modification Factors |
| ANRAM | Australian National Risk Assessment Model |
| AR | Accident Report |
| BCR | Benefit/Cost Ratio |
| CBA | Cost Benefit Analysis |
| CE | Cost Effectiveness |
| CHoCOR | Culpable Homicide Crash Observation Report |
| COTO | Committee of Transport Officials |
| CV | Coefficient of Variation |
| DCA | Definitions For Classifying Accidents |
| EA | Economic Appraisal |
| EAN | Equivalent Accident Number |
| EB | Empirical Bayes |
| ECSA | Engineering Council of South Africa |
| EPDO | Equivalent Property Damage Only |
| FSI | Fatal and Serious Injury |
| FYRR | First Year Rate of Returns |
| GIS | Geographical Information System |
| GPS | Global Positioning Systems |
| HCI | High Income Counties |
| HSM | Highway Safety Manual |
| IBCR | Incremental Benefit Cost Ratio |
| JTRC | Joint Transport Research Committee |
| iRAP | International Road Assessment Programme |
| LoSS | Level of service of safety |
| LMICs | Low- and middle- income countries |
| MVE | Million Vehicles Entering |
| NLA | Network Level Assessment |
| NPV | Net Present Value |
| NRSS | National Road Safety Strategy 2016 – 2030 |
| OECD | Organisation for Economic Cooperation and Development |
| PD | Preliminary Design |
| PDO | Property Damage Only |
| PVB | Present Value of Benefits |

| | |
|---|---|
| PPE | Personal Protective Equipment |
| RAMS | Road Asset Management System |
| RSA | Road Safety Audit |
| RTMC | Road Traffic Management Corporation |
| RSI | Road Safety Inspection |
| RSINV | Road Safety Investigation |
| V-kmT | vehicle-kilometres travelled |
| VPD | Vehicles Per Day |
| VRUs | Vulnerable Road Users |
| SADC-RTSM | South African Development Community Road Traffic Signs Manual |
| SAPS | South African Police Service |
| SARSAM2012 | South African Road Safety Audit Manual 2012 |
| SARSAM2022 | South African Road Safety Assessment Methods 2022 |
| SARSM | South African Road Safety Manual 1999 |
| SARTSM | South African Road Traffic Signs Manual |
| SPF | Safety performance Function |
| SPIS | Safety Priority Index System |
| SSRIP | Safe System Road Infrastructure Program |
| UNDoA1 | United Nations Decade of Action for Road Safety, 2011 - 2020 |
| UNDoA2 | Second United Nations Decade of Action for Road Safety, 2021 -2030 |

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# VOLUME 2: NETWORK LEVEL ASSESSMENT AND ROAD SAFETY INSPECTION

# 1 Road safety assessment context

## 1.1 Introduction

Curative, data-led techniques for identifying and treating accident locations on existing roads are described in Volume 1: Network Screening

Volume 2 of SARSAM 2022 describes a two-tier process for the proactive identification and treatment of safety deficits through conducting Network Level Assessment (NLA) and Road Safety Inspection (RSI). This TRH 29 Volume 2 relates to the proactive inspection and treatment of existing roads.

Similar techniques can be proactively applied to new roads and schemes through Road Safety Audit. This is described in Volume 3: Road Safety Audits.

## 1.2 The proactive approach concept

Methods for identifying potential accident locations have evolved since the onset of the epidemiological approach to road safety with the work of Haddon (1980). The Haddon-matrix provided a compelling framework for understanding the origins of injury problems - assisting with developing ideas for preventing accident injuries of many types as opposed to dealing with the injured afterwards.

'Proactive' tools and approaches are extensively used - some not relying on any knowledge of accident locations to identify high risk locations. For example, road safety audit of existing roads assesses risk, based on knowledge about the road and roadside factors that contribute to risk. Proactive tools and approaches are thus important, as they can identify locations where there is a high risk of severe accident outcomes, and to address these before serious injury does occur.

Importantly, proactive approaches can be particularly useful where accident data are not yet available or where accident details including locational information are not recorded. While this is the case, proactive approaches cannot replace good quality accident data to provide the required evidence base to direct road safety policies, strategies and practices. Proactive tools should necessarily be used in the process of ongoing efforts to improve the recording, quality and availability of accident data whilst there are significant prevalent road safety challenges.

## 1.3 Outline of applicable proactive approaches

Proactive approaches are applied to assess the safety of the road network and to identify deficits that can be treated to improve road safety standards. Often, it is not feasible to conduct detailed reviews of all roads and it will also not be practical to do so since any remedial work will only be implemented over an extended time period. A 'two-level process' would be the practical alternative entailing a high-level investigation deployed to identify and list the risk priority road sections and, on which a criteria-based prioritisation and selection procedure is applied to select road sections (or sites) that will then be subject to a detailed level inspection (World Road Association, 2014), viz:

- Network Level Assessment (NLA) is conducted across a sizeable proportion of the road network every 3-5 years. NLAs are high level reviews of the road network, and
- Road Safety Inspection (RSI) is more detailed and is conducted on roads that have been identified as 'high risk' or that have treatable risk features.

Road networks are typically expanding or changing operationally due to development or other socio-economic factors. Depending on the type of road and its environment, changes may be slow or rapid – so would be the development of any road safety problems. Any monitoring actions should take account of the dynamics of the road network when NLAs or RSIs are planned and scheduled. Typically, roads and corridors carrying the higher volumes of traffic and/or with rapid changing operations will need to receive the higher priority and require more frequent inspection than those with the lower volumes and not much changing. Road authorities, due to funding, resourcing, and other restrictions, need to consider what would be the best monitoring and inspection regime to ensure appropriate coverage of the road network and to maximise the efforts to progressively remediate existing accident risk and preventing the development of new risk situations.

In contrast to Road Safety Audits (RSA), NLAs and RSIs are specifically applicable on existing roads – as opposed to RSA that is done on new roads. With new roads, the projects are defined and subjecting them to RSA is about ensuring built-in safety, whilst NLA and RSI is about finding unsafety and treating it (Van Der Kooi, 1999). Also, unlike maintenance inspections, NLAs and RSIs aim to focus on the intrinsic safety of the road rather than the identification of elements that require maintenance. (Asian Development Bank, 2018)

The two-level NLA-RSI process allows for the consideration of constraints in terms of investigation capacity and budgetary requirements and for adjusting to make the most efficient use of available skilled resources. The high-level investigation – NLA - is primarily a mechanistic data collection exercise that can be conducted by trained staff who need not be experienced Road Safety Assessors. They could be part of the general area maintenance teams who then prepare a summary report for consideration by specialist staff experienced in accident investigation or Road Safety Audit to consider the findings and develop the detailed road safety investment plan from a more detailed/specialised inspection - RSI.

This TRH 29 guideline specifically relate to the Safe Roads pillar of the Safe System. The guideline is designed to help functionaries in road departments ensure that road safety underpins the planning, design and management of their infrastructure assets. This includes proactive and systematic approaches to reducing death and serious injury, and the reactive treatment of locations on the road system which experience a 'high' number of casualty accidents. When these locations (i.e., intersections, routes or road segments and areas of road network) are effectively treated by applying the appropriate engineering solutions, the number and severity of the accidents can be reduced or, preferably, eliminated.


*Figure 1-1: The two-level proactive and systematic approach*

## 1.4 Network level assessment

Network level assessment (NLA) is a proactive safety management tool that:

- comprises a routine, programmed and systematic field survey which is conducted proactively on existing roads to identify risk factors and to achieve enhanced safety
- results in a formal report detailing road hazards and safety issues supported with videos and photographs
- is a standardised survey conducted to collect prescribed data relating to road characteristics (road and environmental features) of existing roads - allowing the identification of sections of road that warrant further road safety assessment (Ogden, 1994).

The survey is not restricted to the consideration of road features (e.g., road markings, signage, drainage, road restraint systems, etc.). Rather, during an NLA, information on the context of the road and surrounding development will also be collected (e.g., road alignment, adjacent development etc.). The NLA also records information relating to how different road users might perceive and use the road (e.g., readability and 'self-explaining-ness', monotony of surroundings, speed choice, etc.) (African Development Bank (b), 2014).

With the characteristics of the road recorded, the information can be examined by more specialist safety practitioners who will develop a plan of high priority accident locations where RSIs need to be conducted (World Road Association, 2014) (African Development Bank (b), 2014).

**When to do a NLA:** A NLA is a systematic process as a means to achieve desired road safety results, e.g., the reduction of fatalities and serious injuries. NLA is a necessary step to have a road safety investment programme that is effective and thus it must be effective in identifying the best opportunities for effective remedial measures and treatments to realise extraordinary results.

NLAs should ideally be conducted for each road section every three to five years (Victoria Auditor General's Office, 2021). Best practices indicate that five years should be the maximum number of years between assessments. As a minimum the NLA annual schedule should cover the busiest 10 per cent of the road network. Preferably, all roads should be covered by a NLA schedule over a maximum number of years (e.g., 5 years), but if budget and resources are limited, a road department may wish to prioritise the assessment of higher volume roads, roads of strategic importance or roads that are known to be higher risk. Another way to prioritise the NLA schedule is according to the road classification (see TRH 26). For example, NLAs may be conducted every 3 years for roads Class 4 and higher, and every 5 years for roads Class 5 (and 6). However, the development activities (or change dynamics) along roads or in an area should be a crucial factor in considering the frequency at which specific roads should be subject to NLA.

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

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

## 1.5 Road safety inspection

The African Development Bank defines Road Safety Inspection (RSI) as an expert assessment of the road environment conducted in reaction to an identified road safety issue on the road network. RSIs involve the expert and in-depth review of the safety of existing roads. In addition to identifying safety problems, the inspection team should attempt to identify and recommend viable and cost-effective measures which will improve.

RSIs are similar in many ways to Post-Opening RSAs (see TRH 29, Volume 3, Part A) which are typically conducted one year after a new road scheme has been opened to use. Although the inspection techniques and methodologies seem similar, but there are significant differences between RSIs and RSAs and they should not be confused with one another. Specifically, **Post-Opening RSAs are conducted on new roads, or new road improvements, as part of the design and construction process.** Roads that are subjected to RSA would therefore be expected to conform to current design practices and standards. In contrast, **RSIs are conducted on roads which may have been operational for many years**, and which may have been designed in conformance to policies, design practices and standards that prevailed at the time (African Development Bank (b), 2014).

**When to do RSIs:** Proactive RSIs are conducted on intersections, routes or road segments and areas of road network that have been identified as a high priority or as with a potential to be effectively remediated (with meaningful results in terms of reducing fatalities and severe injuries) through an initial NLA. RSIs therefore follow the NLA programme. The number of roads that are subjected to RSI in this way will therefore depend on the available budget and number of personnel who are suitably qualified to conduct the inspections.

## 1.6 Proactive approaches in the road system management process

The objective of Road Safety Management is to integrate and coordinate all road safety activities such that a systematic approach is taken to reducing fatal and serious injury throughout the projects' lifecycles. Effective road safety management programmes need to provide an optimal balance between curative and proactive strategies (World Road Association, 2014).

NLA and RSI are used, along with curative data-led approaches, to manage the safety of the existing road network. The existing road network will typically pre-date contemporary or more recent road safety approaches and design standards (also likely not conforming to Safe System principles) - it is thus important that these roads are assessed and treated to ensure they are as safe as they can be.

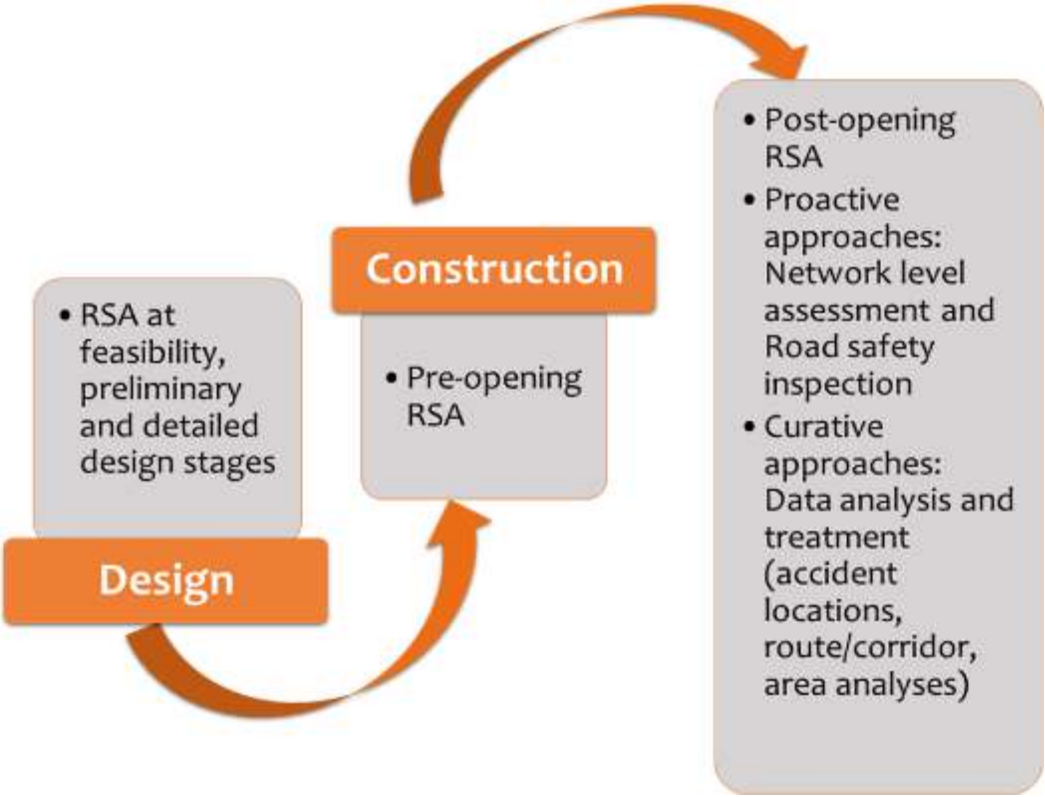



*Figure 1-2: Road system management- road safety approaches throughout project life-cycle*

## 1.7 Proactive approaches and the safe system

### 1.7.1 Safe system in action

The Joint Transport Research Committee (JTRC) of the Organisation for Economic Cooperation and Development (OECD) produced a report titled: 'Towards Zero: Ambitious Road Safety Targets and the Safe System Approach'. This describes the Safe System Approach (SSA) 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 an accident. The report designates 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. Therefore, the road transport systems of countries need to be developed to accommodate human error and take 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 accidents but, arguably more importantly, to ensure that any accidents that occur do not result in death or serious injury (Naumann *et al.*, 2021).

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 acting 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 accidents (for example electronic stability control and Anti-lock Braking System (ABS) brakes) and safety features that protect road users in the event of an accident (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 accidents 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 accidents.
- Safe speeds: Vehicles travel at speeds that suit the function and the level of safety of the road to ensure that accident 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 SSA is also supported by effective road safety management and post-accident response. The Safe System philosophy requires a shift in thinking away from blaming the driver (or road users) for the mistakes they make. The Safe System challenges those responsible for designing the road transport system to share the responsibility to manage the interaction between road users, vehicles, travel speeds and roads.

### 1.7.2 The importance of speed

At lower speeds, a driver will have greater opportunity to react and avoid an accident. Speed also affects the severity of accidents. Higher speed accidents involve more kinetic energy (kinetic energy is proportional to the speed squared) and the more energy that is dispersed in an accident, the more severe it tends to be (International Traffic Safety Data and Analysis Group, 2018).

There are four main accident types that account for most fatal and serious injuries:

- Accidents involving vulnerable road users (VRU's), i.e., pedestrians, cyclists, public transport users (or non-motorised transport (NMT), road-side vendors and motorcyclists.
- Side impact accidents at intersections
- Head-on
- Run-off

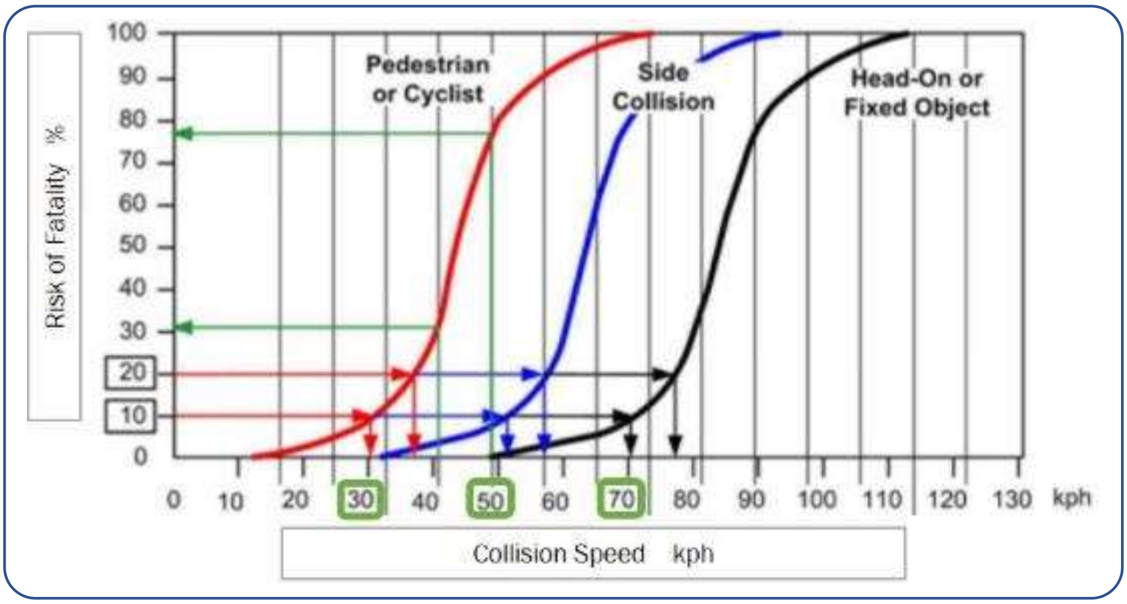



*Figure 1-3: Survivable speeds according to Wramborg (2005)*

Though other accident types do occur across the road network these are less likely to have fatal or serious consequences. Wramborg (2005) used in-depth accident data to plot collision speeds against fatality risk for three of the main accident types.

As speed increases, the fatality risk increases very sharply for each of the accident 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 accidents 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 accidents has been completed by Stigson (2009). According to this work, a road is considered 'safe' (or survivable) for run-off road accidents 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.

### 1.7.3 Applying safe system principles to proactive approaches

Safer road design is a vital component of the SSA to improve road safety and to ensure reductions in casualty numbers and severities. Central to the SSA is the concept of 'forgiving roads' where new roads can be designed in a way that accommodates human error and the frailty of the human body. The SSA promotes the need to manage the energy that is exchanged in an accident impact, such that accident forces are survivable.

For existing roads, the Wramborg (2005) and Stigson (2009) work can be translated into pertinent principles that can be considered during NLAs and RSIs:

- 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 accident occurring
- Road restraint systems need to be installed or clearance of road-side obstacles needs to be conducted if these might threaten survivability of run-off accidents.

The proactive approaches described in this TRH 29 are based on identifying road sections where Safe System rules have been violated and therefore where there are deficits that could result in fatal or serious injury should an accident occur.

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

During a RSI, the expert team can also keep in mind Safe System principles and the importance of speed and the mechanisms underlying typical accident types. The reminder lists provided (Appendix A) will help guide a team to take into consideration Safe System concepts.

## 1.8 Benefits of proactive approaches

Where accident data are not available, it is particularly useful to use proactive approaches to identify and treat high risk locations. Proactive approaches are only just beginning to be formalised, and so there is not as much evidence on the effectiveness of these techniques as would be desirable (African Development

Bank (b), 2014). Although it is not easy to quantify the economic benefits of NLA and RSI, there is compelling evidence that such inspections are highly cost effective. Even saving one human life per year because of these activities would be a significant benefit in relationship to the cost (African Development Bank (b), 2014).

# 2 Institutionalisation of proactive approaches to road safety management

## 2.1 Introduction

A proactive approach to road safety relates to the prevention of road safety problems before they become a part of a pattern of crash occurrence. The focus is on the evolving "Science of Safety", that is, what is known about the specific safety implications of road design and operations decisions. The proactive approach applies this knowledge to the implementation of improvement plans on existing roads to prevent accidents from happening or to limit the severity of the accident, should it happen. Proactive approaches for existing roads are therefore conducted to identify road safety deficits across the network before accidents accumulate (African Development Bank (b), 2014).

A NLA is a proactive approach that involves a systematic review of an existing road through in loco surveillance involving drive- or walkthrough techniques to identify hazardous conditions, faults and deficiencies in the road environment that may lead to road user injury. When a high-risk intersection, route. road segment or area of road network has been identified through an NLA, a RSI can be conducted in more detail to determine whether any of the physical deficiencies detected through a NLA can be treated. This approach can be conducted irrespective of the detail and accuracy of accident data that are available. Clearly the accuracy of such data will have a significant impact on assessing the cost effectiveness of any proposed intervention.

## 2.2 The application of Network Level Assessment and Road Safety Inspection

The operational road management systems that are established in road departments (and those with concurrent functions) should be aligned with contemporary and strategically directed road safety practices to facilitate the effective introduction and continued application of proactive approaches. The framework below assumes that NLAs and RSIs will be conducted in-house (i.e., by the road department/authority itself). Although it would be possible to procure service provider technical assistance to complete NLAs or RSIs, it is preferable to build the in-house capacity, at least for the management thereof, to ensure stewardship over the road network and to take ownership of the road safety problems, there mitigation and remediation.

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

#### Step 1: Establish the regulatory basis for conducting proactive approaches

Road departments have a legal (constitutional) obligation to investigate and improve road safety problems. NLA and RSI can be deployed to support this legal responsibility. NLA and RSI responsibility should rest with the relevant road department/authority for road safety and need to be institutionalised by the cascading down of support from the highest political level (i.e., President/Minister of Transport/Director General) and have clearly defined statutory accountability for any actions or failures of the systems.

#### Step 2: Formalise protocols and procedures

The road department/authority needs to write and adopt a formal protocol or procedure (i.e., policy) for conducting these proactive approaches (NLAs and RSIs) for safety investigations on existing roads. This should include specification of:

- The person or department with specific responsibility for investigation of road safety issues. Although it may not always be possible, the nature and extent of the road safety problems in the country is such that there needs to be a dedicated team of professionals whose focus is entirely on safety issues. They need to be trained and provided with high quality advice and technical assistance until they gain experience.
- The level of resources (financial and personnel) necessary to achieve a focussed improvement in road safety. This will depend on the extent and quality of the road network for which the road department is responsible. At a very minimum, there will need to be a team of two RS Assessors, one of whom assumes the role of the 'Manager' in the of the team. The RS Inspectors can be engineers that would normally have other routine duties.
- Training and experience requirements for inspectors and assessors.
- The detailed process to be followed as set out in formally approved manuals or guidelines. These documents should specify the approach to be taken in the conducting of NLA and RSI.
- Requirements for the level of improvement to be achieved and over what period. This may be a numerical target for conducting safety improvements on, for example, the worst 10% of the strategic or main road network. Longer term casualty reduction targets that can be associated with the improvements can also be developed. Typically, these would be in line with aspects of the NRSS or other imperatives set through national and provincial mandates and policies.
- Mechanisms for monitoring performance. These need to specify how performance should be monitored and evaluated. Potential indicators may

be linked to the NRSS or other requirements, e.g., Provincial Road Maintenance Grant, Municipal Infrastructure Grant, etc.

#### Step 3: Identify personnel

Various personnel are required:

- Manager to oversee, plan and administrate the NLA and RSI schedule
- Road Safety Inspectors to conduct NLA
- Road Safety Assessors to conduct RSI

Requirements for each of these personnel and their responsibilities are described in earlier sections.

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

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

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

It is not complicated to train staff to capture information about road characteristics for NLAs. For RSIs, however, personnel need to gain relevant experience as well as receive appropriate training. Candidate RS Assessors can gain experience through active participation in the road safety assessment work, and it is essential that they receive mentoring and for them to shadow experienced personnel until they have reached the requirements specified earlier.

#### Step 6: Monitor and Review

Before implementing proposed treatments, it is necessary to assess their potential impact to make a business case for investment. Information on the effectiveness of treatments have been compiled from research conducted in various countries in Europe and in the USA and Australia. Little is known about the true effectiveness of the treatments under the different circumstances in South Africa (or generally in Afrika). An understanding of local effectiveness will only be established if road departments monitor and evaluate the performance of any measures implemented. Road departments therefore need to introduce a system for monitoring and reviewing (and reporting) the performance of any implemented NLA or RSI recommendations. It will be especially important that necessary research and development protocols be established to ensure that scientific methods are applied, and that research work is published through peer reviewed channels/platforms.

This can then be used progressively to identify the most appropriate safety improvements to incorporate in revised design standards. This is particularly important in any country where development of the road network is occurring at a fast pace and where research concerning road characteristics and their impact on road safety outcomes is not available.

# 3 Personnel, equipment and safety requirements

This Section provides an overview of the personnel, equipment and safety requirements relevant to NLA and RSI proactive approaches.

## 3.1 Team and personnel requirements

There has been rapid development around road safety management, particularly since the onset of the United Nations Decade of Action for Road Safety 2011 – 2020 (UNDoA1). Many road departments are likely to experience that there are currently a shortage of appropriately trained Assessors or qualified Inspectors, if there are any incumbent functionaries at all. It is essential for long term sustainability to provide opportunities for road safety functionaries 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 NLA team and RSI team is to be encouraged. This will have the following benefits:

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

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

### 3.1.1 Team composition

3.1.1.1 <u>Network Level Assessment</u>

There are several personnel involved in a NLA:

- The Manager
- NLA Team comprising two Assessors
- RSI Team

3.1.1.2 <u>Road safety inspection</u>

A RSI must be conducted by a team of qualified practitioners. The African Development Bank recommend that:

- RSI teams need to include two or more people
- at least one Team Leader and one Team Member are essential.

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

- One of the team should be designated as the Inspection Team Leader. Other members of the Team can have differing specialisms and, as such, bring a fresh perspective to aspects of the assessment and their comments should not be discounted. Every inspection can serve as a training exercise for inexperienced team members and be an opportunity for all members of the Assessment Team to gain more experience.
- Successful Inspectors need to be able to adopt the perspective of different road user groups and imagine how they would be able to cope with the road situation, anticipating for instance how easy it would be for the motorist to make the right turn at an intersection or where a pedestrian would want to cross the road.
- It is essential to have at least one member of the Assessment Team (Leader, Member, Observer or Specialist Advisor) with good local knowledge as this can assist with understanding how the road is used by the local population and the wider context of the site or road.
- Non engineering specialists (e.g., Psychologists/Sociologists) can also help ensure that the RSI deals comprehensively with issues such as road user behaviour (African Development Bank (b), 2014).

The specialist skills and size of the Inspection Team depends upon the type, size and complexity of the accident location or road to be assessed. In addition, traffic police, designers or other specialists (e.g., traffic signals engineers) may be included if their distinctive perspectives would add value to the inspection (African Development Bank (b), 2014).

The following personnel may also be involved as required:

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

### 3.1.2 Qualifications, Experience and Responsibility

#### 3.1.2.1 Management

The purpose of the management requirement is to:

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

The need for a formal steering committee, project management team, or a single project manager will vary depending on the scale of inspection being conducted.

For large scale or regional networks, it is suggested that a steering committee should be established, whereas for small scale or individual inspections a single manager is all that is required.

The Manager:

- Manages and maintains a list of available inspectors, ensuring that there are enough inspectors within the road authority and that they are available and trained/retained as required
- Assigns duties to assessors and inspectors and manages an NLA and RSI schedule
- Oversees the quality of NLAs and RSIs
  The Manager will:

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

This role may be fulfilled by one of the RSI Team.

#### 3.1.2.2 Network level assessment team

On a national level there will need to be a pool of Inspectors (that can also act as Road Safety Auditors). Assessors for NLA need to be trained for the assessment task – qualification and experience requirements are less stringent than for Inspectors. It is recommended that one member of the NLA Team have some experience as an Inspector. The RTMC is currently in the process to facilitate the accreditation and registration of persons that would want to provide services in the capacity of road safety assessing, inspecting, and auditing. Once a road safety programme to target the 2030 goal of reducing fatalities by 50 per cent is established, it may be necessary to have Inspectors/Auditors in each province. Inspectors may already be employed by the road departments as engineers (e.g., traffic management engineer or transport planner) and RSA/RSI/NLA may just be one duty conducted as part of their role when required. Some experience with road engineering is desirable.

The NLA Team need to be impartial, and primarily concerned with road safety and there should be no conflict of interest (African Development Bank (b), 2014).

### Composition

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

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

### Responsibilities

The NLA Team:

- Discuss and liaise with the Manager about preparation – when to visit, optimal site conditions, etc.
- Conduct the Assessment in accordance with defined procedures put in place by the road department
- Report to/meet with the Manager and RSI Team

### Training and Experience of the NLA Team

NLAs should only be conducted by persons who have received the relevant training and have the experience described in this section. Unlike RSAs and RSIs, it is not necessary for the Assessment Team to be specialist road safety engineers, but they must have an understanding and knowledge of road safety principles and hazard identification. It is therefore recommended that local practitioners are included as part of the team.

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

Each Assessor must have at least 2 years' experience working within the road industry (roles could include traffic engineer, safety engineer, maintenance engineer or transport planner). It is not necessary for the Assessment Team Leader or Team Member to have differing levels of training or experience (African Development Bank (b), 2014).

When a NLA is being introduced in a roads department, it is recommended that an Assessment Team should initially be accompanied by an experienced Inspector or

Road Safety Auditor to ensure that the NLA Team is equipped and competent to conduct this task (African Development Bank (b), 2014).

#### 3.1.2.3 Road Safety Inspection Team

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

- Conduct the RSI
- Propose a treatment plan
- Develop a business case for investment.

RSIs should only be conducted 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 RSI depends to a very great extent on the skills, abilities and experience of the Inspection Team. Selecting the right team is essential. Some key criteria are:

- Competence in RSI comes through hands-on experience. Training is helpful at the start but is only a base upon which experience needs to be built.
- RSI is a highly skilled activity which requires an understanding of accident causation, accident investigation (data analysis and incident reconstruction), vehicle performance, road design and the interaction between the road user, their vehicle and their environment.
- It is essential that the process is conducted by an impartial team who are demonstrably independent of the road management section or division or any other interested parties or stakeholders.
- The Inspection Team Leader, Members and Observers must meet the essential experience and qualification requirements described in the table below.

*Table 3-1: RSI Team composition, experience and roles*

| | |
|---|---|
| Team Leader | The Inspection Team Leader has overall responsibility for carrying out the Inspection, managing the Inspection Team and certifying the report. |
| Team Member | The RSI Team Member reports to the Team Leader. They contribute to the Inspection via the Team Leader. Ideally, they will have local experience/knowledge. |
| Observer | A RSI Team Observer is, for many, the starting point of being involved with RSI. As such, there needs to be a flexible approach to the requirements for knowledge and experience. |

| | |
|---|---|
| Specialist Advisor | A Specialist Advisor is not a formal member of the Inspection Team but advises them on matters relating to their specialism. They should be named in the Inspection Report. |

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

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

The Inspection Team should consider if there are any particular features of the project, such as complex signal-controlled intersections, road design, traffic management or maintenance issues that warrant the inclusion of Specialist Advisors to advise them.

## 3.2 Equipment

### 3.2.1 Network level assessment

Equipment required includes:

- A vehicle (with appropriate high visibility markings)
- Video camera (ideally GPS linked system) (typically these cost around R 7 500)
- GPS (can be achieved using a satellite navigation system or smart phone)
- Notepads
- Inspection forms
- Pens
- Personal Protective Equipment (e.g., high visibility clothing and protective footwear)

Optional equipment includes:

- Digital camera
- Dictaphone (optional)

It is imperative that the assessment route/section is recorded on video. The video and other equipment should be mounted (not hand-held) so that it does not impair the driver's field of view. Preferably the video equipment will have geo-referencing capabilities so that the video images can be related to the road chainage, kilometre marker or other measuring points. This will allow the logging of the precise location of hazards.

Some road authorities may already have asset management vehicles that are regularly driven around the network for other purposes. If these provide geo-referenced video outputs, they can be used for NLA and the recording of the information on the road can be done from the office (Sairam, 2016). The video needs to be handed over to the Assessor as part of the report package and used to aid the reviews.

As part of efforts to inculcate shared responsibility and to promote road safety management, branded equipment and vehicles may be considered during the process of developing and introducing the NLA process.

### 3.2.2 Road safety inspection

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

The roads department may choose to provide equipment and support staff (particularly if warning signage or other temporary traffic management is required for the Inspection Team to inspect the site safely).

## 3.3 Team Safety

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

It is essential that site visits are conducted in a safe manner and that the safety of the Assessment Team, road users and other members of the public is not compromised (African Development Bank (b), 2014).

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

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

- Planning and administration
  - The Manager should be notified of any deviations from planned schedules
  - A mobile telephone should be provided for emergencies and for checking in with the Manager at the start and end of each day.
  - The Assessment/Inspection Team must be equipped with sufficient supplies of drinking water and food.
- Vehicle safety
  - Vehicles must be roadworthy and properly equipped with suitable reflective materials and service light. They should travel at the prevailing traffic speed.

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

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

# 4 Proactive process

The Proactive Approach process is broken down into two stages following initial preparations. Stage 1 involves the conducting of NLA across the chosen road network. Stage 2 involves the conducting of RSI on locations/sections that are identified during Stage 1 as being high risk and worthy of in-depth inspection. Following the conducting of the RSI, a treatment plan will be developed and, once implemented, monitored and evaluated (African Development Bank (b), 2014).

## 4.1 Preparation

Two tasks must be conducted in preparation for conducting the proactive approaches described in the rest of this section. The first is to determine the part of the road network that will be subjected to NLA. This will relate to an overall policy for NLA and RSI.

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

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

Note that route/corridor analysis also requires the network to be sectioned in a similar manner and that there would be significant benefits in using the same sections for both tasks (this would allow one single database to be established with NLA data and route/corridor accident data) (Committee of Land Transport Officials (COLTO), 2012).

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

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

## 4.2 Network level assessment

### 4.2.1 Process Steps

Figure 4-1 shows five steps for conducting NLA and identifies responsibilities for each step.


*Figure 4-1: NLA process flow chart*

4.2.1.1 <u>Develop and issue the assessment brief</u>

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

The Assessment Brief should contain:

a) The names of the Road Safety Assessors (referred to as Assessors henceforth)
b) Summary description of the route/area to be inspected - road type, length, location, start points and end points etc.
c) Road sections within the route/area to be inspected (including start and end points for each section, and unique section identifier)
d) Details of the visit procedure according to this TRH 29, Volume 2, the time of day for the assessment and the equipment that will be required or provided
e) Contact points for any queries or issues
f) Timeline for completion of the NLA
g) Health and Safety Risk Assessment and safety guidance.

#### 4.2.1.2 Preparation for an NLA

**Route Planning**

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

The itinerary for each day should be planned to accommodate these requirements.

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

**Safety Checks**

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

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

**Equipment Check**

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

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

#### 4.2.1.3 Drive the assessment route and collect data

The assessment route is driven by the Assessment Team and the form filled in for each section. The NLA form is provided in Appendix C.

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

To note safety issues on the form the Inspectors shall:

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

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

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

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

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

This process is repeated for each pre-defined section.

**Best practice for use of recording equipment**

The use of a video camera to record the NLA, and other recording equipment such as digital cameras and voice recorders, are an essential part of the assessment process and at the minimum inspectors MUST use video recording equipment (African Development Bank (b), 2014).

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

- The Assessment Team with a reminder of key issues when conducting the assessment and when writing the Assessment Report
- A record to the NLA Manager/Assessor
- A record of conditions on-site during the site assessment

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

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

4.2.1.4 Collate Data

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

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

The NLA Manager may wish the NLA Team to enter the recorded information into the NLA database. A summary report of the key findings of the assessment will be made with initial indications as to the areas that need further assessment (e.g., a Road Safety Audit).

4.2.1.5 Pass the NLA Report to Assessors for Action

It will not be possible to conduct a detailed RSI on all sections where hazards have been identified (through the NLA) and so it is necessary for the Road Safety Inspector (referred to as Inspector henceforth) to prioritise further investigation.

The Inspector will therefore need to review the findings of the NLA and prioritise a plan of RSIs according to available resources based on:

- Risk - as assessed by the deficits detected during the NLA and degree of violation of Safe System rules
- Importance of the road/section – based on traffic volumes (if known) and strategic importance of the road/route/section.

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

## 4.3 Road safety inspection

A RSI will either be conducted by an 'in-house' team or by external consultants. If conducted by an 'in-house' team within the road authority, the RSIs need to be planned and an approved programme put in place.

If conducted by an external team of consultants, contracts need to be put in place that specify the scope of the RSI, expected outputs and requirements for the qualifications and experience of the Inspection Team.

Budgetary provision for conducting RSIs, and for addressing any safety recommendations, needs to be considered prior to the inspections.

### 4.3.1 Process steps

The step-by-step process for completing an RSI is outlined in Figure 4-2. Steps 1, 2 and 3 only apply if an RSI is formally procured using external consultants.

If the RSI Team is from within a road authority, then they will simply receive NLA reports as they are conducted. They may also receive the results of accident data analyses or police/community intelligence. Using this information, they will need to develop a prioritised programme of RSIs that should ideally be approved by the Chief Engineer of the road authority.


*Figure 4-2: Inspection process flow chart*

4.3.1.1 Develop and issue the inspection brief (formal procurement of consultants)

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

It is the responsibility of the road authority to develop the brief. Inspection Teams are often engaged through some form of competitive tendering process, or they can be drawn from appropriately qualified and experienced road safety staff within the organisation. Whichever option is adopted, they need to be impartial and separate from the maintaining or design staff involved with the road or area under inspection (African Development Bank (b), 2014).

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

The brief needs to include:

i) Project title
ii) Summary description of the roads to be inspected – the nature, length, location, etc.
iii) Any manuals or guidelines to be adhered to. This will include:
    h) A specification of the required Inspection methodology and reporting system.
    i) Details of necessary meetings, site visits and health and safety requirements.
    j) Confirmation of the reporting format and the level of detail expected for any recommendations that are made.
iv) Background to the Inspection.
    k) Description of the reasons for the inspection (e.g., accident data analysis, NLA findings, or local intelligence).
    l) Overall layout and location plan (minimum scale 1:1250).
    m) Information about the adjacent network and land uses.
    n) Type and level of other information that will be made available (it is unrealistic to make all information available until the Inspection Team is appointed).
    v. Timescales for the Inspection:

    o) Timings for the inspection including information about term-times, seasonal traffic or peak traffic conditions to observe or to avoid. Confirmation concerning suitable weather conditions for visits and daylight and night-time visit requirements.
    p) Timescales for notification and mobilisation of the Inspection Team (typically 2-3 weeks).
    q) Timescales for completion of Inspection Reports.
    r) Timescales for the development of a treatment programme and for follow-up.

4.3.1.2 <u>Commission the Inspection (formal procurement of consultants)</u>

The formal commissioning of the Inspection needs to take place in an equivalent manner as for other works commissioned by the road authority. The road authority’s procurement and contractual processes should be adhered to.

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

#### 4.3.1.3 Collate information and intelligence (formal procurement of consultants)

Following the appointment of the Inspection Team and the formal instruction to commence, the road authority needs to provide relevant information as specified in the Inspection Brief.

The Inspection Team can only inspect the road on the basis of the information provided. It is essential that all relevant documents are provided to the Inspection Team prior to them conducting the inspection.

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

v) Confirmation of the title of the project and scope of the Inspection
vi) Reporting requirements
vii) A set of plans showing the location of the site and, if available:
   s) Horizontal and vertical alignment
   t) Cross section
   u) Signing and lining
   v) Drainage
   w) Lighting
   x) Road restraint system
   y) Landscaping
viii) A blank plan to mark up any issues
ix) Notification of the currently adopted relevant design standards (for any proposed remedial treatment)
x) Traffic flows, composition (including intelligence on pedestrian/pedal cyclist road usage)
xi) Historical speed data
xii) Key traffic generators and attractors
xiii) Intersection control information (including, if available, traffic signal timing information)
xiv) Key contacts with Client/Road authority and police (and interested parties and stakeholders such as local community groups)
xv) Results of any accident data analyses conducted, raw data and any other intelligence
xvi) Times of day that the roads should be inspected and details of specific days that should be avoided, or observed, due to school holidays, seasonal traffic or other factors
xvii) Health and safety requirements including details of any physical access restrictions or times when the site should not be accessed
xviii) Any other pertinent local knowledge or information

#### 4.3.1.4 Review NLA information

In this step the Assessment Brief (if available) and any additional information available will be studied. Any NLA report and video/photographic information will be studied to understand the issues identified. Where this is done in-house, it is likely to merge with the step identified in Section 4.2.1.5. Initial consideration of the supplied information is necessary to identify issues for:

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

#### 4.3.1.5 Conduct a site visit

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

**Planning**

Site visits:

- Need to be conducted at different times of the day and at night-time. They should be planned at different times of the day such as during busy periods, during the start or end of school, on market days etc. It may be important to avoid (or observe) school holidays or other times when traffic conditions are atypical. A night-time visit, conducted 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 Inspection Team to take the perspective of all prospective road users (drivers, pedal cyclists, pedestrians etc.).
- Must be conducted safely. The safety of members of the Inspection Team, other road users and construction or other personnel must not be compromised by the site visit.

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

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

**Site Review Principles**

The Inspection Team should bear in mind the key principles for achieving a safe road environment when conducting the site visit so that they are able to associate with potential problems. These issues are described in Figure 4-3.

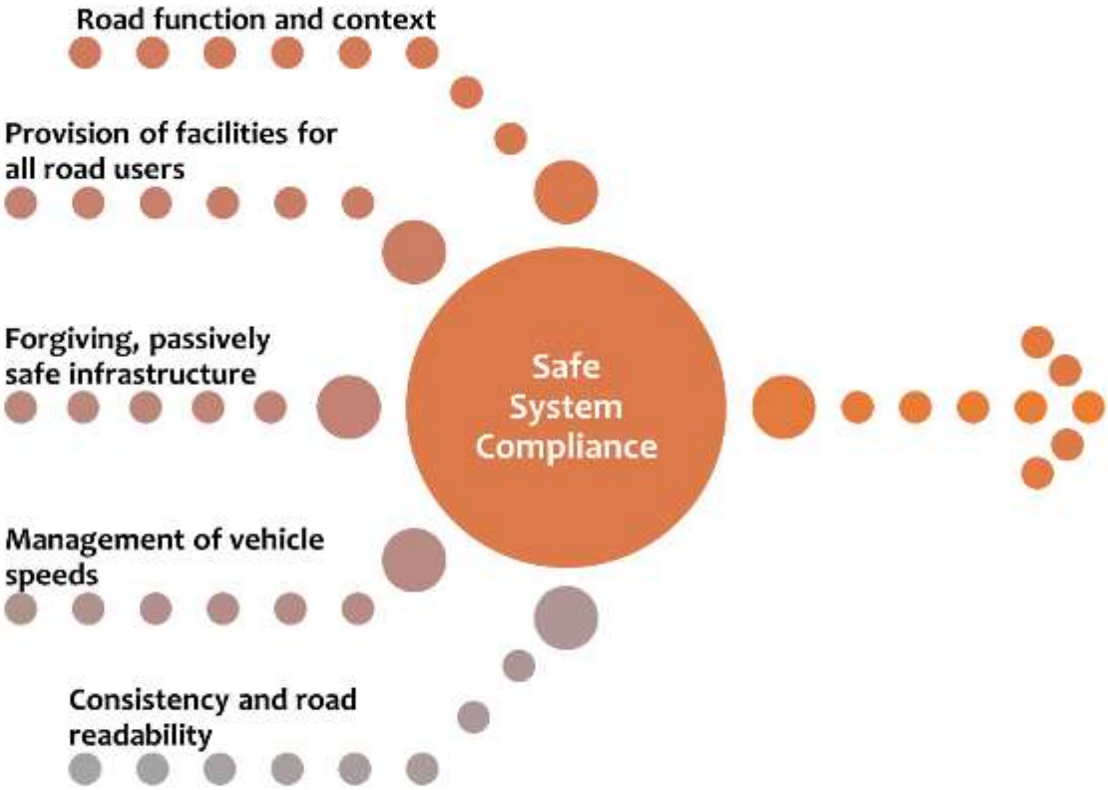



*Figure 4-3: Requirements for Safe System compliance (African Development Bank (b), 2014).*

Table 4.2. provides various aspects for the members of the RSI Team to consider when planning site visits.

*Table 1-2: Considerations for conducting site visits*

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

| | |
|---|---|
| Provision of facilities for all road users | • Are there likely to be pedestrians, carts, animals, pedal cyclists, or motorcyclists using this road? Have they been provided for?<br>• Are there facilities for public transport (e.g., bus stops/laybys/pedestrian crossing points)?<br>• Are there rest stops provided?<br>• Is there provision for special road users (e.g., mobility or visually impaired, older or younger road users etc.)?<br>• Are facilities provided for journeys to schools? |
| Forgiving, passively safe infrastructure | • Would the main accident types be survivable on this road at expected speeds?<br>• Would the road environment minimise injuries for all accident types? |
| Management of vehicle speeds | • Is the speed limit appropriate for the function of the road?<br>• Are drivers likely to obey the speed limit?<br>• 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?<br>• Are there any features that can distract driver attention or misguide a driver?<br>• Is the driver guided, warned, and informed about the road ahead?<br>• Is there consistency in the design throughout the scheme and with nearby roads?<br>• Does the scheme control the passage of the driver through conflict points and other difficult sections? |
| Additional guidance on the aspects that need to be considered through the site visit is given in Appendix A – Reminder lists. | |

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

Every site is different and local conditions can interact and create risks that are not always immediately apparent. An experienced Assessor will be familiar with situations where, for example, bends are correctly designed and signed but, because of local factors, they do not look as acute as they are (African Development Bank (b), 2014).

The expertise which Assessors utilise involves the site-specific inspection of risks based on a consideration of the interaction of unique local characteristics of a location including vehicle mix, speeds, driver behaviour, road alignment, sufficiency of signs, etc.

### Different Viewpoints

The location that is being assessed should be visited during daylight and during the hours of darkness. The team should also experience the use of the site from other road users' perspectives. This is likely to involve walking the route and crossing roads; it may also involve riding or driving other types of vehicles through the site. In most instances, it is necessary to also inspect the site on foot and to observe traffic conditions and road user behaviour from the street level (African Development Bank (b), 2014).

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

### Recording findings

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

- A reminder of key issues when conducting the inspection and when writing the Inspection Report
- A record of conditions during the site visit

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

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

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

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

**Community intelligence and consultation**

When a site visit is conducted it can be specifically useful to consult with local interest groups and the wider community. This has several advantages:

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

#### 4.3.1.6 Conduct the inspection

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

The Inspection Team should remember to:

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

**Use of reminder lists**

Two sets of reminder lists have been developed for use during the Inspection:

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

The reminders present different questions regarding the safety of all users but they are not exhaustive and should not be relied upon as the definitive extent of what needs to be examined. The reminders should be seen as Aide Memoire only to assist in ensuring all items are considered by the Inspection Team. The inspection should not be conducted as a 'tick list' exercise.

**Conflict studies (optional)**

RSIs will often involve a specific location, such as for example an intersection, rather than a route or a larger road network. Where site specific data are limited, a conflict study involving observing, recording and evaluating 'near-misses' can provide an alternative source of information about risks and likely accident patterns at sites (Archer, 2005). The field of conflict measuring is rapidly evolving with the use of video and image processing technologies, including the utilisation of drones, being developed. This is affording the more ubiquitous application of conflict measuring with much improved consistency and objectivity, as well as with greater resource efficiency[7].

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

Walker et al (2005) used a similar definition of a conflict and split interactions between pedestrians and vehicles into three increasingly severe categories: encounters, conflicts and accidents. The frequency of encounters and conflicts from the Ross Silcock research (Silcock, 1998) was quoted and, from a total of 32,000 pedestrians observed, 5% were involved in an encounter and 0.3% were involved in a conflict. These studies can therefore add to the understanding of accidents without requiring the retrospective analysis of an actual accident.

Conflict studies can be conducted by making, and recording, observations from the road-side or by observing interactions on video (Zeng, 2014). It should be noted that whilst the most common conflicts are often like the most common manoeuvres, this is not always the case. In some instances, movements which are less common can be disproportionately over-represented in conflicts.

Therefore, as well as identifying information about conflicts, it is also necessary to record some indicative traffic counts to help to understand the rate of risk exposure associated with any conflict. The inspection of conflicts involves an element of subjective judgement, and it is therefore important to ensure that suitably skilled personnel conduct the analysis and that it is conducted in a consistent manner. If sites are to be compared, or ranked, based on conflict studies, then it is important that these studies are carried out by the same person.

[7] See www.microtraffic.com/ for example.

| CLASSIFICATION | DESCRIPTION | EXAMPLE |
|---|---|---|
| 1 | Encounter, precautionary action | Pedestrian stopping in carriageway to allow vehicle to pass |
| 2 | Controlled action | Pedestrian deviate from route or vehicle undertakes controlled braking |
| 3 | Near miss | Rapid deceleration, lane change or stopping |
| 4 | Close miss | Emergency braking or violent swerve |
| 5 | Accident | Contact between two parties |

*Figure 4-4: Example of conflict classification*

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

Conflicts can be recorded on site using basic sketches. These sketches record the manoeuvres and the road user types involved in each conflict, along with the frequency and the severity. Figure 4-5 shows an example of a conflict measuring study sheet where the focus was on pedestrian-vehicle conflicts at a T-junction. **Error! Reference source not found.** shows an example of a conflict measuring study s heet for vehicle-vehicle conflicts at an intersection (African Development Bank (b), 2014).

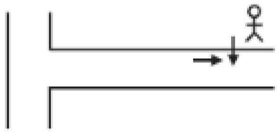
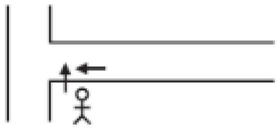
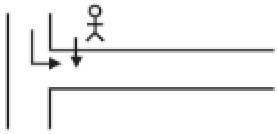
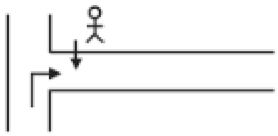
| | Conflict Severity | | | | |
|---|---|---|---|---|---|
| Sketch of conflict | 1 | 2 | 3 | 4 | 5 |
|  | III | III | I | | |
|  | IIII | II | | | |
|  | III | III | | | |
|  | ~~IIII~~ III | III | II | | |
|  | ~~IIII~~ | II | II | | |

*Figure 4-5: Example of a conflict measuring study sheet for pedestrian-vehicle conflicts at a T-junction*

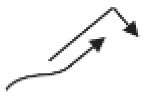
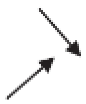
| | Conflict Severity | | | | |
|---|---|---|---|---|---|
| Sketch of conflict | 1 | 2 | 3 | 4 | 5 |
|  | ~~IIII~~ | IIII | | I | |
|  | | | II | | |
|  | ~~IIII~~ II | II | III | I | |
|  | ~~IIII~~ I | IIII | II | II | |

*Figure4-6: Example of a conflict measuring study sheet for vehicle-vehicle conflicts at an intersection*

### Use of risk assessment matrices to semi-quantitatively assess risk

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

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

This risk assessment process can be conducted in a systematic manner using a risk matrix to produce semi qualitative risk 'values' which can enable a comparison to be made between the risks associated with different hazards at a particular site or, indeed, at different sites (African Development Bank (b), 2014).

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

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

### The risk level is determined from a defined table.

The subjective assessment as to the likelihood of an accident happening (i.e., how often the hazard will cause or contribute to an accident) is determined using the risk defining table (*Table* ).

*Table 4-2: Accident risk level matrix*

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

The severity of a hazard is determined from a subjective assessment of the outcome if the hazard causes or contributes to an accident.

*Table 4-3: Likelihood of an accident happening*

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

Any type of accident could potentially result in a fatality. It is therefore important to consider the most typical or plausible outcome rather than the worst possible outcome (because the worst possible outcome would always be catastrophic).

*Table 4-4: Hazard severity*

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

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

Recommend measures

For example: A risk might be assessed as: Probable x Marginal = Medium Risk.

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

Each problem identified in the inspection will have one (or more) workable solutions that could reduce both the risk and hazard. For each segment of road, countermeasure options are 'tested' for their potential to reduce deaths and injuries.

For example: a section of road that has poor pedestrian provision and high pedestrian activity might be a candidate for a footpath or pedestrian crossing facility. Similarly, where there are numerous roadside obstacles in combination with surprising or poor standard bends, clearing roadside obstacles or installing a vehicle restraint system may be considered (African Development Bank (b), 2014).

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

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

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

4.3.1.7 Write the inspection report

A formal inspection report should be completed for all inspections that are conducted. Copies of this should be retained by both the Inspection Team and the head of the relevant roads department to form a verifiable audit trail. The Inspection Report provides a concise written record to identify road safety problems and actions that need to be taken to improve road safety. The report provides the formal documentation on which decisions about corrective action will be based. **Error! Reference source not found.** provides a framework for all RSI Reports.

*Table 4-5: Framework for the Inspection Report*

| | |
|---|---|
| Background description | • Inspection Team Members as well as the names and affiliations of other contributors to the inspection<br>• Details of who was present at the site visit/s, when it was conducted and what the conditions were on the day of the visit (weather, traffic, etc.)<br>• The findings of any accident data analyses/NLAs conducted that prompted the RSI |
| Issues and recommendations (these may be tabulated to allow responses to be added) | • An A3 or A4 location map marked up with references relating to the issues identified<br>• Each specific road safety problem identified separately, supported with reasoning, stating:<br>○ The location of the problem<br>○ The nature of the problem<br>○ The type of accident that is likely to occur (or has already occurred) as a result of the issue<br>○ Where available, illustrative photograph(s)<br>○ Where appropriate (and/or required) details of any conflict study findings<br>○ The assessed risk level (obtained by use of risk matrices) |
| Recommendations for action to mitigate or remove the issue | • A list of the documents considered for the inspection |

| | |
|---|---|
| | • Analysis of any operational data available along with issues identified during observations of traffic using the site. |

4.3.1.8 Feedback

On completion of the Inspection Report the RSI Manager and Inspector(s) will give feedback to the NLA Team and recommendations will be taken forward into the development of a Treatment Plan as described. This feedback will include a review of the types of features identified and whether any additional hazards have been identified through the detailed RSI that could be identified using NLA in the future. This will enable the NLA Team to re-assess the NLA procedure and make improvements or adjustments as may be required.

## 4.4 Development of a treatment plan

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

The Inspection Team will need to take the findings and recommended treatments from the RSI and develop a treatment plan that can be implemented over a defined period. Before conducting NLAs and subsequent RSIs, it is necessary to ensure that a budget is in place to implement recommended treatments.

It will rarely be possible to implement all treatments and so it will be necessary for the Inspection Team to prioritise a programme of treatments. One way of doing this will be through Economic Appraisal to ensure that the best impact is achieved for the investment. There will be some recommendations that can be put into a dedicated schedule of safety improvements. Others may require immediate action. Further treatments may be more suited to incorporation into maintenance activities at little, or no, additional cost.

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

### 4.4.1 Economic appraisal

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

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

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

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

#### 4.4.1.1 Estimating accidents

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

Another reason it is extremely important to improve the quality and accuracy of accident data (see TRH 29, Volume 1). Without accident data any economic appraisal can only be a basic estimate. If accident data are available, this will much improve the accuracy of the EA.

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

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

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

For example: The average number of fatal, serious or slight injury run-off road accidents per kilometre per year across the network is 1.75

The section in question is 3km in length and is considered to have a high traffic volume (if precise traffic volumes are known then a more sophisticated method can be adopted)

Then it would be anticipated that 1.75 (run off accidents per km) * 3 (3 kms length) * 2 (factor of two to reflect high traffic volume) = 10.5 fatal, serious or slight run-off accidents would occur on the road section.

If required, the number of accidents can then be multiplied by a factor to estimate the number of casualties (since, on average, more than one casualty will be involved in each accident).

This factor can be derived from dividing the number of causalities by the number of accidents nationally. If there are 11,000 fatal, serious or slight accidents every year and 15,500 fatal, serious or slight casualties, the factor would be 1.41 (15,500/11,000). So, on the 3km stretch, 14.8 fatal, serious or slight casualties would be expected.

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

#### 4.4.1.2 Effectiveness of treatments

Countries which have been performing road safety management and evaluation for many years may have gathered evidence on the effectiveness of treatments. In this case it is beneficial to use local evidence concerning the effectiveness of a treatment. However, the availability of such information in Africa is likely to be limited. Instead, it is necessary to use information about the effectiveness of treatments from other regions of the world and apply road safety engineering judgement and experience when considering the impact in the African context (African Development Bank (b), 2014).

One significant benefit to improving the quality and analysis of accident data is that it will become possible to evaluate the impact of treatments in the African context.

Building a regional resource containing evidence on the impact of treatments should be considered a priority. Sharing such results will allow for the building of an evidence base quickly. Earlier sections provide guidance on simple approaches to evaluation that can be used to start to build an evidence base.

There are several international sources on the effectiveness of treatments. The first source that can be consulted is the iRAP Road Safety Toolkit[8]. The iRAP Toolkit compiles best practice information on road safety treatments from across the world. In the toolkit there is information about the effectiveness of a treatment, relative cost, implementation issues and references to sources that provide more detail.[9]

In the example used in the estimating accidents section (Section 4.4.1.1), 10.5 fatal, serious or slight accidents are expected on a 3km section in a given year. If installing a VRS has an effectiveness of 40-60% in reducing run-off accidents (see iRAP toolkit), then a conservative estimate is that 40% of the 10.5 accidents would be saved per year = 4.2.

#### 4.4.1.3 Economic appraisal methods

**Full cost benefit analysis**

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

To do full CBA, the following information is required:

- To calculate costs:
    - Treatment implementation cost
    - Approximate annual maintenance costs
    - Treatment lifespan
- To calculate benefits
    - Treatment effectiveness
    - Treatment lifespan

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[8] https://toolkit.irap.org.

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

- Value of a life, serious injury, slight injury and damage only accident

- Standard official CPI factors/GDP growth factors/Discount rates.

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

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

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

The major factors determining present value are the timing of the expenditure and the discount (interest rate). The higher the discount rate, the lower the present value of expenditure at a specified time in the future. If the discount rate for roads is 6% then R1 of value this year, if it accrues next year would be valued at 6% less (i.e., 94 cents and the following year 88 cents, etc.).

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

**First Year Rate of Returns**

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

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

The formula is:

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

### Cost Effectiveness

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

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

The main parameters required are:

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

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

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

- Number of relevant accidents per year.......................................................... 10.5
- Expected reduction or measure effectiveness................................................40%
- Expected saved accidents per year......................................................................4.2
- Cost of measure.........................................................................................R400,000
- Cost Effectiveness is.........................................................R9,524 (400,000/4.2)

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

This method does not require accident cost estimates, although estimates of the effectiveness of treatments are required. Disadvantages include that the approach does not consider accident severity. Clearly this does require an estimate of the number of accidents, and this is currently one of the main challenges to be faced.

### 4.4.2 Implementing a Treatment Plan

Once a treatment plan has been devised and prioritised, implementation should follow. Where there are major changes to a site, section or road, these should be subjected to Road Safety Audit (see Volume 3).

All road safety treatments should be subjected to Monitoring and Evaluation (see Section 6 of this TRH 29, Volume 1) as an integral part of implementation

# 5 Monitoring and evaluation

Monitoring and evaluating the impact of treatments is critical to refining and improving the treatment of high-risk locations or sections over time. Building an evidence base on the effectiveness of treatments under different conditions in the African context is particularly important. Ideally such evidence will be shared among similar countries through a road safety observatory or through collaborative initiatives (African Development Bank (b), 2014). Reliable accident data are required for formal evaluation.

## 5.1 Monitoring

Monitoring is the operational checking that a scheme is performing as expected. This may involve site visits to physically monitor the site to ensure road users understand the change and also the review and analysis of accident data (World Road Association , 2012).

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

## 5.2 Evaluation

Evaluation is a formal process to check the impact of a treatment/combination of treatments on accident and casualty numbers. It is used by practitioners to understand what has worked, and what has not. It is a vital part of effective road safety management because intelligence on the impact of treatments under different conditions is important if limited resources are to be spent in the most effective manner possible (World Road Association, 2012).

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

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

The three most used statistical approaches to structure before/after testing are the 'Naïve', the 'Yoked Site/Comparator' and the 'Unpaired Site/Comparator' methods. All of these require accident data.

These are summarised as follows (World Road Association, 2012):

- The naive before/after method is discredited because it fails to consider any external potentially confounding issues. The accidents before the treatment are compared simply with the accidents in the after period. The results from this method are likely to be very inaccurate since no account of any longer-term trends is taken.
- For the yoked site/comparator method, treated sites are paired (individually) with similar but untreated sites for the analysis. Thus, the number of accidents in the after period needs to be reduced significantly when compared with any reductions observed at the comparator. This method takes account of some confounding effects, though it does not take account of regression to the mean 2. It is technically difficult to identify suitable untreated comparator sites since often all sites with a particular problem will be treated in a programme.
- In the unpaired site/comparator method, the analysis is like the yoked design; however, the comparator does not need to be similar to the site in its features. It does, however, need to be significantly larger than the site with many more accidents in it. It is much easier to identify the required comparators for this method (adapted from ITE, 2009).

The chi-squared ($X^2$) test has been used to assess whether the after accidents have changed significantly. This is quite an easy test to perform which does not require any assumptions to be made about the underlying statistical distribution of the data (Odonkor, 2020).

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

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

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# APPENDIX V2-A: REMINDER LIST

Experience has shown that whilst very long checklists can appear to be thorough, the use of such lists is problematic (African Development Bank (b), 2014).

- 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 reminder list).

- Some people can be over reliant on checklists

There is a risk that checking against a lengthy list of reminders 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, including many comments which are not relevant to the road which is being considered.

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

Two sets of reminder lists have been developed:

- The first set (B1) are high level road safety issues
- The second set (B2) is a high-level list of physical road elements that should be examined during the site visit

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

### A1 High-level reminders - 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.)
- o 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, motorcyclist, 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

A2 High level reminder list - Physical road elements to consider during the site inspection

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

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

- Signing: Clear and understandable for all road users; visible in the day and at night; visible
- under different weather conditions (e.g., heavy rain, fog, smoke, smog, 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 V2-B: TYPICAL ROAD SAFETY SOLUTIONS/TREATMENTS

This appendix contains a compendium of a selection of typical engineering measures for consideration as effective safety improvements in various circumstances and in response to different types of accidents. The examples given are neither exhaustive nor complete. The pictures are included for demonstration purposes and any picture is not necessarily displayed to suggest a good or poor practice example. The described typical engineering measures should be applied with circumspection as their appropriateness is dependent upon particular local and/or site-specific circumstances.

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

Each treatment is described in brief with notes on benefits and implementation issues. Although a treatment could have a positive impact on one accident type, there might be negative consequences for other accident types and road users. For instance, converting a single carriageway to a dual carriageway to reduce head-on accidents can result in an increase in pedestrian risk and potentially higher speed lane change accidents.

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

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| Central painted island (with diagonal bars) | Low | • Fewer head-on and overtaking accidents.<br>• Can provide refuge for turning vehicles away from through traffic lanes.<br>• Some reduction in speeds.<br>• Possible (though limited) protection for pedestrians. |  | • If rumble strips, or other raised pavement devices are also used, the risk to motorcycles and pedestrians (trip hazard) must be considered.<br>• Can be used for opportunist overtaking opportunities increasing risk of accidents.<br>• Maintenance of markings. |

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| Converting a single carriageway road into a dual carriageway road | High | • Separation of the opposing traffic flows, and therefore reduced head-on accidents.<br>• Simpler traffic movements leading to less opportunity for conflict.<br>• Redirection of turning movements to safer locations.<br>• Protection for turning traffic.<br>• Reduced traffic congestion. | <br> | • This treatment is costly, and other lower cost treatments (such as median barrier installation) should also be considered.<br>• Requires a large amount of land.<br>• Potential to increase pedestrian and lane change accidents.<br>• Community acceptance of the medians that restrict turning movements or restrict pedestrian movements may be an issue. |

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| Delineation (includes signing, road marking, marker posts, etc.) | Low | • Road markings are very cost effective.<br>• Delineation improvements have been shown to reduce head-on road accidents.<br>• Helps drivers to maintain a safe and consistent lateral vehicle position within the lane.<br>• Reduction in night-time and low-visibility accidents. |  | • Road markings are ignored (and physical barriers to crossing the centre line are needed).<br>• Poorly designed or located delineators can add to crash risk.<br>• Too many signs can confuse drivers.<br>• Road studs require an excellent quality road surface.<br>• Delineation needs to be consistent throughout an entire country.<br>• The retro-reflectivity of lines and signs is an important consideration for road use at night and in the wet.<br>• Maintenance of markings. |

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| Grade separation | High | • Improved traffic flow.<br>• Simplifies potentially complex movements typical at T-junctions and intersections.<br>• Can also include roundabouts<br>• for high traffic flows.<br>• 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.<br>• Adding on-ramps and off-ramps to a freeway can increase high speed weaving and merging accidents.<br>• Interchanges can negatively impact the appearance of an area.<br>• They may separate communities due to their size.<br>• Difficult for pedestrians unless specific routes are provided.<br>• Grade separating rail crossings can involve vertical realignment of a long length of rail track (because trains cannot travel on steep grades), which is very costly. |
| Horizontal realignment | High | • Better traffic flow.<br>• Horizontal realignments often include lane widening, shoulder improvement, and delineation treatments. |  | • Road realignment is costly and time consuming because it usually involves rebuilding a section of road.<br>• Horizontal curve realignments require considerable design and construction effort.<br>• These projects may also require the purchase of land. |

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| Intersection visibility Improvement - Sight Distance | Low to medium | • Adequate sight distance provides time for drivers to identify hazards and take action to avoid them.<br>• Improved sight distances on the approaches to intersections and through<br>• curves can reduce accidents at these high-risk locations.<br>• Good forward visibility at pedestrian crossing facilities will give drivers more time to react.<br>• Rear end accidents can be reduced with | <br> | • Sight distance improvement can be high cost if crest and/or curve realignments are required or if the line of sight is outside the road reserve requiring land acquisition to remove obstructions such as embankments, buildings etc.<br>• In some situations, such as intersection approaches, excessive forward visibility can lead to high speeds on approach and take attention away from the intersection.<br>• In specific cases, adjustments to reduce sight distances can be helpful in reducing approach speeds. Care must be exercised when taking this approach.<br>• At intersections sight lines and visibility splays are often required at larger angles to the user's normal viewpoint (for example, in a motor vehicle the driver may have to look through the side windows).<br>• Ensure traffic signs and signal heads are not obstructed by vegetation or street furniture. |

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| | | improved forward visibility. | | |
| Lane Widening | Medium to high | • Additional manoeuvring space.<br>• Space for two wheeled users. |  | • Lane widening can be costly, especially if land must be purchased.<br>• Making lanes wider than 3.6 metres does little to reduce accidents.<br>• A lane that is too wide might be used as two lanes and this can increase sideswipe accidents.<br>• Because vehicle speeds increase when roads are widened, lanes should be widened only when it is known that the narrow lane width is causing accidents. |
| Median crossing control | Low to medium | • Reduction in intersection crash types.<br>• Improves local access.<br>• Provides an additional emergency access point leading to improved emergency service response times. |  | • Additional road space may be required.<br>• If the median crossing is used to access a side road, then intersection considerations for cross movements (such as visibility and stopping distance) will apply.<br>• Roadside hazards need to be removed or sufficiently protected.<br>• Drainage structures and steep slopes within the median can increase risk.<br>• The slopes should be as flat as possible.<br>• If the slope cannot be made traversable, it should be protected by safety barrier. |

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| Shoulder sealing | Medium | • Wider shoulders provide opportunity for an errant vehicle to recover. |  | • Shoulder widening and shoulder sealing can be done at the same time to reduce costs.<br>• Edge-lines can be improved at the time of upgrading the shoulder (especially when sealing).<br>• Shoulders should not be too wide or drivers may use them as an additional lane.<br>• Sealing can reduce 'edge drop' (where there is a difference between the height of the road surface and the height of the shoulder).<br>• Edge drop can make it harder for vehicles which have left the road to get back onto the road. Pulling of the road requires coming to almost a full stop before getting off the travelled way. |

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| Median vehicle restraint system (VRS) (safety barrier) | Medium to high | • Reduced incidence of head-on accidents.<br>• Can help to prevent dangerous overtaking manoeuvres.<br>• Can relocate turning<br>• Movements to safer locations. | <br> | • Median barriers can restrict traffic flow if a vehicle breaks down and can block access for emergency vehicles.<br>• Pedestrians are often reluctant to make detours and may attempt to cross median.<br>• In some regions the materials used in median barriers may be at risk of being stolen.<br>• The ends of median barriers must be well designed and installed.<br>• Clearly visible signs and enforcement are needed to ensure that drivers do not drive on the wrong side of the median.<br>• Not all barrier types will restrain all vehicle types.<br>• Barriers may be a hazard to motorcyclists. |

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| One-way system | Medium | • Reduces head on accidents.<br>• Improves traffic flow. | <br> | • Because speeds can increase on one-way networks, traffic calming measures may be required (especially if the lanes are wide).<br>• Before a network is made one-way, traffic circulation in the area surrounding the network must be considered.<br>• Converting a network to one-way system can be costly as it may involve rebuilding traffic signals, repainting road markings and replacing and adding signage. |

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| Parking control | Low to Medium | • Converting angle parking to parallel parking provides extra road space.<br>• Banning parking lessens the potential for sideswipe or rear-end accidents. | <br> | • Parking at the side of a road means pedestrian activity is inevitable.<br>• Therefore, speed limits should not exceed 50km/h where parking is provided.<br>• Converting angle parking to parallel parking requires replacement of line marking.<br>• Changes to parking signs and kerbs may also be necessary.<br>• The community and business owners often object to the removal of parking in commercial centres.<br>• Parked cars can obscure crossing pedestrians, particularly children. |

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| Pedestrian crossing – unsignalised | Low | • A clearly defined crossing point where pedestrians are 'expected' to cross.<br>• Disruption to traffic flow is comparatively low.<br>• Reduced pedestrian accidents if installed at appropriate locations, and if pedestrian priority is enforced. | <br> | • Unsignalised crossings – Not suitable where traffic volumes or speeds are high.<br>• Signalised crossings – compliance with signals must be good if significant casualty reductions are to be achieved.<br>• Pedestrians will only use crossings located at, or extremely near, to where they want to cross.<br>• Pedestrian fencing can be used to encourage use of pedestrian crossings.<br>• Consider incorporating a pedestrian refuge island.<br>• Through-traffic must be able to see pedestrian crossing points in time to stop.<br>• Advance warning signs should be used if visibility is poor. Other high visibility devices (such as flashing lights) may also be used.<br>• Parking should be removed/prohibited from near pedestrian crossings to provide adequate sight distance.<br>• Crossing will only be effective if other road users give way to pedestrians. education and enforcement may be necessary to ensure pedestrians have priority. |

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| Pedestrian crossing – signalised | Medium | • Clearly defined crossing point where Pedestrians are 'expected' to cross.<br>• Reduced Pedestrian accidents if installed at appropriate locations, and if pedestrian priority is enforced. |  | • Visibility devices (such as flashing lights) may also be used.<br>• Parking should be removed/prohibited from near pedestrian crossings to provide adequate sight distance.<br>• Crossing will only be effective if other road users give way to pedestrians.<br>• Education and enforcement may be necessary to ensure pedestrians have priority. |

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| Pedestrian fencing | Low | • Helps to guide pedestrians to formal crossing points.<br>• Can help to prevent unwanted pedestrian crossing movements.<br>• Physically prevents pedestrian access to the carriageway.<br>• Can help to prevent motorists from parking on the footpath.<br>• Provides useful guidance for visually impaired pedestrians. |  | • It is important that pedestrian fencing does not obstruct the drivers' view of pedestrians on the footpath, or those about to cross the road.<br>• The fence height, placement and construction material should be selected to minimise any potential sight obstruction between vehicles and pedestrians about to cross the road.<br>• Consideration should be given to the design of the fencing to ensure that the risk to errant vehicles is limited upon impact.<br>• When used at staged or staggered crossings on pedestrian refuges, fences should be aligned so that pedestrians walk along the refuge in the opposite direction to the flow of traffic they are about to cross and face oncoming traffic as they are about to leave the median. |

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| Pedestrian over-bridge/underpass | High | Traffic flow improvements. |   | • Pedestrians will only use crossing facilities located at, or extremely near, to where they want to cross the road.<br>• This is particularly the case for over-bridges since steps are normally involved.<br>• Pedestrian fencing can be used to encourage pedestrians to use crossing facilities.<br>• Cyclists may also be able to use the facilities – ramps would be required which need more land space.<br>• Personal security at underpasses should be considered. |

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| Pedestrian refuge island | High | • Separating traffic moving in opposite directions to reduce head-on and overtaking accidents.<br>• May slow vehicular traffic by narrowing the lanes.<br>• 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.<br>• Refuge islands should be placed where there is a demand from pedestrians to cross.<br>• Where cyclists are present, refuge islands must not narrow the lanes too much.<br>• Turning movements from driveways and intersections must be considered in planning the location of pedestrian refuges. |

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| Regulate roadside activity | Low | • Removal of commercial activity or relocation of bus stops at the side of the road may remove the need for drivers to take last minute evasive action to avoid these.<br>• Reduction in VRU accidents. |  | • Roads should be designed to allow for changes in land-use over time.<br>• Building regulations should specify the limits beyond which buildings must not extend.<br>• Illegal development can only be controlled if there are alternative sites for commercial activity.<br>• Where activities near the road are permitted, countermeasures may be required to maintain safety and they should be restricted to one side of the road. |
| Restrict /Combine Direct Accesses | Medium to high | • Reduces the number of potential conflict points.<br>• Reduces traffic friction and improves flow on the main road.<br>• Improved traffic management at upgraded access points. |  | • In most situations, it would be difficult to justify and fund construction of a service road on its own merits due to prohibitive cost.<br>• This type of project is undertaken as part of a major road duplication project.<br>• Minor intersection closures can often be achieved in operation with the local road authority, especially when safety at these intersections has been a subject of repeated complaint. |

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| Roadside hazard protection (vehicle restraint systems – roadside safety barriers) | Medium | • If properly designed, installed and maintained, barriers should reduce the severity of accidents involving 'out of control' vehicles.<br>• Provides protection for substantial structures. |  | • VRS should only be built if the existing hazard cannot be removed<br>• The terminals or end treatments of VRS can be dangerous if not professionally designed, constructed and maintained.<br>• VRS should be located to minimize high impact angles and should also allow space for vehicles to pull off the traffic lane.<br>• Roadside barriers can be a hazard to motorcyclists.<br>• Ensure appropriate clearance behind safety barrier is considered particularly for flexible and semi-rigid barriers.<br>• Although concrete barriers do not deflect, allowance must be made for any hazards taller than the barrier to be offset far enough from the face of the barrier so that during impact vehicles (particularly tall ones) do not lean over the barrier and strike the hazard. |

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| Roadside hazard removal | Low to medium | • Reduced road furniture repair costs associated with crash damage.<br>• Improved recovery potential for vehicles.<br>• Improved survivability of run-off road accidents. |  | • The width of the safety zone required depends on traffic speeds.<br>• After roadside hazards are removed, the roadside should be left in a safe condition.<br>• Large stumps and deep holes are hazards that may remain after removal of a tree.<br>• Replacement of removed trees with more appropriate plants should be considered, otherwise re-growth or soil erosion may affect the site.<br>• It is not always possible to remove roadside hazards, particularly in urban areas where space is limited.<br>• Reducing vehicle speeds is an alternative solution. |

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| Roundabout | Medium to high | • Minimal delays at lower traffic volumes.<br>• Little maintenance required.<br>• Crash severity is usually lower than at crossroad 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.<br>• High painted kerbs around the island can reduce the risk of it being run into.<br>• Poor visibility on the approach to roundabouts, or high entry speeds, can lead to accidents.<br>• Facilities to help pedestrians cross the legs of the intersection should be provided in most urban locations.<br>• Roundabouts can be difficult for large vehicles, particularly buses, to use.<br>• Designers should be conscious of the risk that roundabouts can be present for cyclists and other slow vehicles, such as animal drawn vehicles.<br>• Care must be taken in the design of roundabouts to ensure adequate deflection upon approach to reduce vehicle speeds |

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| Rumble strips | Low | • Can be parallel or transverse.<br>• Warning to motorists approaching the centreline.<br>• Improved visibility of centre lines.<br>• Raised awareness on the approach to other hazards or devices i.e., road humps. | <br> | • Gaps in the rumble strips may be needed in some areas to allow water to drain from the road surface.<br>• The noise made by rumble strips can be difficult for drivers of larger vehicles to hear.<br>• Consideration must be given to those living near to the road as rumble strips can generate noise.<br>• Rumble strips can be a hazard to motorcyclists. |

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| School zones | Low to medium | • School zones and crossing<br>• Supervisors can reduce Pedestrian risk.<br>• School zones aim to reduce vehicle speeds.<br>• School crossing supervisors can help to control pedestrian crossing movements and provide a safe place to cross. | <br> | • Traffic signs and road markings must make it clear to motorists that they have entered a school zone.<br>• Consider incorporating flashing beacons to complement the school zone signs and markings.<br>• Through-traffic must be able to see pedestrian crossing points in time to stop for them.<br>• Advanced warning signs should be located on approaches with adequate forward visibility.<br>• Parking provision should be carefully considered within school zones with adequate sight distances at pedestrian crossings. |

| | | | | |
|---|---|---|---|---|
| Segregated diverge approach side - signalised | Low to medium | • Reduced accidents Between turning vehicles and oncoming through-traffic.<br>• Reduced severity of accidents throughout the intersection. |  | • Adding diverge signals reduces intersection capacity.<br>• It may be necessary to lengthen diverge lanes to fit longer traffic queues.<br>• Other signal changes can be used to improve intersection capacity when signalised turns are implemented. |

| | | | | |
|---|---|---|---|---|
| Segregated diverge approach side - unsignalised | Low to medium | • Reduced loss of control while turning accidents.<br>• Improved traffic flow. Increased intersection capacity | <br> | • Painted diverge lanes must be clearly delineated and have good sight distance.<br>• Diverge lanes should be long enough to allow a vehicle time to stop within it (clear of through-traffic).<br>• If a diverge lane is too long, through drivers may enter the lane by mistake.<br>• Signs at the start of the diverge lane may help prevent this.<br>• Installing diverge lanes can increase the width of the intersection and cause problems for pedestrians trying to cross.<br>• One solution is to provide a pedestrian refuge island between lanes. |

| | | | | |
|---|---|---|---|---|
| Segregated pedestrian facilities | Low to medium | • Improves facilities for pedestrians (improves accessibility).<br>• May help to increase walking as a mode of transport (environmental benefits and reduced traffic congestion).<br>• Walking can improve health and fitness. |    | • Routine maintenance programme is needed to ensure that footpaths are kept clean and level, free from defects and to prevent vegetation from causing an obstruction.<br>• Signage should be used to warn drivers of pedestrians if the road shoulder is commonly used as an informal footpath.<br>• Street traders, public utility apparatus and street furniture should not be allowed to obstruct the footpath. |

| | | | | |
|---|---|---|---|---|
| Segregated facilities – bicycle/ motorcycles | Low to medium | • Increased use of pedal and motorcycles (reduced road congestion).<br>• Associated health and Environmental benefits that come with increased pedal cycle use. | <br><br> | • On-road cycle lanes are cheaper than off-road paths if shoulder sealing is not required. Though this does still lead to some interaction with motorised traffic.<br>• Traffic calming treatments or narrow road sections such as bridges can force pedal and motorcycles out into traffic, resulting in conflicts.<br>• Parked vehicles may also force pedal and motorcycles out into main traffic, and so parking enforcement is very important for the success of on-road lanes.<br>• Surface quality must be high or it will pose a safety risk.<br>• Cycle lanes should be maintained to ensure that it is preferable to use the facilities rather than the shoulder or roadway.<br>• Maintenance includes repairs to the pavement surface and vegetation clearance.<br>• Adequate sight distance must be provided around bends and at path intersections.<br>• This also aids personal security.<br>• Cycle paths should be clear of obstructions and service covers. This includes keeping others such as vendors and adjacent land owners from encroaching on the path.<br>• Where an obstruction is necessary,<br>• it should be made obvious, and lines should be used to guide cyclists safely past. |

| | | | | |
|---|---|---|---|---|
| | | | | • Adequate crossing facilities need to be provided. |
| **Service road** | High | • Can reduce the number of conflict points (intersections) along a route.<br>• Can be used by local traffic and vulnerable road users as an alternative to the (often higher speeds and higher volume) main road.<br>• Safer loading/ unloading of commercial vehicles. |  | • Service roads require large amounts of space.<br>• Where space is limited, a service road may fit behind the properties.<br>• Parking and other potential visual obstructions should be carefully controlled where service lanes re-join the main road. |

| | | | | |
|---|---|---|---|---|
| Shoulder sealing | Medium | • Wide shoulders allow vehicles to pull off the road in emergency situations.<br>• Sealed shoulders can provide a cycling space and can be marked as cycle lanes.<br>• Provide structural support to the road pavement.<br>• Sealing can reduce 'edge drop'.<br>• Edge drop can make it harder for vehicles to get back onto the road. | <br> | • Shoulder widening and shoulder sealing can be done at the same time to reduce costs.<br>• Edge-lining can be improved at the time of upgrading the shoulder (especially when sealing).<br>• Shoulders should not be too wide, or drivers may use them as an additional lane.<br>• Controls may be necessary to prevent informal businesses from using shoulders. |

| | | | | |
|---|---|---|---|---|
| Shoulder sealing | Medium | • Wide shoulders allow vehicles to pull off the road in Emergency situations.<br>• Sealed shoulders can provide a cycling space and can be marked as cycle lanes.<br>• Provide structural support to the road pavement. Sealing can reduce 'edge drop'.<br>• Edge drop can make it harder for vehicles to get back onto the road Wide shoulders allow vehicles to pull off the road in Emergency situations. | <br> | • Side slopes should be free of hazards and objects that may cause vehicle snagging.<br>• Maximum traversable gradient is 1:3.<br>• On downward slopes, a clear run-out area may also be required at the base of the slope.<br>• The provision of traversable side slopes may require the removal of native flora, which can result in erosion, sedimentation of waterways and removal of animal habitats.<br>• The provision of traversable side slopes may have property impacts and require extensive land acquisition.<br>• In areas where the side slope transitions from an upward slope to a downward slope (and vice versa), the rate of change in gradient of the crossfall should be gradual to ensure that the side slope can be traversed |

| | | | | |
|---|---|---|---|---|
| Side slope improvement | Medium | • 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 accidents.<br>• Flatter side slopes are generally less likely to erode.<br>• The cost of providing a traversable slope maybe less than the cost of establishing and maintaining steep slopes. | <br> | • Side slopes should be free of hazards and objects that may cause vehicle snagging.<br>• Maximum traversable gradient is 1:3.<br>• On downward slopes, a clear run-out area may also be required at the base of<br>• the slope.<br>• The provision of traversable side slopes may require the removal of native flora, which can result in erosion, sedimentation of waterways and removal of animal habitats.<br>• The provision of traversable side slopes may have property impacts and require extensive land acquisition.<br>• In areas where the side slope transitions from an upward slope to a downward slope (and vice versa), the rate of change in gradient of the crossfall should be gradual to ensure that the side slope can be traversed. |

| | | | | |
|---|---|---|---|---|
| Signalisation | Low to medium | • Can increase intersection capacity.<br>• Can reduce certain types of accidents (especially right-angle accidents).<br>• Can improve pedestrian and cyclist safety. | <br><br> | • Signalising an intersection may have no safety benefit where compliance is poor and can reduce the capacity of an intersection.<br>• Drivers need to be educated so they understand the meaning of the signals.<br>• Signals used at intersections with low traffic flows and fixed timings are likely to be disobeyed.<br>• Well-designed traffic signals will usually reduce total accidents but will sometimes increase specific (low severity) crash types (e.g., rear-end accidents).<br>• Traffic signals should not be used in high speed locations.<br>• In urban areas it can be difficult to ensure that traffic signals have sufficient visibility.<br>• Before installing traffic signals, information on traffic volumes, pedestrian volumes, intersection approach speeds and previous accidents at the site should be considered.<br>• Traffic signals need continuous power.<br>• 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.<br>• If reflective, they can help reduce night-time/ poor visibility accidents. | <br> | • Poorly designed or located signs can add to crash risk.<br>• The message they convey needs to be clear and unambiguous<br>• Too many signs can confuse drivers.<br>• The retro-reflectivity of signs is an important consideration for road use at night and in the wet.<br>• Maintenance of signs in rural and isolated areas can be problematic.<br>• Signs may be stolen in some areas. |

| | | | | |
|---|---|---|---|---|
| Skid resistance | Low to medium | • Improved safety for roads where many accidents happen in wet weather.<br>• Resurfacing provides an opportunity to fix other road surface problems, such as crossfall and rutting.<br>• Provides the opportunity for adding or replacing road surface delineation such as painted markings or reflective road studs.<br>• Can extend life of pavement surface. | <br> | • Skid resistance improvements gained by retexturing and resurfacing will lessen over time, especially on roads with lots of heavy vehicle traffic and in tropical climates.<br>• As such, regular monitoring of skid resistance is important.<br>• The skid resistance of the entire road surface (right up to the edge) should be maintained for the safety of bicycles and other slow-moving vehicles.<br>• Warning signs should not be considered a solution to the problem of poor skid resistance.<br>• Warning signs can be used temporarily, until other solutions are carried out.<br>• Existing road surface must be sound - therefore pre-patching and repairs may be necessary prior to application.<br>• These treatments will not typically add any strength to the road pavement. |

| | | | | |
|---|---|---|---|---|
| | | • Retexturing has environmental benefits<br>• (Lower cost and energy) over some traditional hot mix asphalt resurfacing.<br>• Often quick and repeatable Treatments with low traffic disruption.<br>• In most cases roads can be driven on immediately after application. | | |

| | | | | |
|---|---|---|---|---|
| Speed management | Medium | • Reductions in travel speeds save lives and prevent injuries.<br>• Lower speeds can reduce the severity of all accidents.<br>• Reduced speeds will also reduce the likelihood of accidents occurring.<br>• The wider benefits of reducing speeds include<br>• improved fuel consumption, lower greenhouse gas emissions and less traffic | <br> | • Reduced speed limits need to be signed clearly and repeater signs used to remind road users of the speed limit.<br>• Road engineering treatments should ideally accompany reduced speed limits to encourage compliance.<br>• Enforcement may be necessary to achieve compliance.<br>• Speed limits should appear credible so that drivers will adhere to them.<br>• 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).<br>• Vertical traffic calming measures (e.g., speed humps, bumps and tables) should only be used in low-speed environments.<br>o Horizontal traffic calming measures (e.g., chicanes and pinch-points) may offer significant benefits.<br>• Traffic calming devices can impede emergency vehicles and cause discomfort for bus passengers. |

| | | | | |
|---|---|---|---|---|
| | | | | • Some traffic calming devices are hazardous to motorcyclists.<br>• Community support and consultation is recommended before speed limits are changed or traffic calming installed. |

| | | | | |
|---|---|---|---|---|
| Street lighting | Medium | • Street lighting helps to reduce night-time accidents by improving visibility.<br>• Can reduce pedestrian accidents by 50%.<br>• Can help to aid navigation.<br>• Street lighting helps people to feel safe and can help to reduce crime.<br>• Route lighting can help to reduce glare from vehicle headlights. |  | • The provision of street lighting poles can introduce hazards to the roadside.<br>• Frangible poles should be considered particularly in areas where there is low pedestrian activity. Alternatively, the poles can be protected by roadside safety barrier.<br>• It is important to achieve the correct spacing of lamp columns to prevent uneven lighting levels along a route.<br>• 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.<br>• Adequate clearance must be provided to overhead lines.<br>• Low pressure sodium lamps may be used to reduce light pollution particularly in urban areas. |

| | | | | |
|---|---|---|---|---|
| Right turn lanes – signalised | Low to medium | • Reduced accidents between turning vehicles and oncoming through-traffic.<br>• Reduced severity of accidents throughout the intersection. |  | • Adding turn signals reduces intersection capacity.<br>• It may be necessary to lengthen turn lanes to fit longer traffic queues.<br>• Other signal changes can be used to improve intersection capacity when signalised turns are implemented. |

| | | | | |
|---|---|---|---|---|
| Right turn lanes – unsignalised | Low to medium | • Reduced accidents between turning vehicles and oncoming through-traffic.<br>• Reduced severity of accidents throughout the intersection. |  | • Painted turn lanes must be clearly delineated and have good sight distance.<br>• Turn lanes should be long enough to allow a vehicle time to stop within it (clear of through-traffic).<br>• If a turn lane is too long, through drivers may enter the lane by mistake.<br>• Signs at the start of the turning lane may help prevent this.<br>• Installing turn lanes can increase the width of the intersection and cause problems for pedestrians trying to cross.<br>• One solution is to provide a pedestrian refuge island in the median. Adding turn signals reduces intersection capacity.<br>• It may be necessary to lengthen turn lanes to fit longer traffic queues.<br>• Other signal changes can be used to improve intersection capacity when signalised turns are implemented. |

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

# APPENDIX V2-C: NETWORK LEVEL ASSESSMENT FIELD INVESTIGATION FORM

## Network Level Assessment Form Record Sheet

Assessment route..........................................................................................................

Assessment section ......................................... RAMS description ......................................

Start point....................................................................................................................

End point.....................................................................................................................

Date.............................................................................................................................

Commencement time ....................................................................................................

Finish time....................................................................................................................

NLA Team Leader..........................................................................................................

NLA Team Member .......................................................................................................

**General prevailing conditions**

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

Mark one

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

***Road type (single, carriageway, freeway)***

Mark one

| | |
|---|---|
| Single carriageway | ☐ |
| Dual carriageway (non-freeway) | ☐ |
| Freeway | ☐ |

***Functional classification according to TRH 26 (R1, R2, R3, R4, R5, R6, U1, U2, U3, U4, U5, U6)***

| Mark one | **R_** | **U_** |
|---|---|---|
| Class 1 | ☐ | ☐ |
| Class 2 | ☐ | ☐ |
| Class 3 | ☐ | ☐ |
| Class 4 | ☐ | ☐ |
| Class 5 | ☐ | ☐ |
| Class 6 | ☐ | ☐ |

***Type of development***

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

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

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

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

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

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

***Number of through lanes***

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

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

***Lane width***

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

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| 2.75 m | | | ………………………………… |
| 3.2 m | | | ………………………………… |
| 3.7 m | | | ………………………………… |
| Other (please specify) | | | ………………………………… |

***Environment***

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

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

**Transitions**

***Transitions - speed limit changes***

No speed limit changes

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

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

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

| | Yes | No | Notes |
|---|---|---|---|
| Speed limit set according to SARTSM Volume 2, Chapter 20 | ☐ | ☐ | ................................... |

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

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

***Speed limit compliance***

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

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

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

Speed limit higher than 50 km/h ☐

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

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

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

***Signing and road markings***

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

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

***Readability of the section***

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

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

***Forward visibility***

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

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

<u>Curves</u>

***Curve type***

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

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| Section mostly straight with no curves | ☐ | ☐ | ..................................... |
| Curves are slight | ☐ | ☐ | ..................................... |
| Curves are sharp | ☐ | ☐ | ..................................... |

***Curve quality***

No curves ☐
Curves all at good standard ☐
There are notable problems (marked below) ☐

Mark <u>all that apply</u> to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| Curves are inconsistent along section | ☐ | ☐ | ..................................... |
| Curves are difficult to drive at prevailing traffic speeds | ☐ | ☐ | ..................................... |
| Poor advance warning/signing | ☐ | ☐ | ..................................... |
| Presence of curve hidden | ☐ | ☐ | ..................................... |

<u>Road sides</u>

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

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

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

***Vehicle restraint systems (VRS)***

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

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

***Slope***

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

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| 1:3 or more (steep) | ☐ | ☐ | ………………………………… |
| 1:3 to 1:5 (moderate) | ☐ | ☐ | ………………………………… |
| 1:5 or less (flat) | ☐ | ☐ | ………………………………… |

**Intersections and accesses**

***Intersection type***

No intersections ☐

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

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| At-grade non signalised, no road markings | ☐ | ☐ | ………………………………… |
| At-grade non signalised intersection, road markings | ☐ | ☐ | ………………………………… |
| At grade signalised intersection | ☐ | ☐ | ………………………………… |
| Roundabout | ☐ | ☐ | ………………………………… |
| Merge/diverge | ☐ | ☐ | ………………………………… |
| Grade separated | ☐ | ☐ | ………………………………… |
| Other (please specify) | ☐ | ☐ | ………………………………… |

***Turning lanes/widening***

No at-grade intersections ☐

Mark the options that corresponds to the majority of the section and note any exceptions, their nature, extent and location

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| Right turn lanes/widening provided to assist traffic turning across opposing flow | ☐ | ☐ | ………………………………… |
| Left turn lanes/widening provided to assist left turning traffic flow | ☐ | ☐ | ………………………………… |
| No turning lanes/widening provided | ☐ | ☐ | ………………………………… |

***Intersection density***

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

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

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

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

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

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

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

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

***Access density***

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

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

**Vulnerable Road Users**

***Pedestrian - presence***

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

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

***Cyclist - presence***

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

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

***Motorcyclist - presence***

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

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

***Pedestrian facilities***

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

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

***Cyclist facilities***

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

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

***Motorcyclist facilities***

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

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

***Parking***

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

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| Parking provided on street | ☐ | ☐ | ...................................... |
| Parking provided off street | ☐ | ☐ | ...................................... |
| No parking provided - no need | ☐ | ☐ | ...................................... |
| No parking provided - clear need | ☐ | ☐ | ...................................... |

## <u>Median</u>

### *Median treatment*

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

| | Majority | Exceptions | Notes regarding exceptions |
|---|---|---|---|
| Unmarked | ☐ | ☐ | .................................... |
| Surface treatment, e.g., rough surfacing | ☐ | ☐ | .................................... |
| Road markings | ☐ | ☐ | .................................... |
| Separation | ☐ | ☐ | .................................... |
| Separation with physical features, e.g., kerbing | ☐ | ☐ | .................................... |
| Median barrier (guardrail or rope barrier) | ☐ | ☐ | .................................... |
| Median barrier (Rigid - New Jersey type concrete) | ☐ | ☐ | .................................... |

### *Obstacles in median*

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

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

South Africa
COTO
Committee of Transport Officials

# TRH 29: 2022

# South African Road Safety Assessment Methods (SARSAM)

## Volume 3
## Road Safety Audit
## Part A: Policy and Procedures

Volume 1: Network screening

Volume 2: Road Safety Assessment

Volume 3: Road Safety Audit

Part A: Policy and Procedures

Part B: Conducting Road Safety Audits

Draft Standard (CDS) version 1.0

March 2022

# FOREWORD

## Compiled under the auspices of the:

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## Existing publication:

This document forms part of the update of the South African Road Safety Audit manual, 2nd Edition, May 2012 (SARSAM 2012)

## Document versions:

**Draft Standard:** This draft of Volume 3, Road Safety Audit: Part A has been prepared to address RSA Management Policies and Procedures and should be read with Volume 3, Part B describing the execution of road safety audits. They have been prepared for the Update of the South African Road Safety Assessment Methods manual and remains the intellectual property of the RTMC.

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## Comments:

Comments on this working draft should be provided in writing and e-mailed to the developers of the document, Messrs CSIR for attention of the Project Manager, Mr Michael Roux at mproux@csir.co.za.

This document and its various parts will only be published in electronic format.

# PREFACE

TRH 29 consists of three mutually supporting volumes related to successive diagnostic practices to improve road safety on the South African road network. These volumes are:

- Volume 1: Network screening
- Volume 2: Road Safety Assessment
- **Volume 3: Road Safety Audit (This volume)**

The South African National Road Safety Strategy 2016-2030 (NRSS) accepted the vision of "Safe and Secure Roads". South Africa aims to contribute towards the reduction of an unacceptable global road safety problem that claims the lives of some 1,3 million people annually. NRSS aims to address this problem on a national scale across different subject areas. This document will fall under the Safer Roads and Mobility theme of the United Nations' 2nd Decade of Action for Road Safety, 2021–2030. One of the strategic themes adopted for achieving Safer Roads is the implementation of a Road Safety Audit Programme on new and upgrade road infrastructure projects.

Volumes 1 and 2 of TRH 29 provides guidelines on applying curative methods for the identification and improvement of hazardous locations, roads, and routes. They also provide proactive assessment methods for the identification and treatment of road safety deficiencies.

**Network screening** (Volume 1) is a process for reviewing a transport or road traffic network with the objective of identifying and ranking sites from most likely to least likely to realise a reduction in accident frequency following the implementation of appropriate safety improvement measures.

**Road Safety Assessment** (Volume 2) is a two-tiered process, namely:

3) **Network Level Assessment (NLA)** which is a routine, programmed and systematic field survey on existing roads to identify risk factors that can be mitigated against to achieve enhanced safety, and
4) **Road Safety Inspection (RSI)** is an expert assessment of the road environment conducted in response to an identified road safety issue on a section of the road network. RSI involves an expert and in-depth review of the safety of existing roads. Apart from identifying safety problems, the assessment team should be looking out to identify and recommend viable and cost-effective measures which will improve safety.

**Road Safety Audit** (Volume 3) provides guidelines on Road Safety Audit - a systematic assessment of plans for new road schemes (including on existing roads), intended to ensure that new roads have the lowest attainable accident potential across all road users.

The audit process aims to avoid future accidents by removing unsafe features before they are constructed and to build in safety features that will limit casualty severity to the minimum possible.

Road safety auditing can be traced back to the mid-1980's when accident investigators in the United Kingdom (UK) became concerned that even newly built road projects were included on the country's black spot listings. This led to the development of a policy requiring that the design of road projects should be reviewed by a departmental road safety engineering team prior to the construction thereof. It was found that this review process improved the road safety performance of road projects. Through formalization of this process the principle of road safety audits was established. The success of this process was replicated by parallel developments in road safety auditing in Australia.

Road Safety Audit is a proactive road safety engineering tool based on the philosophy that road authorities do not have to wait for the accumulation of serious injury and fatal accidents statistics before positive steps can be taken to reduce the risks of such. It plays a significant role in ensuring that the road environment is forgiving, self-explaining and provides for the needs of all road users while being aligned with the principles of

Road safety audits may be conducted at all stages of the life cycle of a roads or traffic related project (on existing roads, from conception to the final constructed project, as well as after opening to traffic). Given that South Africa is currently in a process of road safety audit capacity development, road authorities should endeavour to introduce road safety audits at the earliest possible stages of specific projects – this will provide the highest road safety return on such investment.

A road safety audit is conducted by a qualified and experienced road safety audit team led by a road safety audit team leader recognized as a specialist road safety engineer and accredited such by the Engineering Council of South Africa (ECSA). The size of the road safety audit team is determined by the size, complexity, and stage(s) of the project to be audited. The audit team leader is the lead auditor that is responsible for compiling the road safety audit report and representing the audit team in engaging with the client (the road authority or project owner). The audit team members assist, collaborate, and contribute to the road safety audit.

The successful implementation of the entire road safety audit process and the implementation of the remedial measures recommended by the road safety audit team would make a meaningful contribution to ensure that road safety problems are not repeatedly introduced on the road network.

It is our firm belief that the South African Road Safety Assessment Methods 2022 manual, (this TRH 29) would pave the way for our real contribution to meeting the objectives of the NRSS and of the UNDoA2.

# OVERVIEW OF VOLUME 3: ROAD SAFETY AUDITS PART A

TRH 29 Volume 3: South African Road Safety Audit (as part of SARSAM2022) consists of two mutually supportive parts, Part A, and Part B.

**PART A: POLICY AND PROCEDURES**

Part A addresses road safety audit policy for utilization on the South African public road network and describes the management procedures associated with road safety audit in South Africa.

Part A introduces road safety auditing including a short background to the Safe System Approach which is industry best practice at the time of writing, and which underpins the road safety audit process described in SARSAM2022. Part A also describes the management process for the appointment of the road safety audit team, the oversight required and the receipt of the road safety audit report from the audit team. It recognizes the need to consider recommendations made in the road safety audit report and to respond to the recommendations in the road safety audit report in a clear and unambiguous manner and to identify remedial measures to be implemented or the reasoning why deviation from the recommended remedial measures was deemed necessary.

**PART B: CONDUCTING ROAD SAFETY AUDITS**

Part B is a continuation of Part A and describes the road safety audit process from the viewpoint of the road safety audit team – focusing on what needs to be done at each stage of the process.

Part B describes the responsibilities of the different parties to the road safety audit process with emphasis on the responsibilities of the road safety audit team. It introduces the Safe System Approach as the basis for conducting road safety audits in contrast with the system that had been described in the 2$^{nd}$ edition of the Road Safety Audit Manual (SARSAM2012). Part B also describes the risk assessment procedure which in SARSAM2022 becomes the responsibility of the road safety audit team.

Part B describes the different types and stages of road safety audits in more detail and the different reports that result from road safety audit. It indicates how these different road safety audit reports lead to the final client disposition report that records the acceptance of remedial measures for individual road safety concerns.

Part B also includes a case study for a design stage road safety audit as well as a typical road safety audit report and prompt lists as guidance to the road safety audit team.

Part B includes an appendix containing typical road safety concerns intended to sensitise the road safety audit team on concerns that can be observed regularly, and which may have been considered appropriate prior to the implementation of the Safe System.

# ACKNOWLEDGEMENTS

A road safety audit manual is a comprehensive guide for the formal road safety audit of road and traffic designs before they are built, and for the road safety investigation of existing roads.

This Manual describes the road safety audit process, together with practical guidance for road safety practitioners. It is recommended reading for all practitioners and decision makers who are responsible for road safety, for designing new road projects and for managing roads.

As the science of road safety auditing is constantly developing, this Manual recognises the benefits of standardising road safety audit procedures and practices and has drawn extensively on the experiences of countries or organisations where road safety auditing is being done and, on the guidelines, and procedures in use in these countries.

The RTMC would like to recognise and acknowledge the references that had been made to the following international road safety audit manuals:

- African Development Bank, Transport and ICT Department, Road Safety Manuals for Africa, July 2014
- Asian Development Bank, Road Safety Audit, CAREC Road safety engineering manual 1, March 2018
- AUSTROADS, Guide to Road Safety Part 6: Managing Road Safety Audits, Austroads publication No. AGRS06/19, Edition 1.2, February 2019
- AUSTROADS, Guide to Road Safety Part 6A: Implementation of Road Safety Audits, Austroads publication No. AGRS06A/19, Edition 1.0, February 2019
- FHWA, Road Safety Audit Guidelines, Publication No. FHWA-SA-06-06, 2006
- Highways England, UK Design Manual for Roads and Bridges: Road Safety Audit, GG 119, October 2018
- Indian Roads Congress, Manual on Road Safety Audit (First revision), August 2019
- Institution of Highways and Transportation, Road Safety Audit, October 2008
- National Roads Authority Ireland, Road Safety Audit Series: GE-STY-01024–01027, 2017
- New Zealand, Interim RSA procedures for projects, 2013
- PIARC Technical Committee on Road Safety (C13), Road Safety Manual, 2018
- United Nations Economic Commission for Europe, Road Safety Audit and Road Safety Inspection on the TEM network, 2018

# ABBREVIATIONS

| | |
|---|---|
| BRT | Bus Rapid Transit |
| COTO | Committee of Transport Officials |
| CPD | Continuous Professional Development |
| CWZ | Construction Work Zone |
| DoRA | Division of Revenue Act, 2017 |
| ECSA | Engineering Council of South Africa |
| FSI | Fatal and serious injury accidents |
| MAIS | Maximum Abbreviated Injury Scale |
| NLA | Network Level Assessment |
| NMT | Non-Motorised Transport |
| NRSS | National Road Safety Strategy |
| PRMG | Provincial Road Maintenance Grant |
| QSE/EME | Qualifying Small Enterprise/ Exempt Micro Enterprise |
| RSA | Road Safety Audit |
| RSInv | Road Safety Investigation |
| RSI | Road Safety Inspection |
| RTMC | Road Traffic Management Corporation |
| SARSAM2012 | South African Road Safety Audit Manual, 2$^{nd}$ edition, 2012 |
| SARSAM2022 | South African Road Safety Assessment Methods |
| SARSM | South African Road Safety Manual |
| SARTSM | South African Road Traffic Signs Manual |
| SADC RTSM | Southern African Development Community Road Traffic Signs Manual |
| SSA | Safe System / Safe System Approach |
| TMH | Technical Methods for Highways (COTO) |
| TTM | Temporary Traffic Management |
| TRH | Technical Recommendations for Highways (COTO) |
| UK | United Kingdom |
| UNDoA | United Nations Decade of Action for Road Safety. 2011–2020 |
| UNDoA2 | United Nations 2$^{nd}$ Decade of Action for Road Safety, 2021–2030 |
| UNGA | United Nations General Assembly |
| VRUs | Vulnerable Road Users |
| WB | World Bank |
| WHO | World Health Organization |

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# PART A: POLICY AND PROCEDURES

# 1 Introduction

## 1.1 Road safety perspective

Road deaths and trauma is a global public health problem which seriously impacts the global economy. The World Health Organization (WHO) estimated that the annual number of road traffic fatalities amounts to 1.35 million fatalities. This results in a fatality rate of about 18 fatalities per 100 000 population. Road traffic injuries are the 8$^{th}$ leading cause of death for all age groups and the leading cause of death for people in the age group of 5 – 29 years. Pedestrians and cyclists represent 26% of all fatalities worldwide but increase to 44% in Africa.

The Road Traffic Management Corporation (RTMC) recorded a total of 12 503 road accident-related fatalities in South Africa during 2019. The comparable loss of lives on South African roads varies between 24 – 26 people per 100 000 population. Pedestrians and cyclists represented 41,5% of road accident fatalities, which is significantly higher than the global proportion of such fatalities.

The cost of accidents is an enormous socio-economic burden placed on a developing low-and middle-income country, already struggling to eradicate poverty. The RTMC's estimated 2015 cost of accidents in South Africa adjusted for 2019, is estimated to exceed R174 Billion. which is more than 3.4% of the South African GDP.

## 1.2 Road safety strategy

Prior to 2004 little had been done to elevate road safety concerns on a global scale, until the launch of the global "*Road Safety is no accident* "- campaign. In 2009, the WHO and the World Bank (WB), published the 'Global Status Report on Road Safety – Time for Action', highlighting the growing public health burden of road deaths, especially in the developing world.

The Global Status Report made a powerful case for urgent measures to address the road safety problem as a global development priority. The report resulted in the United Nations General Assembly (UNGA) proclaiming the period 2011 to 2020 as the Decade of Action for Road Safety (UNDoA) with a goal to stabilise and then reduce the forecast level of road traffic fatalities around the world by 50 % through increased safety remedial activities conducted at country, regional and global levels.

The Global Plan to implement the UNDoA provided for a road safety model of five strategic pillars targeting:

i. Road safety management,
ii. Safer roads and mobility (Infrastructure)
iii. Safer vehicles
iv. Safer road users
v. Post-accident response

The Stockholm Declaration in February 2020 recognized that the goals of the UNDoA would not be met in time and adopted various resolutions to improve road safety, encouraging the UNGA to endorse these resolutions.

UNGA in August 2020[10] endorsed the Stockholm Declaration and declared the period 2021 to 2030 the 2nd UN Decade of Action for Road Safety (UNDoA2) with a goal to reduce the number of fatalities and serious injuries by 50 % by 2030. The resolution encouraged UN Member States, i.a., to:

- Meet the road safety targets contained in the 2030 Agenda for Sustainable Development,
- Ensure political commitment to develop and implement road safety strategies and plans.
- Invite the adoption of comprehensive legislation on key road safety factors.
- Include road safety as an integral element of planning and design underpinned by a Safe System Approach,
- Promote road safety knowledge and awareness.
- Strengthen institutional capacity, i.a., relevant to infrastructure improvements,
- Give special attention to the safety needs of vulnerable road users, such as pedestrians and cyclists as well as children, youth, older persons, and persons with disabilities,
- Actively protect and promote pedestrian safety and mobility,
- Invest in road safety at all levels including allocation of dedicated budgets for institutional and infrastructure improvements.

South Africa adopted the National Road Safety Strategy 2016 to 2030 (NRSS) with the vision of "***Safe and Secure Roads***". The NRSS conforms with the aspects raised in the UNDoA and the Global Action Plan five pillars model. The strategy emphasises the fact that road safety is everybody's shared responsibility, individually and collectively. This principle is embodied in the Safe Systems Approach which also underpins the Global Action Plan. The NRSS identifies key challenges and strategic themes for each of the five pillars of the Global Action Plan.

The strategic themes for Pillar 2: Safer Roads and Mobility (relating to Infrastructure), which is the pillar relevant to road safety audit as an intervention, are:

- Identify and address high road safety risk locations,
- Provide self-explaining and forgiving road environment,

---

10 *UN General Assembly, Resolution 74/299, August 31, 2020*

- Implement road safety audit programme on new and upgraded infrastructure.

It is against this background that SARSAM2012 has been updated to reflect current best practice which is incorporated in SARSAM2022.

## 1.3 Safe System Approach

The Safe System Approach towards the improvement of road safety reflects current best road safety engineering management practice and has been adopted by numerous road authorities worldwide. It also forms the core principle in the NRSS. The Safe System Approach to road safety improvement or Safe System can be defined as:

*A road safety approach which recognises that road users will continue to make mistakes and that roads, vehicles and speeds should be designed to reduce the risk of accidents and to protect them in the event of an accident.*

This definition comprises four essential components[11] which together reflect a holistic view of road safety, namely:

- Safe roads and roadsides
- Safe speeds
- Safe vehicles
- Safe road users

[11] *Post-Crash Care represents a fifth Safe System component but relates to the medical response and treatment of the injured and the post-crash rehabilitation. This largely falls outside the Transport Sector. The sub-component that may be ascribed to the Transport Sector could be referred to as Post-Crash Response which may be defined as the accessibility of medical or trauma practitioners to an accident scene to reduce the likelihood of death through the provision of prompt medical care in the golden hour.*


*Figure 1-1: Safe System components*

The Safe System Approach has at its core the need to constrain accident forces within the limits of human tolerance. Road infrastructure should be forgiving and consider the vulnerability of the human body to avoid death or serious injury in the event of an accident. The primary strategy supporting the Safe System Approach lies in the concept of survivable speeds. This becomes the guiding design principle in the drive to *Design for Safety*, rather than *Design to Standards*.

Fundamental to the Safe System Approach is designing a road or traffic scheme that contributes towards the tolerance of the body to sudden changes of momentum or kinetic energy to avoid fatal and serious injury (FSI) accidents based on the following concepts:

- *Functionality*: roads should be physically and visually different to demonstrate their differing functions,
- *Homogeneity*: there should be limited interaction between road users travelling at different speeds, in different directions and between vehicles and road users of different mass or type,
- *Predictability:* roads should be “self-explaining”, and the function and road rules should be clear to road users,
- *Forgivingness:* roads and roadsides should be forgiving in the event of an accident and accommodate driver error,
- *Status awareness:* road users should be able to assess their own capability of performing the driving task.

The Safe System Approach presumes that loss of life is never an acceptable price to pay for improved mobility. It reiterates that humans make mistakes, and that from an ethical and moral point of view, should not be killed, maimed, or seriously injured because of road traffic accidents (RTAs). Designers and planners of the road traffic system therefore has a responsibility to design the system in a manner that prevents this road related trauma.

## 1.4 Development of the road safety audit (RSA) concept

Road safety auditing can be traced back to the mid-1980's when accident investigators in the United Kingdom (UK) became concerned that even newly built road projects were included on the country's black spot listings. This led to the development of a policy requiring that the design of road projects should be reviewed by a departmental road safety engineering team prior to the construction thereof. It was found that this road safety review process improved the road safety experience. Through formalisation of this process the principle of road safety audit was established. The success of this process was replicated by parallel development of road safety auditing in Australia.

The first road safety audit manual was published by the Institution of Highways and Transportation in 1990 as guidelines to conduct road safety audits and to improve awareness and encourage the use of the process. The benefits of road safety auditing as a proactive action to improving road safety is recognized across the world. Numerous countries developed their own road safety audit guidelines based on the UK and Australian (AUSTROADS) documents. Such guidelines have also been developed by organisations such as the multilateral development banks, e.g., the African Development Bank (AfDB), as well as regional economic cooperation such as Central Asia Regional Economic Cooperation (CAREC).

South Africa published a Road Safety Manual (SARSM) in1999 which addressed a broad range of road safety engineering issues, including road safety auditing in Volume 4 of SARSM. Volume 4 was extracted and updated as a stand-alone road safety audit manual and published in 2012 as the second edition of the South African Road Safety Audit Manual, (SARSAM2012). Extensive development has since taken place in road safety engineering. This includes adopting the Safe System Approach in the improvement of road safety, Vision Zero (Swedish road safety strategy), the principles of survivable speeds and forgiving roads and the global acceptance of the principle of shared responsibility for the improvement of road safety. These principles have also been adopted by South Africa as reflected in the NRSS and are being incorporated in the current updating of SARSAM2012 toward the publication of the 3rd edition of the South African Road Safety Audit Manual, being published as TRH29 Volume 3 in SARSAM2022.

## 1.5 Application of the Safe System Approach in RSA

The adoption of the Safe System Approach (SSA) as an important driving principle in improving road safety in South Africa also has a profound effect on road safety audit. In the past, the road section subjected to a RSA often had been assessed against a background of the applicability of typical design standards to reduce accidents. The core principle for applying the Safe System Approach lies in the recognition of the vulnerability of the human body and its limited tolerance to the forces acting upon it during an accident. The application of the Safe System Approach in road safety audit provides a different focus on the identification of road safety concerns compared to the current SARSAM2012.

Applying the Safe System Approach to road safety audit increases the importance of identifying potential hazards in the road environment combined with assessing safe speeds or survivable speeds in the road safety audit process, rather than merely assessing potential road infrastructure hazards as the primary focus of a road safety audit.

'***Survivable speeds'*** is the core philosophy underpinning the success of the Safe System Approach as proven in the Swedish Vision Zero strategy.

Survivable speeds refer to the speed threshold above which the risk of a fatal or serious injury rapidly increases and differ depending on the type of accident. These speeds have been postulated by Wramborg[12], and are shown in Figure 1.2.

Auditing against the background of survivable speeds for different types of accidents requires that the auditor review these risks as a core responsibility during the audit. This requires the assessment during the audit process to focus on identifying and managing risk based on:

- Exposure to conflicts typically associated with different accident types contributing to serious injuries and fatal outcomes.
- Likelihood of such an accident occurring,
- Severity of the accident should it occur.

Numerous studies on changes in speed limits or recorded average speeds correlate with changes in fatal and serious injury accidents and should be considered when road safety audits are conducted within the Safe System Approach. The effect of changes in operational speeds should be considered when recommendations are formulated to resolve road safety concerns.

---

12 *Wramborg P. 2005, A new approach to a safe and sustainable road structure and street design for urban areas', Road safety on four continents conference, 2005, Warsaw, Poland, Swedish National Road and Transport Research Institute (VTI), Linkoeping, Sweden. Google Scholar*

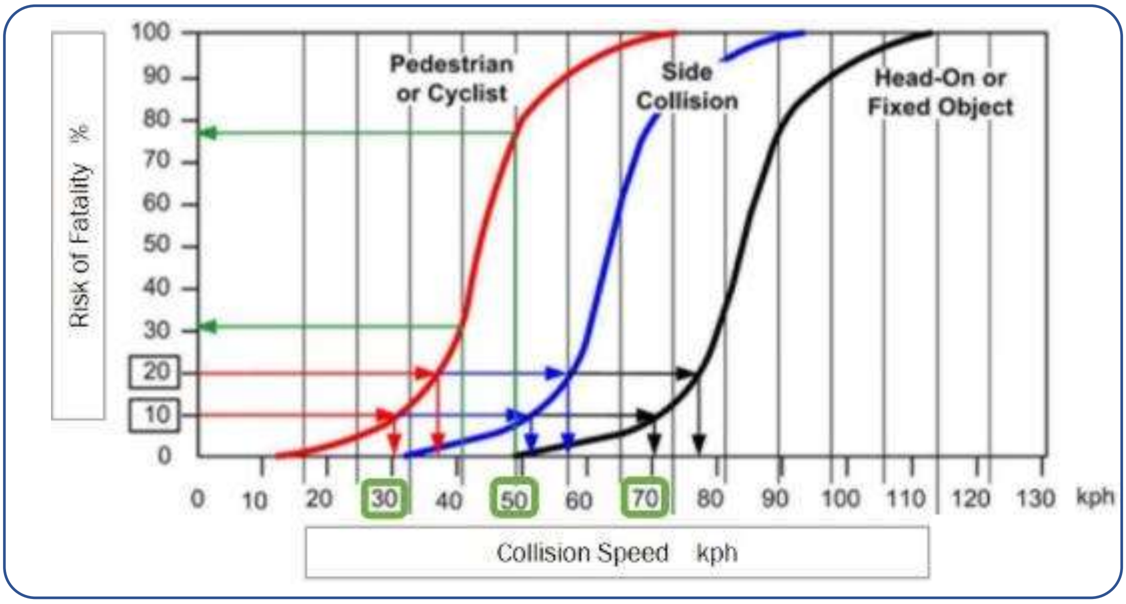


*Figure 1-2: Survivable speeds*

The effect of such changes is widely reported in road safety engineering research. Table 1.1 provides a generalised overview of the variation in number of accidents and casualties with changes in the average speeds on a road section.

***Table 1-1: Changes in casualties and accidents resulting from a change in speed***

*Source: Elvik et al (2004) in PIARC Road Safety Manual*

| | Relative change (%) in the number of casualties or accidents | | | | | |
|---|---|---|---|---|---|---|
| Change in speed (%) | -15% | -10% | -5% | +5% | +10% | +15% |
| Casualty or Accident | | | | | | |
| Fatalities | -52 | -38 | -21 | +25 | +54 | +88 |
| Serious injuries | -39 | -27 | -14 | +16 | +33 | +52 |
| Slight injuries | -22 | -15 | -7 | +8 | +15 | +23 |
| All injured road users | -35 | -25 | -13 | +14 | +29 | +46 |
| Fatal accidents | -44 | -32 | -17 | +19 | +41 | +65 |
| Serious injury accidents | -32 | -22 | -12 | +12 | +25 | +40 |
| Slight injury accidents | -18 | -12 | -6 | +6 | +12 | +18 |
| All injury accidents | -28 | -19 | -10 | +10 | +21 | +32 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Property damage only accidents | -15 | -10 | -5 | +5 | +10 | +15 |

## 1.6 The Role of the RSA Team

*The road safety audit team reviews the project through the eyes of all road-users, identifying areas of increased personal risk of injury or fatality or of perceived undue personal risk.*

The role of the client and the design team in any new or upgrading road or traffic related project has been well defined over the years. These two parties have the responsibility to review all the conditions related to such a project with the objective of implementing a project that balances the needs of the different road users or affected communities within economic and environmental constraints, whilst retaining constructability of the project.

It is against this background that a road safety audit should be considered. Even with the careful application of design standards by competent professionals, the design process might not remove all hazards for road users. The objective of a road safety audit is to identify aspects of engineering interventions that could give rise to road safety concerns and to suggest modifications that could reduce such concerns. A road safety audit, however, is not a check on the compliance of a project to design standards. The role of the road safety audit team is therefore much more a case of reviewing the project through the eyes of different road-users to identify areas where the road-user may be exposed to increased levels of risk of being involved in an accident which could cause death or injury. This is being done to identify aspects that may potentially contribute to incidents or accidents on the project or potentially increase the severity of such accidents. The road safety audit is therefore a biased review of project safety details.

The RSA Team should work within the framework of the Safe System to identify road safety concerns which could contribute to an increased risk of fatalities or serious injuries. These safety concerns should be included in the road safety audit report together with appropriate recommendations to reduce this risk.

Because of the biased opinion expressed by the road safety audit team, the road safety audit team does not give any *instruction* to modify designs to reduce the exposure to incidents or accidents. The road safety audit team contributes a road-user safety viewpoint for consideration by the design team or client road authority, improving the degree of informed road safety decision-making.

The decision to accept or reject road safety audit recommendations rests with the design team in coordination with the relevant road authority. It is possible that these parties may disagree with the road safety audit team on the likelihood of an accident or on the severity of the accident or risk to the road-user. It is also possible that the design team may offer a different remedial measure for implementation. The road safety audit close-out procedure allows for the implementation of a scheme that would be more sensitive to the possible risks experienced by road-users. It is, however, essential that the decision process and the finally agreed decision be properly recorded.

## 1.7 Legal exposure in road safety auditing

A concern raised about conducting road safety audits is the potential increased risk of the road authority to be held liable in a civil lawsuit if a road safety audit identified road safety concerns that could have contributed to an accident. However, the contrary point of view is that a road safety audit demonstrates a proactive approach to identify and mitigate road safety problems as defence in liability litigation.

Road safety auditors may have similar concerns arising from the possibility that road safety concerns might not have been identified during the road safety audit and only become clear in hindsight and the cause of the accident is revealed in a forensic investigation.

To assist in better understanding the vulnerabilities to risk in delict, an overview of the legal environment related to delict and negligence is included in the Appendix to Part A of this Manual.

# 2 The Road Safety Audit Process

## 2.1 Definition of Road Safety Audit (RSA)

In SARSAM2022 Road Safety Audit is defined as:

> ***A RSA is a formal technical assessment process of a new road or traffic project, in which an independent and qualified team proactively identifies potential road safety concerns that may lead to serious injuries or fatalities of all road users and suggests measures to mitigate such risks applying Safe System principles.***

The RSA process results in a report describing potential safety concerns and measures to mitigate those risks that should be considered prior to advancing to the next stage of the design process or to physical construction or taking over completed construction works.

## 2.2 Objectives of RSA

The primary objective of the RSA process is to eliminate the risk of serious injuries and fatalities resulting from traffic accidents that may be influenced by the road facility or adjacent environment in new or upgrading road or traffic projects.

Secondary objectives of the RSA process include the following:

- Minimise the need for remedial measures after the opening of a new road project,
- Recognize the importance of safety in road planning, design, and implementation for all road users,
- Improve the standards of road design to ensure that all road users are given adequate protection and information with special focus on Vulnerable Road Users (VRUs), especially pedestrians.
- Improve the awareness of road safety engineering principles,
- Improve the awareness of, and contribute to, improvement in safe design practices.
- Ensure that road design is forgiving, thus allowing motorists to recover from error, or to incur least harm when an accident is inevitable.
- Reduce the full life-cycle cost of a road project by reducing its accident cost.
- Develop a culture of road safety among those responsible for the delivery and maintenance of road infrastructure.

## 2.3 Essential elements

The key elements of any RSA on a project encompass the following aspects:

- The RSA focuses solely on safety aspects of the project,
- The RSA is carried out by a team that is independent of the client or road authority, design team or the contractor,
- The RSA is completed by applying Safe System principles to eliminate or reduce the potential for serious injury or fatal accidents,
- The RSA is carried out by a team with appropriate experience and training, and which understands the Safe System Approach to improve road safety,
- The RSA considers all road users,
- The RSA is a formal documented process,
- The RSA requires a formal close-out response by the road authority or client of all identified road safety concerns.

**The RSA is NOT:**

- A quality control review, a design review, or a peer review,
- A judgement of the quality of a project,
- A compliance check on standards, guidelines or drawings and specifications,
- An opportunity to redesign or to suggest changes to aspects not related to a safety concern.
- An informal check, inspection, or consultation,
- A means of comparing one project or option with another.

The Institution of Highways & Transportation (IHT) (2008) explains that it will be necessary for the road safety auditor to ask and report on two key questions pertaining to the project being audited:

- “**Who can be hurt in an accident on this part of the road/ project and how might that happen?”** and
- **“What can be done to reduce the potential for that accident, or to limit its consequences?”**

Both these questions need to be answered with reference to the principles of the Safe System Approach and the relevant speed regime.

## 2.4 The Benefits of Road Safety Audits

Road safety auditing is a recognised accident prevention road safety engineering tool that has the following benefits:

- A reduction in the likelihood of accidents on the road network,
- A reduction in the severity of accidents on the road network,
- An increased awareness of safe design practices among traffic engineers and road designers,
- A reduction in the need to modify projects after they are built,
- A reduction in the life-cycle cost of a road,
- A more uniform road environment that is more easily understood by road users,
- A better understanding and documentation of road safety engineering,
- Eventual safety improvements to standards and procedures,
- More explicit consideration of the safety needs of vulnerable road users.

## 2.5 Projects which may be road safety audited.

### 2.5.1 New Projects

Road safety audits are applicable to all types of road projects, on all types of roads. It is therefore prudent to recognise that all projects can benefit from a road safety audit. What is critical to achieving the Safe System goal is the scale of any potential risk that may result from the project and not the scale of the project as such.

Projects can be as small as a pedestrian crossing or a bus stop layby, or as large as a freeway or interchange or a complete township development. The scope of audits ranges from everything within the road corridor to specific facilities such as those for pedestrians or vulnerable road users and may be located within a public road, other public or private property.

Road safety audits can be conducted on new road projects that include, but are not limited to:

- Freeways and expressways,
- Pedestrian and cycle routes and facilities,
- Temporary traffic management schemes (from a Safe System perspective, not as a compliance review),
- Local area traffic management schemes (such as commercial areas and residential streets),
- Transportation hubs.

Road safety audits can also be conducted for other schemes that are not specifically road-based projects where safety concerns are likely to arise from:

- Vehicle–pedestrian conflicts in a new carpark,
- Increased numbers of pedestrians crossing the adjacent road,
- Filling stations with possible queue-back from the forecourt into the feeder road or street,
- Location of accesses,
- Access/egress/unloading for service vehicles at shopping centres
- etc.

### 2.5.2 Upgrading projects

Upgrading projects that are subject to road safety auditing are strengthening and improvement projects that comply with the following descriptions:

#### *2.5.2.1 Strengthening projects*

Strengthening projects typically include maintenance treatments such as the addition of thick surfacings, or the removal of part of the existing pavement structural layers and the addition of layers to restore or improve structural integrity and to increase the strength of the pavement. It is normally applied at the end of a pavement's structural life when the pavement's problems are only structural of nature and no quality-of-service problems are anticipated in the medium to long term.
Strengthening works are divided into the following work types:

a) REHABILITATION:
Rehabilitation is most effective on pavements that are exhibiting signs of structural deterioration (crocodile cracking and rutting, in particular) but not to such an extent that complete reconstruction (removal and replacement of the base and/or sub-base) will be more economical. Rehabilitation could include the reworking (but not removing) of the top 150 mm of the existing pavement to form a uniform platform for the addition of new pavement layers. Rehabilitation increases the structural capacity of the pavement to a condition that is very near or equal to that of an equivalent new pavement.

b) RECONSTRUCTION:
Reconstruction is the removal of part or all of the existing pavement layers (both bound and unbound layers) and the construction of a new pavement. Reconstruction is appropriate when the pavement has structurally failed, and the sub- grade requires strengthening (including sub-drainage construction) in order for the new pavement to perform properly. Since reconstruction consists of the removal of the structure of the existing pavement, it offers the opportunity to correct sub-grade or base deficiencies, to slightly adjust the vertical geometry, to add drainage structures, etc. These options are not viable when the pavement is only rehabilitated.

Reconstruction increases the structural capacity of the pavement to a level that is required for the medium to long term.

c) BRIDGES:
This refers to the works related to strengthen an under-designed bridge to enable it to carry the required or revised design loads.

*2.5.2.2 Improvement projects*

Improvement projects comprise works that aim to improve the quality of service on roads with adequate remaining pavement structural life, but with an unacceptable quality of service. Improvements are normally applied to roads experiencing an unforeseen growth in traffic due to i.a. change in use of the road. These include measures of improving quality of service on existing roads such as relieving traffic congestion, improving road safety, restoring road rideability, etc.

Improvement works are divided into the following work types:

a) LEVEL OF SERVICE:
This comprises works that retain the existing pavement structure but increases the width in selected areas (i.a. addition of climbing lanes) throughout the length of the section to improve overtaking and lane changing opportunities
b) CAPACITY:
This comprises works that retain the existing pavement but increases the width over the total length of the section. These include partial widening and lane addition.
c) ALIGNMENT:
This comprises works that change the road geometry for part of a section, but that retain some of the existing pavement structure. These include local geometric improvements, and intersection improvements.
d) BRIDGES:
This comprises works that retain the existing bridge but increases the width over the total length of the bridge. It also includes all work related to improve the horizontal and vertical clearances over and under the bridge, also including changes to bridge barriers.

The Road Authority/ maintenance manager or design team shall recognise the advantages of conducting road safety investigations and implementing road safety remedial measures on road sections earmarked for like-for-like replacement such as resurfacing when construction equipment would be on-site.

## 2.6 Exceptions and Self-certification

If a project would have no impact on road user behaviour or the project would be limited to a low-speed environment less than the safe speed requirements for potential pedestrian and other vulnerable road user accidents, or if the project is a like-for-like replacement, the design team may approach the client or road authority with a motivated application for such project to be exempted from the RSA requirement. Such motivation should take the format of a road safety statement addressing contents which would normally be found in a RSA report, as well as a review of accident statistics on that section of road, clearly indicating the conditions for which the safety of the project is claimed and that accident statistics indicate that road safety remedial measures are not required.

The client/ road authority shall respond to the application, clearly indicating the terms and conditions set for such exemption.

# 3 Stages of Road Safety Audit

## 3.1 Overview

Road safety audits are being conducted at specific stages of the design and implementation of a project. These stages are coordinated with the level of detail associated with each of the different planning and design stages.

## 3.2 Road safety audit policy

Internationally, it has been shown that a road safety audit is An effective and efficient road safety tool that may be used both during planning projects and on existing roads. It is a proactive tool, which means that one does not need to wait for the accumulation of accident and casualties before positive steps can be taken to reduce or prevent such accidents and casualties.

One of the most positive ways to ensure that road safety audit becomes firmly established in a road authority is to establish a road safety audit policy. Road safety audits may be done at all stages in the life cycle of a road. It is essential that maximum benefit be gained from the RSA process in an environment where financial and skilled resources may be restricted. It is therefore necessary that a clear policy be established to detail when road safety audits should be conducted.

The concept of road safety auditing as a pro-active measure to review and improve road safety is not confined to new road projects only but is equally well suited to be used on existing roads, albeit described as road safety appraisals, assessments, or investigations.

The Division of Revenue Act (Act 1 of 2018) in Transport Vote 35 (DoRA, 2017: pp. 173) and Provincial Road Maintenance Grant (PRMG) requires that

> *"all Provinces will be expected to collect and provide information on the following:*
>
> - *road safety assessments, appraisals, and improvements.*
> - *a representative sample of all roads to be assessed which is about 10 per cent of Provincial Road Network for field checking by an independent assessor as agreed by the Department of Transport (DoT) utilising the agreed rates to confirm the correctness of the assessment made.*
> - *Provinces will be required to submit above data to the national data repository as per the format described in TMH18."*

It is recommended that every road authority accepts a basic road safety audit policy statement that includes the minimum intervention levels for undertaking road safety audits as shown in Exhibit 3.1.

## Road Safety Audit Policy of
### *[Name of road authority/municipality]*

**Introduction:**

Best practice requires road safety audits (RSA) of all new and upgrading works. The design and construction standards of *[Name of authority]* focus on the highest road and traffic standards in compliance with the National Road Safety Strategy. Potential safety concerns shall be identified and eliminated through RSA before construction commences. Guidelines for the management and conducting of RSA shall be as described in the SA Road Safety Audit Manual 2022 (SARSAM2022) or latest revised update.

**Policy Objectives:**

This policy applies to all roads to be constructed within the jurisdiction of *[Name of Authority]*. This policy sets out the minimum RSA requirements of roadwork projects to ensure that road safety is embedded in the project as envisaged in SARSAM2022. The primary objective of this policy establishes the requirement for RSA of construction or reconstruction works under the following project development stages:

| AUDIT | FREEWAYS ARTERIALS/ NUMBERED ROUTES | | | COLLECTORS/ PROVINCIAL ROADS | LOCAL STREETS/ DISTRICT ROADS |
|---|---|---|---|---|---|
| | New Projects | Upgrading Projects | | | |
| | | Strengthening | Improvement | | |
| **Stage 1 RSA:** Feasibility/ Conceptual Design or Planning | ✓ | ✓ | ✓ | Not required | Not required |
| **Stage 2 RSA:** Preliminary Design | ✓ | ✓ | ✓ | Optional | Not required |
| **Stage 3 RSA:** Detail Design *(See Note 1)* | ✓ | ✓ | ✓ | ✓ | ✓ |
| **Stage 4 RSA:** Traffic Management | Recommend | Recommend | Recommend | Optional | Optional |
| **Stage 5 RSA:** Pre-opening | Recommend | Recommend | Recommend | Recommend | Optional |
| *Number of Audits* | *Min 3* | *Min 3* | *Min 3* | *Min 2* | *Min 1* |

*Note 1: All Strengthening, and Improvement projects should be audited at the Stage 3 RSA level.*

*Note 2: Night-time site visits are recommended during design stage road safety audits but should be conducted during the Stage 5 Pre-opening stage RSA.*

The need for independent road safety appraisals stems from the framework attached to the Provincial Roads Maintenance Grant (PRMG) as published in the Division of Revenue Bill, 2018 (National Treasury, 2018). One of the conditions included in the framework states that the framework must be read in conjunction with the practice note as agreed with National Treasury. Section 4 of this practice note includes a requirement for provinces to conduct road safety appraisals and improvements on existing road networks (DoT, 2018). In conjunction with this requirement, the framework attached to the PRMG requires provinces to submit an annual road safety audit report (National Treasury, 2018).

## 3.3 Pre-Construction Phase Audits

Pre-construction phase audits provide for RSA based on different stages in the planning and design process of the project, namely:

### 3.3.1 Conceptual design stage Road Safety Audit: (Stage 1 RSA):

This RSA takes place at a higher level where the types of road safety concerns are restricted to the broader road safety principles associated with the project. It addresses different road-user groups in a wide approach and provides the opportunity to influence fundamental aspects such as design speeds and design criteria, potential changes in route choice and impact on the surrounding road network and developments.

The Stage 1 RSA often needs to be conducted with limited design information while considering broad contextual issues recognizing existing patterns that would directly or indirectly influence separate groups of road users and their practices.

A Stage 1 Road Safety Audit has the following objectives:

- Identify the potential safety problems that can influence survivable speeds for the following aspects:
    - Project scope
    - Choice of route, layout and/or treatment
    - Design standard selection
    - Impact on the adjacent road network
    - Access Control: Provision of accesses/ intersections/ interchanges
    - Continuity of routes
- Consider the design and operating speeds,
- Assess the relative safety performance of various alternatives for the road project.

### 3.3.2 Preliminary Design Stage RSA: (Stage 2 RSA):

This RSA is conducted towards the end of the preliminary design process when the horizontal layout and typical intersections have been completed.

The Stage 2 RSA addresses the conditions primarily related to standards and layout of roads and intersections.

A Stage 2: Preliminary Design Stage Road Safety Audit has the following objectives:

- Address the design standards utilised for the preliminary design,
- Consider, among others, how the survivable speeds would be influenced by the following:
  - Alignment (horizontal, vertical),
  - Sight distances,
  - Layout of intersections and configuration of interchanges,
  - Widths: Lanes and shoulders,
  - Cross-section and superelevation of pavement,
  - Location of accesses,
  - Provision for different road user groups: Pedestrians, cyclists, heavy vehicles, etc
- Evaluate whether any deviation from guidelines and design standards would impact safety negatively,
- Determine how possible staged implementation of the project could influence road safety; If staging is proposed then the safety of each stage should be considered as well as the transition from one stage to the next,
- Consider the issues normally listed in the Stage 1 Road Safety Audit if the Stage 2 Road Safety Audit is the first audit of the road project.

At this stage of the design process, fundamental decisions regarding route choice, the overall design and layout of the project have already been decided.

The audit team may still suggest changes to horizontal or vertical alignment, provision of a median, lane and shoulder width, provision of cycle lanes or sidewalks or channelization, if deemed necessary to preserve or establish survivable speeds.

Accesses provided should be reviewed for upstream and downstream effects, possible conflicting movements, sight distance and the possible consolidation of access points.

Any such recommendations should be based on the consideration of safety issues only and should be supported by justifiable safe system background reasoning, which need not necessarily be included in the road safety audit report.

The ability of the design to safely accommodate future widening, expansion or extension may also be considered. Specific attention needs to be given to assess the safety of different usage scenarios.

### 3.3.3 Detailed Design Stage Road Safety Audit: (Stage 3 RSA)

This RSA takes place after completion of the detailed design but before the contract documents are prepared. At this stage, the design drawings should be completed to such a level of detail that they can be used in the preparation of contract documentation.

If the audit team are concerned about a potential lack of sufficient details, the audit team may request such additional details from the client or project manager to allow the audit to be completed without possible conditional findings. This stage is the last opportunity to influence the safety of a design before construction commences.

This audit is focused on aspects of detail of how the road layout, traffic arrangements and information transfer to the proposed road user groups would influence survivable speeds. It is also the stage where the influence of the violation of driver expectation on Safe System approaches such as forgiving road design would be identified best. It is important that any issues that have not been satisfactorily been resolved from earlier audits be reiterated in the Stage 3 audit. It may well happen that the proposed remedial measures for such an outstanding issue be different in this stage than an earlier stage because the flexibility to influence the design is less.

A Stage 3: Detailed Design Road Safety Audit has the following objectives:

- To consider, among others, how safe and survivable speeds and the forgiving road be influenced by the following:
  - Any changes since the Stage 2 Audit,
  - Road traffic signs and markings.
  - Road lighting,
  - Intersection detail,
  - Roadside hazard management issues (clear zones, traffic barriers, fixed objects etc.),
  - Needs and requirements for Vulnerable Road Users (pedestrians, cyclists, individuals with disabilities) or special classes of vehicles (heavy vehicles, buses, service vehicles, etc.),
  - Traffic management and control drawings for the proposed accommodation of traffic during construction,
  - Drainage,
  - Landscaping,
  - Cross-section and side-slopes, etc.
- To review those findings of earlier stages and the implementation of mitigating measures,
- To consider the issues listed in the Stage 1 and Stage 2 Road Safety Audit if the Stage 3 Road Safety Audit is the first audit of the road project.

If the project will be implemented in separate phases, each phase should be considered as well as the transition between phases. The transition between phases is specifically also important for the proposed traffic management for the accommodation of traffic during construction.

In the case of smaller projects where a single design stage RSA would be appropriate, it would be acceptable to conduct a combined Stage 2 and Stage 3 RSA, acknowledging that the risk exists for the identification of concerns that might require remedial measures which one would not expect at a Stage 3 RSA.

## 3.4 Construction Phase Road Safety Audits

Three different road safety audit stages are possible during the construction phase of any project. Only two of these are included in the construction phase as formal staged road safety audits, namely:

- Stage 4: Work Zone Traffic Management Road Safety Audit, and
- Stage 5: Pre-opening Road Safety Audit.

The third possible stage is the auditing of changes to the design during construction. Such audits should be handled as Interim road safety audits[13].

### 3.4.1 Work Zone Traffic Management Stage Road Safety Audit (Stage 4 RSA)

This RSA reviews the accommodation of traffic scheme advanced by the contractor. The audit team shall recognize the guidance given to contractors in the SA Road Traffic Signs Manual, Volume 2, Chapter 13: Road Works Signing.

A Stage 4 RSA reviews the proposed scheme against the principles of the Safe System Approach in terms of survivable speeds and forgiving roadsides realizing the speeds would be lower because of lower design standards on diversions and deviations.

Particular attention should be given to the following aspects:

- Compliance with driver expectation principles in an environment that can be dynamically changing.
- Appropriateness of the proposed traffic management scheme, especially conditions in transition areas,
- Adequacy of advance warning,
- Proposed and actual speed limits,
- Conflicts between permanent and temporary features,
- Any aspects of the layout that could be misread by road users leading to the violation of driver expectancy,

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13 *See Section 3.5.2*

- Likelihood of mud or dust obscuring devices, or of driving directly into the setting sun,
- Appropriateness of vehicle restraint systems/ barriers and the correct installation and the safety of the terminals,
- Adequate provision for pedestrians and public transport vehicles like minibus taxis,
- Conflict points between site traffic and the public,
- The effect of congestion during peak periods,
- The effect of an incident within the detour/ deviation areas.

The RSA Team shall be particularly careful in reviewing the safety of the project during the change-over between different phases of the construction process.

### 3.4.2 Pre-opening Stage Road Safety Audit (Stage 5 RSA)

Stage 5 RSA should be conducted before the opening of a road or traffic scheme to traffic but not before substantial completion of the project; enabling the audit team to review conditions as it would be experienced by different road user groups under typical operational conditions.

Pre-opening stage road safety audits represent the last opportunity that the audit team may identify potential road safety concerns before the road is opened to all road users. The team should have the opportunity to conduct a site visit of the whole project, especially intersections and tie-ins with the existing network in comparable conditions which road-users would use the project once opened to traffic.

It is particularly important to also conduct a night-time site visit to review the site under conditions when the road user cannot be assisted by wider perception of the road environment to safely use the facility, or where night time lighting conditions may influence the driver’s perception of road use conditions.

The potential for making significant changes to the road safety situation on-site during a Pre-opening stage road safety audit is limited and the audit team may have to accept that the mitigating measures that may be recommended at this stage would similarly be limited in scope.

If it is not possible to audit the project before the road is opened to traffic, the Stage 5 audit may be conducted after the opening of the road, but within one month after such opening and with the approval of the client. Under such conditions it is essential that a proper risk assessment be done for road safety auditing in close proximity of the moving traffic.

During the Stage 5 RSA the Road Safety Audit Team may need to walk, drive and possibly cycle the project to assess that:

- Sufficient provision is made for the different road users of the road project,
- There is adequate protection or mitigating treatment of roadside hazards,
- There is no undue influence on safety as result of variations between actual construction and detail design,
- Road signs and markings, lighting and other night-time related issues are appropriately addressed,
- The issues listed in the Stages 1, 2 and 3 Road Safety Audits have been considered and appropriately closed out prior to completion of the Stage 5 Road Safety Audit.

In the Stage 5 RSA it is also important that the audit team confirm that temporary signage, markings, construction equipment, barriers, fencing, materials and debris that may constitute hazards, either as physical entity or as the causal factor for road user confusion, are removed from the newly constructed road facility to ensure that the site as perceived by the road-user would present as a forgiving road. It is also essential that sections of obsolete roadway or diversions which could cause confusion be identified for removal.

The implementation of the mitigating factors agreed upon in a Stage 3 RSA, should also be assessed in a Stage 5 RSA. If these issues had not been resolved satisfactorily, they should be re-iterated in the road safety audit report.

The traffic management scheme in large projects often calls for certain sections of the project to be completed and partially taken over or be made available for beneficial use by road users, when another part of the construction is being constructed. The ability to gain access to such a partially opened section of the project to conduct a pre-opening stage RSA or for the contractor to access that section under traffic, may be restricted or subject to increased risk. Under these conditions it may be feasible to conduct a partial pre-opening stage road safety audit on the section of road to be taken over as an interim road safety audit. This would allow the RSA team and the contractor safer access to the site to conduct the road safety audit and to implement mitigation measures, respectively.

## 3.5 Other road safety audits

### 3.5.1 Thematic road safety audits

Thematic road safety audits are audits focusing on specific road user groups, rather than reviewing the safety of a facility for all road-users. Road safety audits typically require that the audit considers all road-users being affected by the proposed project. To an increasing extent, specialized facilities are being developed for non-motorised transport such as jogging tracks and/or cycle tracks which would be used outside of the typical road environment.

It is also recognized that in certain areas an increased concentration of road-users with specific needs can be identified, such as older pedestrians or those that are hearing or visually impaired. Areas around hospitals and places of care are prime candidates for a thematic RSA. Schools and routes towards schools are also examples where thematic road safety audits might prove particularly beneficial, given the behavioural patterns of young children. Other examples may be found in areas such as public transport hubs, rest-and-service areas along freeways, and major shopping malls or sports venues.

It is prudent for a shift in emphasis in areas such as these to specifically address the needs of the prevalent special interest road-user groups.

A thematic road safety audit should be conducted when facilities for specific road-users are developed in such a manner that they would be open for public access or use, rather than a facility with access restricted to an isolated group. The subject matter incorporated in a proposed thematic RSA should be clearly set out in the audit brief to the RSA team.

The thematic road safety audit brief and the RSA team should recognize the need for design elements to start with the road-user group with the highest degree of vulnerability and proceed stepwise to groups with lesser vulnerability.

In a thematic road safety audit, the audit team should pay particular attention to the following:

- The traffic zones applicable to the road user group under review, such as streets, street crossings, parking areas or transit areas,
- The aspects specifically related to the type of facility, such as pedestrian facilities, or traffic control devices or the type of exposure of the concerned road-user group to possible hazardous incidents,
- Design elements such as differential speeds, route continuity, or connectivity with reduced exposure to safety concerns, placement or obstructions of utilities, inter-visibility with vehicular traffic, etc.
- The risk that pedestrians may disobey design elements such as pedestrian channelization or restrictive conditions.
- The possible violation of road-user expectancy, for example the risk of using a marked pedestrian crossing under impression that a painted crossing would guarantee driver compliance.

Thematic road safety audits may be conducted at any stage in the planning and design process but would have the greatest benefit when done at the planning, detail design and pre-opening stages. It is also important to address the exposure of such vulnerable groups in construction work zones.

### 3.5.2 Interim road safety audits

An Interim road safety audit is not a specific stage RSA but forms an integral part of the road safety audit process in applying the Safe System. An Interim road safety audit can be undertaken on any aspect of the road project at any stage, offering a more focused road safety audit. It is the Road Authority’s responsibility to recognise the benefits of an Interim road safety audit and develop the road safety audit brief allowing for Interim road safety audits to be used constructively in the road safety audit process.

They should be conducted in the same manner as other road safety audits in the process and be undertaken by the road safety audit team together with specialist advisors pertinent to the type and nature of the interim road safety audit if required. Interim road safety audits are additional to the design and the construction stage road safety audits and should only be undertaken under special or extraordinary circumstances and at the request or approval of the Road Authority/ Client.

All information contained within the interim road safety audits must be gathered and assessed like any other road safety audit as part of the full and final road safety audit process.

### 3.5.3 Existing Roads

The road safety audit procedure should also be applied on an existing road or traffic facility to identify road safety concerns which are not evident from accident statistics.

In SARSAM2012 this assessment procedure has been referred to as a Stage 6 Road Safety Audit or Road Safety Appraisal. In this Manual, such a road safety assessment on an existing road is referred to as a Road Safety Investigation (RSINV).

A Road Safety Investigation (RSINV) is a formal systematic examination of an existing road location, in which an independent and qualified team reviews on-site conditions and historical evidence to identify existing or potential road safety problems and suggest measures to mitigate those problems.

In the Audit Brief for such a RSINV, the client shall indicate the need to combine reactive and pro-active elements in the investigation process. The RSA team/ RSINV team shall also use the Safe System principles in assessing the risks associated with safety concerns on such an existing road and on the proposed remedial measures.

# 4 The Road Safety Audit Team

## 4.1 General Requirements

The Road Safety Audit Team shall comprise of no less than two qualified persons – the Audit Team Leader and an Audit Team Member, unless approved by the road authority in the case of a small project. There is no upper limit on the size of the Audit Team provided the team would still be able to properly conduct a road safety audit site inspection. Specialist advisors may be consulted and/or involved to attend site inspections if required by the road authority or dictated by the complexity of a particular project (Appendix A2 B5.1: Personnel Requirements)

Road Safety Auditors who audit full time to the exclusion of other accident investigations or road safety engineering work would normally not be desirable.

The specialist skills and size of the RSA Team depend upon:

- the road safety audit project size,
- the stage of the road project (conceptual design or planning, preliminary design, detail design, construction or pre-opening stage or existing roads),
- the complexity of the project.

The road safety audit team shall be experienced in the type of project to be audited and the stage of the required audit. The appointment of the RSA team shall be at the discretion of the road authority, as to the appropriateness of the respective individuals nominated to conduct the road safety audit for a project. A road safety audit report submitted in support of a project where the RSA team was not approved by the road authority may be rejected.

Road safety auditing at the different stages of design requires RSA Team members with different levels of knowledge and experience:

- **Feasibility/ Conceptual stage RSA:** The issues to be examined are often broader and much more subtle compared with later stages and should only be conducted by very experienced road safety auditors. An experienced road design engineer who is familiar with road design standards and would be able to visualise the layout in three dimensions should be included. If the project includes unusual aspects, the inclusion of a specialist in that field, either as audit team member or as specialist advisor to the audit team for that aspect should be considered,
- **Preliminary Design stage RSA:** Similar skills are required as for the conceptual design stage RSA, but not all the members need be as experienced. Team members with local knowledge of road user activities or relevant specialist experience may be included, where possible.

- **Detail Design stage RSA:** In addition to the skills described for preliminary design stage RSA, it would be beneficial to have audit team members familiar with the type of details included at detail design level, for example, traffic signal control, traffic signs and markings, street lighting, vehicle or road restraint systems or barriers, bicycle facilities or any other road user issue,

- **Work Zone Traffic Management stage RSA:** It would be particularly meaningful if one of the audit team members would be experienced in the management of construction work zones similar to the complexity of the project to be audited,
- **Pre-opening stage RSA**: The inclusion of an experienced traffic officer with local knowledge of traffic patterns and road user activities, a representative of the maintenance agent and a representative from the community to participate in the site inspection for a Pre-opening stage RSA may be considered to improve the level of local integration and the transition to the operational phase of the project.

## 4.2 Requirements for the RSA Team

The RSA team members shall be nominated by the RSA sub-services provider in *curricula vitae* in a prescribed format. The *curriculum vitae* should demonstrate that the previous experience of road safety audit, accident investigation or road safety engineering would be relevant to the project to be audited in terms of type and complexity. The Continuous Professional Development (CPD) record should also focus on road safety audit, accident investigation and road safety engineering.

The typical requirements for the different members of the RSA Team are described in this section. Notwithstanding these requirements, it remains the prerogative of the road authority to accept the nomination of an audit team leader or member based on an overview of the nominee's experience and skills as provided in the *curriculum vitae.*

### 4.2.1 RSA Team Leader

- Registered as a Senior Auditor by the Engineering Council of South Africa with post-nominal accreditation *RSAud(S)* OR
- Holder of a recognized international Certificate of Competence and experience of road safety audit in South Africa OR
- As a transitional measure for a period of 3 years, *[or as indicated by the road authority]*
    - Attended at least 5 days formal crash investigation or road safety engineering training,
    - Successfully completed a recognised road safety audit course of at least 4 days duration,
    - Have at least five years' experience in a relevant road design, construction or traffic engineering field; (team leaders for complicated projects should have more experience),
    - Have at least three years' experience of crash investigation or road safety engineering,
    - Undertaken at least five road safety audits within a period of two years as an audit team leader or team member, including at least three at design stages,

    - Demonstrate a minimum of two days CPD in the field of road safety audit, crash investigation or road safety engineering in the preceding twelve months.

### 4.2.2 RSA Team members

- Registered as a Senior Auditor or Auditor by the Engineering Council of South Africa with post-nominal accreditation *RSAud(S) or RSAud* OR
- Holder of a recognized international Certificate of Competence and experience of road safety audit in South Africa OR
- As a transitional measure for a period 3 years, *[or as indicated by the road authority]:*
    - Attended at least 5 days formal crash investigation or road safety engineering training,
    - Successfully completed a recognised road safety audit course of at least 4 days duration,
    - Have at least three years' experience in a relevant road design, construction or traffic engineering field,
    - Have at least two years' experience of crash investigation or road safety engineering,
    - Undertaken at least three road safety audits within a period of two years as an audit team leader or team member, including at least three at design stages,
    - Demonstrate a minimum of two days CPD in the field of road safety audit, crash investigation or road safety engineering in the preceding twelve months.

### 4.2.3 RSA Observers/ Audit Trainees

- Attended at least 5 days formal crash investigation or road safety engineering training.
- Successfully completed a recognised road safety audit course of at least 4 days duration.
- Have at least one year experience of crash investigation or road safety engineering.

Whereas the role of an RSA Observer/ Audit Trainee would be to learn and practically experience a road safety audit, they are not considered part of the RSA Team but could participate in design phase road safety audits. The number of such observers shall be restricted to no more than two observers to retain the size of the road safety audit party to a manageable size.

Persons with limited experience of on-site conditions should not participate as RSA Observers in Pre-opening stage road safety audits where complex traffic conditions would prevail.

#### 4.2.4 Specialist Advisor to the RSA Team

If the project has unusual or specialist features, the road authority may consider the inclusion of a specialist advisor to assist the RSA team in that aspect. Such a specialist need not participate in any of the activities of the team that would not be related to the specialist input required from him/her.

Care should be taken that the RSA team does not become unmanageably large for site inspection purposes. Alternatively, it may be beneficial for the audit team leader to conduct separate site visits with technical and non-technical members to avoid that the input of either group would be stifled.

#### 4.2.5 RSA Team continuity

It is preferable but not mandatory, that the same RSA team undertake all the audit stages of a particular project whenever possible. This is advantageous from a point of view of economy and consistency of approach. Any changes to the audit team or its individual members will be subject to approval by the road authority representative.

# 5 Administration and Management of Road Safety Audits

## 5.1 Introduction

This section of the Manual describes the administration and the management procedures related to the procurement of independent road safety audit sub-services for a particular project, the commissioning of the road safety audit and the professional services rendered by the road safety audit team. It also describes the close-out process of the road safety audit reflecting on the responses by the design team to the concerns and recommendations made by the audit team and records the disposition of the road authority on each individually identified road safety concern and recommendation.

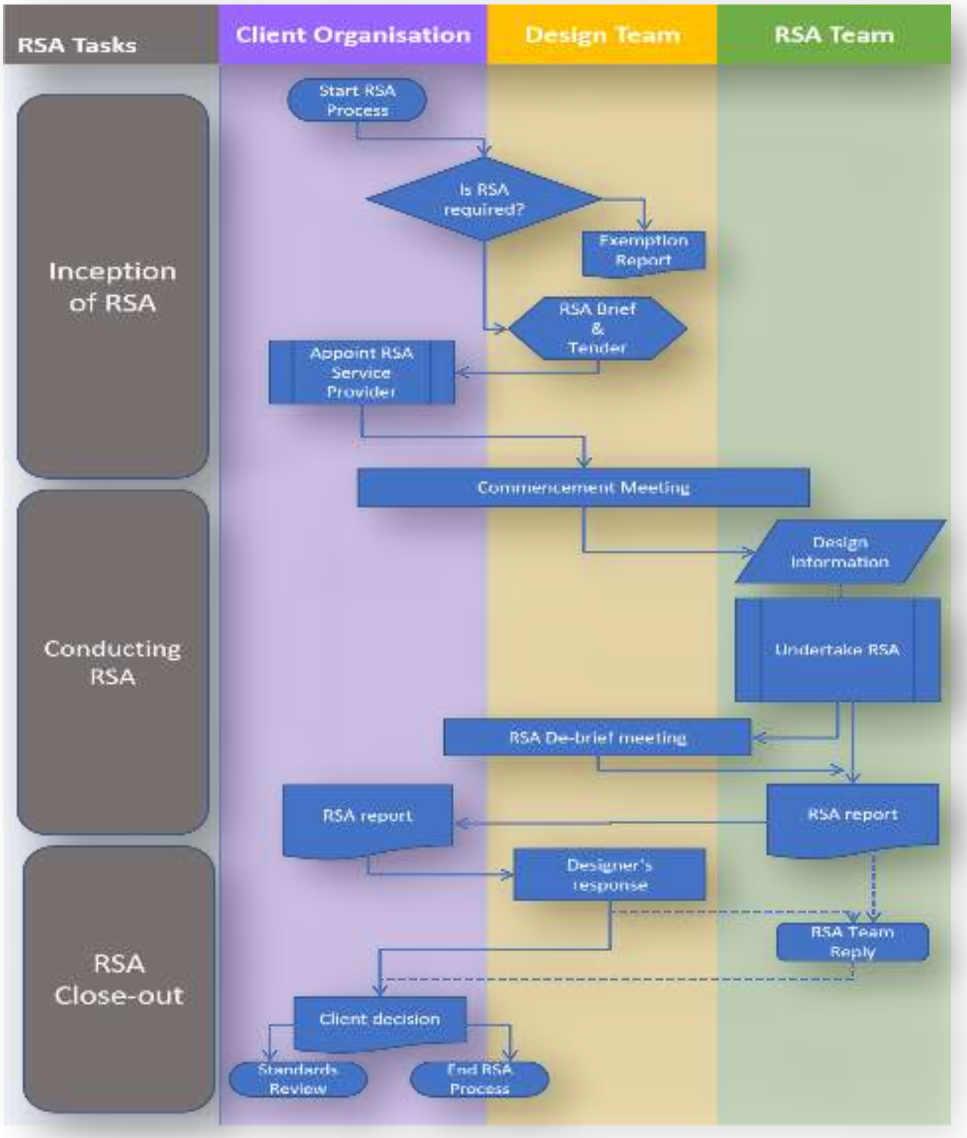


Figure 5-1: RSA process and responsibility matrix

In Figure 5.1 this procedure is described by means of a flow diagram indicating the different elements in the process as well as the appropriate organization responsible for each.

## 5.2 Inception of the Road Safety Audit

### 5.2.1 Decision to proceed with RSA

The model road safety audit policy (see section 3.2) recognizes the need that all new and upgrading projects should be subjected to a road safety audit. The policy also allows for certain projects to be excluded from road safety audit if the complexity thereof is limited or if the scope of the works does not materially influence the conditions which the road-user would be subjected to, for example, like-for-like replacement. The policy also identifies the burden to motivate such exclusion of the road safety audit to rest with the service provider responsible for the project as such.

The first step in the road safety audit process is therefore to determine if the project requires a road safety audit or not. Should the service provider (design team) believe that reasons exist why the project should not be subjected to a road safety audit in accordance with the road safety audit policy, the service provider shall prepare an exemption report to motivate such exclusion or to motivate for a combined Stage 2/3 design stage road safety audit or to motivate that the road safety audit be deferred until pre-opening of the project. Such an exemption report should summarize the reasoning and indicate the conditions upon which the service provider relies for the exemption or deferral and should be prepared acknowledging the principles of the Safe System Approach.

The service provider shall proceed under the assumption that the relevant stages of the road safety audit would be required until such time that the road authority/ client allows for the relaxation sought in the application for exemption.

### 5.2.2 Road Safety Audit Brief

The service provider shall prepare the tender documentation to invite road safety auditors to submit a quotation to conduct independent road safety audit services on the project as a sub-service provider. The invitation shall provide the standard information normally provided by the road authority for price quotations for professional services.

To review the competency of the road safety audit team to conduct the road safety audit, the tender documentation shall require appropriate information on the proposed road safety audit team (see Appendix A2: Pro-forma Terms of Reference). This information shall include clear indication of acceptable accreditation of the road safety auditors, the currency of training as a road safety auditor, with clear indication if such training included the Safe System approach. Road safety auditor information shall also include information on the experience which the road safety service provider relies on to prove appropriate experience.

The tender invitation shall provide a summary of project information which will be provided to the successful road safety audit service provider clearly indicating:

- Information on the stage and scope of the road safety audit
- Information on the project scope and objectives
- Required road safety audit schedule to be met.
- Availability of:
    - previous audits and road safety audit reports showing responses and client decisions,
    - Traffic information
    - Accident information (where applicable)
    - Appropriate design report and/or design standards adopted for the project.
- Possible additional information that would contribute towards better understanding of the project.

This information shall be consistent with the Terms of Reference of the road safety audit. The road safety audit brief shall be prepared by the design team/ service provider and shared with the road safety audit services provider during the commencement meeting.

### 5.2.3 Terms of Reference

The success of any road safety audit depends firstly on the clarity of the brief given to the road safety audit team, spelling out the scope of works of the audit and the requirements of the client. The terms of reference should follow the principles set out in the RSA Manual with clear understanding that it would be the task of the road safety audit team to objectively review the safety of the project, identify road safety concerns and associated risks, and recommend relevant remedial measures (Appendix A2: Proforma Terms of Reference).

The terms of reference for a road safety audit should include at least the following aspects:

- Project title,
- Required stage of the road safety audit,
- Parties to the project, identifying the road authority, client representative, design service provider and any other directly involved stakeholders,
- Background to the project including possible earlier road safety audits,
- Road safety audit manual to be used as the basis for the audit,
- Full scope of the services required including possible phased auditing and provision for interim audits,
- The need for night-time inspections,
- Required qualifications and experience of the road safety audit team,
- The format for the RSA report,

- Schedule to complete the road safety audit and submit interim road safety audit reports or road safety audit technical notes (if needed) and the final road safety audit report,
- Liaison requirements and
- Additional aspects required by the road safety audit service provider, including possible downstream involvement in the audit close-out process or continuation in follow-up road safety audits,

A pro-forma terms of reference for the road safety audit is included as Appendix V3A2 to Volume 3 Part A of this Manual.

### 5.2.4 The Road safety audit team

The success of the road safety audit depends (to a large extent) on the knowledge and experience of the RSA Team and the ability of the team members to anticipate potential road safety concerns based on the application of the Safe System principles. It is therefore essential that the road authority or client approve a knowledgeable RSA Team that has the experience to anticipate the risk of occurrence of different types of incidents that may lead to serious or fatal accidents.

5.2.4.1 Selection of the RSA Team:

- The road safety audit service provider shall provide the client organization authority with nomination forms for the positions of RSA team leader and team members that clearly confirm the accreditation of the proposed member and his/her road safety engineering background, road safety audit training and experience appropriate to the specific road safety audit to be conducted.
- Proposed team members that do not have experience of the specific type of work or stage of road safety audit should not be approved for use on such a road safety audit as the RSA Team Leader, nor the RSA Team member – especially not if the project would be complex or in a high-speed environment where the risk of fatalities would be higher. Nothing, however, precludes the client to accept such a qualified but inexperienced road safety auditor to occupy a position of RSA Observer on such a road safety audit.
- It is important to realise that the context for auditing at the earlier stages in the project life cycle would require a greater degree of conceptualizing road safety concerns than during the later stages when the designs have been developed to a greater degree. It is thus advisable that conceptual or preliminary design stage road safety audits (Stages 1 and 2) be undertaken with experienced road safety auditors.
- A pro-forma nomination form for road safety audit team members is appended to this manual for the use by the client.

5.2.4.2 Independence of the RSA Team

- A fundamental principle of a road safety audit centres on the need to review the project through 'fresh eyes' – allowing for an impartial and objective review. This underpins the requirement that the RSA Team should be independent of the client, design team or the contractor. With limited numbers of experienced road safety auditors available, it is possible that auditors that are independent of the design team, but part of the design service provider staff be used as RSA Team members. This shall, however, not be allowed in the case where the design team provides services directly to a contractor, such as in a Design/Build project. In such case the RSA Team shall be a third-party independent road safety audit team.
- To support ongoing development of road safety auditors the inclusion of a road safety observer from the design organization or the client organization may be approved subject to a prerequisite that such an observer shall refrain from any action that may impose on the independence of the road safety audit team.

  To retain credibility in the audit process, the client shall be satisfied as to the independence and the competence of the RSA Team to undertake the road safety audit objectively and impartially. It is advisable, but not an absolute requirement that auditors should be from organisations other than the design organisation and separately appointed to provide road safety audit sub-services compliant with terms of reference specifically prepared for the project under review. Should the audit team and the design team be from the same organization, it is of paramount importance that the audit team retains full independence to review the project and suggest appropriate remedial measures.
- The requirement for independence does not preclude direct contact between the RSA Team, the design team, and the client. This may be advantageous in situations where clarification is required, for example in the Audit Brief. Conditions may also occur where a lack of timely identification of a road safety concern by the RSA Team could lead to designs with locked-in road safety concerns. Under such conditions the design team may raise a specific road safety question to the RSA team with the knowledge and approval of the client.

  Such a query and relevant response by the RSA Team shall be treated as an Interim road safety audit which would still be subject to review at completion of the relevant road safety audit stage. At no time, would the road safety recommendations in this Interim RSA be considered as an instruction to the design team to proceed in a specific manner, nor would it bind the RSA Team when the full road safety audit is conducted, and the full context of the road safety environment be available for review.

- Neither the client nor the design team shall influence the outcome of the road safety audit by motivating specific design considerations or issues to the RSA Team. The RSA Team shall also not entertain any suggestions from the design team or the client to change the content of the RSA report, unless such changes stem from findings related to situations outside the scope of the audit.

- The RSA Team should not make recommendations other than in broad terms or in concept. Recommendations that are made in greater detail may be seen as encroaching on the responsibility of the design team and suggesting reduced independence from the design process.

#### 5.2.5 Appointment of RSA Sub-Service provider

The submittal of price quotations to provide independent road safety audit sub-services shall be in accordance with the procurement rules and practices of the client organization.

The appointment of the RSA Sub-service provider shall be done by the client organisation in accordance with its standard procurement procedures.

The appointment of the RSA Sub-service provider shall also include that the client ascertains the competency and experience of the proposed road safety audit team considering the size and complexity of the project.

### 5.3 Conducting the RSA

#### 5.3.1 RSA briefing and sharing of information

A commencement meeting shall be convened with the client, design team and the road safety audit team at the onset of the audit. The commencement meeting provides the opportunity for all parties to discuss the scope of the audit and available information and for the RSA team to request further information or clarification of previously provided information. It also allows the RSA Team to better understand the objectives leading to the project and share the programme for the RSA with other parties, especially if on-site safety or security support would be required for the audit (Appendix V3A2 b4.2 Methodology for the road safety audit).

Appendix V3A4 (Proforma Checklist) to this Manual contains a listing of subject matter that may be provided to the RSA Team as an audit brief.

#### 5.3.2 Desktop study

The RSA team shall review the drawings and reports submitted by the design team to identify potential safety concerns and the proposed interaction between road-users for verification on-site. The RSA Team may make use of the prompt lists in SARSAM2022 Volume 3, Part B (TRH29) (or another appropriate prompt list) for guidance during this review but should extend the review based on the experience of the team of similar projects.

Comments should be limited to those aspects that have specific relevance to safety considerations that have a direct causal or demonstrable relationship to the intrinsic safety of the project components, or the road-user vulnerability seen in the Safe System context of the project.

The review of the drawings shall be conducted for all stages of the road safety audit as required by the audit brief or Terms and Conditions of the sub-services agreement.

### 5.3.3 Site visit

All road safety audits should include a daytime site visit to verify possible potential road safety concerns identified during the desktop study of the project drawings. Projects that are located in a greenfield environment and which would be impossible to access should at least be reviewed at the tie-in locations with existing roads. The RSA Team should identify the times when the worst road safety conditions would be experienced. For example, if the road safety concerns identified potential capacity related concerns, then the site visit should take place during peak hour to assess highest traffic volume conditions; if speed related problems are the primary safety concern, then off-peak site visits should be considered when higher speeds would be prevalent. Site visits for Stages 1 and 2 road safety audits in a greenfield environment should also assess the potential interruption of existing informal travel patterns in that area ensuring that any negative impacts are offset by appropriate remedial measures.

It is preferable that the site visits be conducted by the entire RSA team. Improvement in high quality video recordings allows such recordings to be reviewed in a controlled office environment ensuring that different members of the audit team may be exposed to the same conditions experienced on-site without being exposed to the risks inherent in site inspections. Video recordings should (as much as possible) reflect the conditions which the road user groups would be experiencing. Higher level drone videography would only give a broad indication of the lay of the land and not the conditions which the road user would be experiencing.)

When video recordings are used in support of site visits, the recordings should be uploaded and reviewed on software platforms allowing the geo-referenced integration with mapping software. Any site visit should at least use geo-referenced photographs to be able to accurately locate safety concerns. Using commercial video platforms such as Google Street View as an alternative to conducting site visits is an unacceptable practice. It is also unacceptable to use an inexperienced RSA Observer or a non-auditor to video record the project site *in lieu* of a site visit by the RSA Team.

Night-time site visits shall be undertaken in accordance with the Terms of Reference but at least during Detail design stage and in Pre-opening stage road safety audits.

Upon completion of the site inspection the road safety audit team shall review the findings made on site and correlate these with the information gleaned earlier and the concerns identified for verification on-site.

The road safety audit team or the team conducting the site inspection shall complete a site visit risk assessment prior to conducting the RSA site inspection and shall wear personal protection equipment during the site inspection. This is of paramount importance in Pre-opening stage RSA and any Interim audits being done to allow partial take-over of works and in any site visits that require exposure to active traffic.

### 5.3.4 De-briefing meeting

Convening a de-briefing meeting after the site inspection and before finalizing the RSA report is advantageous whenever a large or complex project has been audited. It offers the opportunity for the RSA team to provide insight to the client and the design team on the issues likely to be included in the RSA report but also allows the RSA team to make sure that the audit team understood the dynamics of the project. It also allows the RSA team to confirm possible background to departure from design standards if these were found to be contributing to road safety concerns.

The de-briefing meeting allows for the identification of possible out of scope concerns before it finds its way into the RSA report. The de-briefing meeting also offers the opportunity to the RSA team to remark on aspects which have been found to be particularly good – issues which are not normally include in the RSA report.

### 5.3.5 The RSA Report

The road safety audit report shall be prepared based on the review of the drawings and the observations by the RSA team (Appendix A5: Typical list of contents for RSA report). The RSA report should be concise, while clearly identifying the location of the safety concern and the Safe System principles that are violated. Each road safety concern should be clearly numbered and defined as specifically as possible, with supporting photographs or illustrations as appropriate. The definition for a road safety audit used in this manual reflects on the technical focus of the road safety audit, rather than a gut-feel comment of potential concerns. Appropriate standards, guidance or reports should be referenced within each road safety concern with the emphasis on compliance with the Safe System approach, but clearly distinguished from compliance testing to design standards.

Each potential accident identified as a safety concern should be risk assessed in accordance with the risk assessment methodology detailed in this report. If the severity of an accident is identified as exceeding tolerable levels (regardless of reduced likelihood) this should be highlighted in the report.

The Road Safety Audit report shall be written in an objective manner avoiding judgmental terminology such as “unsafe, unacceptable, sub-standard, deficient” etc. The RSA report is also not a tool to redesign the project nor to prove to the client that the RSA Team is “better” than the design team. Findings shall be recorded from the perspective of describing the problem, rather than framing it from the perspective of the solution.

An appropriate mitigating measure addressing the safety risk should be recommended for each road safety concern. Recommendations should be constructive and aligned with the stage of Road Safety Audit being undertaken. In general, recommendations in Stages 1 and 2 would be more of a conceptual nature and those in Stages 3 to 5 more related to aspects of detail.

The road safety audit team shall recognise that certain strategic decisions underpin the project. These decisions would normally have been discussed in-depth during the planning and design stages of the project and are expected to provide a balanced approach. Recommendations that question such strategic decisions should be avoided unless they represent a serious threat to road safety of the project. In such cases the recommendations should still focus on the improvement of the design principle rather than the rejection of the premise. The RSA Team shall refrain from making any recommendations that are not specifically driven by road safety concerns.

The RSA report shall be signed off by the RSA Team Leader clearly indicating that the road safety audit was conducted in accordance with the guidelines contained in this Manual. The audit statement shall also indicate any deviation from these guidelines or from the audit brief.

The RSA Sub-service provider shall forward the completed road safety audit report to the client. The client would normally forward the report to the design service provider for review and response. The client may return the report to the RSA team if aspects outside the scope of the audit are included in the report or if the audit violates guidance given in this manual or in the audit brief. The client may also instruct the RSA team to directly copy the report to the design team for consideration and response.

## 5.4 Close-out of the RSA

### 5.4.1 Designer’s Response Report

The designer’s response is intended to recognize that a different road safety viewpoint may exist which may be considered to improve the safety of all or some road-users. It offers the opportunity for fine-tuning a design to reduce the exposure to hazardous conditions by balancing them with the current design proposals. The format of the Designer’s Response Report fits in the Decision Tracking Form included in Appendix V3A6 to this manual.

The designer's response report is not intended as a defence of the design. Should the designer disagree with specific aspects raised in the RSA Report, the design team should respond using a fundamental assessment of the identified road safety concern and not a mere "*designed to standards*"-response.

The design team should refrain from motivating why a specific approach has been taken unless this response would show that the original design provides a greater degree of mitigation than the RSA team's recommendation. For each road safety concern raised in the RSA report, the Designer's Response report makes provision for the design team to agree or disagree from the audit team as to the assessment of the safety concern. It also provides the opportunity for the design team to accept, reject or to propose revised mitigation measures.

In formulating its response, the design team shall also consider the following aspects, and respond taking the road safety concerns into account:

- Is the defined issue within the scope of the project as identified in the RSA Brief?
- Would the recommendation made in the RSA report mitigate the safety issue, reducing the probability of occurrence and/or its severity?
- Will the recommendation lead to other non-safety issues, for example mobility or environmental issues?
- What is the cost implication of implementing the recommendation or could a different more cost-effective solution be used in reducing the severity of potential accidents?

The designer's response report is not intended to attack the RSA Team's recommendations but should have as objective the recognition that a potential road safety concern may exist. The response report advises the client as to meaningful improvement of such an identified road safety concern to give greater protection to road-users.

### 5.4.2 RSA Team reply

Provision is made in the close-out process of the road safety audit for the RSA team to reply to each of the designer's responses. The close-out process is not intended as a means to enter into discussion on the merits of the designer's responses, but rather to minute whether the RSA Team agrees that possible revised mitigation measures suggested by the design team would contribute to the improvement of the safety concern without compromising other safety aspects of the project. In all aspects a principle of "Do no harm" should prevail.

### 5.4.3 Client Decision Report

The Client Decision Report is a summary report used to record final decision by the client. A template in the format of a decision tracking sheet is proposed in Appendix V3A6 which would record the safety concerns identified and the recommendations made by the RSA team, provide for the designer's response and the RSA team reply as well as the decision by the client. If a safety issue is to be accepted, the Client

Decision Report should outline the responsibility for actions that should be taken to reduce the level of risk of the safety issue occurring. If a safety issue is rejected, justification for the rejection should be documented and an alternative action be recorded if possible.

The format of this tracking sheet is included as Appendix V3A6 to this Part of the Manual. This sheet provides for a status indication for the close-out decision by the client for each of the road safety concerns and for the sign-off by each of the parties to the RSA process.

It is recommended that a copy of the completed and signed off decision tracking sheet be bound into the Road Safety Audit report as part of the project completion documentation of the Road Safety Audit.

# APPENDICES

# APPENDIX V3-A1: LEGAL IMPLICATIONS OF ROAD SAFETY AUDITS

**Note:**

**The information provided here is not legal advice. It is intended to sensitise the reader to those aspects of the civil law that could assist a road authority or road safety auditor in minimising the risk of incurring liability or being considered negligent.**

**Objectives:**

- To provide a basic description of legal principles involved in potential litigation,
- To sensitise the road authority and the road safety auditor to the risks involved in the conduct or not of road safety audits.

Concern has been raised that conducting road safety audits might increase the risk of the road authority to be found liable in a civil suit if an audit identified safety deficiencies that could have contributed to a crash. The opposite viewpoint is also possible, namely that a road safety audit demonstrates a proactive approach to identify and mitigate possible road safety problems and could thus be used as a defence in liability litigation.

## Criminal Law and Law of Delict

Road and local authorities are subject to the criminal law and can be prosecuted comparable to an individual. A road or local authority also has certain statutory duties with respect to the planning, design, construction, operation, management, control, maintenance and rehabilitation of roads that expose them to a civil lawsuit. Such a lawsuit is possible if an injured road user can show that a road authority has done something that a reasonable road authority would not have done or has failed to do something that a reasonable road authority would have done.

### Criminal Law

Criminal Law is directed at offences against public interests. Punishable criminal conduct is referred to as a “crime” or “an offence” and is prosecuted by the state in a public trial. The offender is called “the accused” when on trial. A crime is the unlawful blameworthy conduct punishable by the state. Punishable criminal conduct could be a contravention of either a common law offence or a statutory offence or both.

All crimes are defined by law which means that the elements of the specific crime are known and specified in the charge sheet (or other method of informing the accused about the charges against him.)

The Constitution and the law of criminal procedure demand that the accused shall be provided with sufficient information to be defended in a trial.

A crime (when committed) is investigated by the police. The complainant or the victim who has suffered harm or injury because of the commission of such crime cannot decide to proceed or withdraw the criminal charge. The National Prosecuting Authority decides to prosecute the crime and even if the complainant does not want to proceed with the criminal charge, the decision is not that of the complainant. The state bears the onus to prove beyond reasonable doubt that the accused is guilty of the alleged crime.

When an accused person or organization is convicted of a crime, the criminal sanction or punishment that follows may be imprisonment, a fine, correctional supervision or other forms of punishment provided for in the Criminal Procedure Act 51 of 1977 or other Acts.

Law of Delict

Delict is a concept of civil law in which a wilful wrong or an act of negligence gives rise to a legal obligation between parties for which damages can be claimed as compensation for which redress is not dependent on a prior contractual undertaking to refrain from causing harm. A delict may be defined abstractly in terms of infringement of rights. The South African Legal System uses the law of delict as opposed to torts. The Law of Delict is recognised as comprising of five generic elements that all must be satisfied before a claim can be successful. These are:

- **Conduct** - which may consist of either a commission (positive action) or an omission (the failure to take required action),
- **Wrongfulness** - the conduct complained of must be legally reprehensible. This is usually assessed with reference to the legal convictions of the community,
- **Fault** - once the wrongfulness of the conduct is established, it is necessary to establish whether it is blameworthy. However, in certain instances it is possible to find liability without fault, such as in cases of vicarious liability,
- **Causation** - the conduct that the claimant complains of must have caused damage; in this regard both factual causation and legal causation are assessed. The purpose of legal causation is to limit the scope of factual causation. When considering the event that has happened, it is asked whether the damages sustained were foreseeable or too remotely connected to the incident to even consider.

- If the consequence of the action is too remote to have been foreseen by an objective, reasonable person the defendant will escape liability as only reasonably foreseeable damage may be recovered by an action in negligence,
- Damage - finally the conduct must have resulted in some form of loss or harm to the claimant for him to have a claim. This damage can take the form of patrimonial loss (a reduction in a person's financial position, such as is the case where the claimant incurred medical expenses) or non-patrimonial damages (damages that cannot be related to a person's financial estate, but compensation for something like pain and suffering),

South African law follows a conservative approach to the extension of delictual liability and although organs of state and administrators have no delictual immunity, something more than a mere negligent statutory breach and consequent economic loss is required to hold them delictually liable for the improper performance of an administrative function.

In terms of the South African approach, breach of a statutory duty is regarded as being *per se* unlawful. To entitle a person to sue for breach of a statutory duty, it must be shown that:

- the statute was intended to give a right of action,
- that the claimant was one of the persons for whose benefit the duty was imposed,
- the damage was of the kind contemplated by the statute,
- the defendant's conduct constituted a breach of the duty, and
- the breach caused or materially contributed to the damage.

## The Difference between a Delict and a Crime

The difference between a delict and a crime can be described as follows:

- Delict is a civil/private wrong whereas crime is a public wrong,
- Action of delict is brought by the person who suffered the harm; criminal actions are brought by the State,
- Delict must be proved on the balance of probabilities while the commission of a crime must be proved beyond reasonable doubt,
- Main aim of an action in delict is to compensate the victim; in crime to punish the guilty.

## Negligence and Liability

In delict the conduct-requirement is defined as a voluntary human act or omission. A juristic person may act through its members and may thus be delictually liable.

The capacity to act also encapsulates understanding as to the consequences of one's actions. The South African law of delict is founded on the basic principle that harm caused by wrongful and blameworthy (or culpable) conduct can be recovered by delictual action. A wrongdoer who caused damage could be delictually liable only if there was fault on his part, which may be intentional or negligent.

Negligence arises where someone acts without taking proper care – they have not acted as a "reasonable person" would have acted. The test for negligence is:

- Would a reasonable person in the position of the defendant [wrongdoer] foresee the possibility of his or her conduct causing damage to another person?
- Would a reasonable person have taken steps to guard against the possibility of harm? and
- Did the defendant fail to take the steps that a reasonable person would have taken to guard against this possibility of harm?

For liability to attach, harm must be caused in a wrongful manner. Without wrongfulness a defendant cannot be held liable. Wrongfulness is a conclusion of law that the court draws (or does not draw) from the facts pleaded and proved by the claimant. One cannot "prove wrongfulness" though one can prove facts from which the court may be prepared to draw the conclusion that the defendant acted wrongfully. This can therefore relate to either a defendant's positive action or a defendant's omission to act. The general rule is that a person does not deliberately act unlawfully when he merely fails to prevent damage or bodily injury to another. Liability only follows if its failure was unlawful, and it would only be unlawful if, under the specific circumstances, there was a legal duty on the said person to act positively to prevent the damage, and he failed by acting in accordance with such a duty. Whether such a legal duty exists is answered by means of the legal conception of the public morals.

Usually, one person cannot be held liable for the actions of another, but an employer can be held liable for the actions of employees, arising out of the scope and course of their employment; this is referred to as vicarious liability.

The right not to suffer physical injury at the hands of another is constitutionally entrenched, and there is an injunction on our courts to develop the common law in accordance with the spirit, purport, and object of the Constitution. That same right has always existed at common law. At common law where there is bodily harm, it gives rise to a specific civil claim where proof of fault in the form of negligence has always been necessary. Other than expert evidence, an exception to proving negligence can be used by the claimant to show that the defendant deviated from standard practice.

This allows the claimant to infer negligence of the alleged wrongdoer merely from the fact that the incident, which was under the exclusive control of the defendant, actually happened, that the incident would not have happened in the absence of negligence, and that the claimant did not contribute to the harm by his own negligence. The burden of proof then falls on the defendant to refute this *prima facie* inference of negligence that has been created.

## Possible Defences in Delict Cases

If any of the generic elements of a delict can be shown to be missing, there is no case to answer. For example, the defendant may be able to prove the absence of negligence or show that the act was committed by some other person altogether or that any one of the five base elements were not proved by the claimant.

The common law test for unlawfulness in case of omissions is that the court must find that a failure to fulfil a legal duty existed and that such failure caused harm. The existence of a legal duty will be a value judgement on what is reasonable and will also include the court's assessment of the "common convictions of society".

Defences to negligence

The most straightforward defences are:

- that a reasonable person would not have foreseen the harm; or taken the steps necessary to guard against the harm,
- that one acted reasonably (i.e., if a reasonable person would not have done it then the defendant (accused) does not need to do it either).
- A partial defense is to establish that someone else was also at fault (contributory negligence) to have one's damages reduced according to the degree of fault of the other person.

The State is not immune against claims based on invalid administrative action, but the negligent breach of a statutory duty that causes loss is not enough to establish liability. The existence and breach of a constitutional norm or fundamental right will always be relevant during an enquiry into delictual unlawfulness but will not *per se* lead to a finding of unlawfulness, as all circumstances will be considered in an enquiry and normative policy factors will determine liability. Policy considerations of fairness and reasonableness must be considered when imposing a legal duty (duty of care) and ultimately liability to make good the harm suffered by a claimant.

## Statutory Duties of Road Authorities

Road Infrastructure and Traffic Acts

Road authorities in South Africa are subject to at least two pieces of legislation that govern their conduct as far as potential exposure to delictual liability is concerned. The primary legislation is the founding legislation for that authority, whether an agency like South African National Roads Agency Limited (SANRAL) or a provincial or local authority. In all these acts the responsibility to establish and maintain roads are given to such agencies or authorities.

Whereas certain legislation specifically avoids the setting of a legal duty and empowers the authority to do certain tasks, the court ruled in cases that the community considered such a task as part of the duties of the road authority. Notwithstanding restrictive conditions in legislation the courts have considered claims where negligence had been based on the omission to comply with such tasks or functions.

A second piece of legislation that governs the operations of any road authority is the National Road Traffic Act, 1966 and its National Road Traffic Regulations, 1999. The Act clearly specifies the responsibility for the display of road traffic signs on public roads. Whereas the Act provides for the display of those signs that the responsible authority may deem fit, the Regulations to the Act clearly indicate that any road traffic sign should be displayed in accordance with the SADC Road Traffic Signs Manual. This immediately establishes the Traffic Signs Manual as the reference document to determine if signs have been installed in the way that the reasonable professional would have done. It is therefore essential that the road authority and those that are advising the authority on signs for projects should take cognisance of the conditions which the signs should comply with and be aware of the potential risks involved if the signs are not being displayed as intended in the legislation.

Access to Information

An additional piece of legislation exists in the South African legal environment that may have an impact in the arguments surrounding possible litigation on perceived negligence. This legislation is the Promotion of Access to Information Act, 2002.

Although this legislation has nothing to do with negligence, *per se*, it does provide the opportunity for a claimant to discover reports available to the authority leading to an argument that the road authority had known about deficiencies in the road environment and should therefore have acted to remove such deficiencies or to have, at least, safeguarded the situation for the general travelling public.

## Implications for road safety auditing

Liability arising from the conduct of an audit

The main concern for the road safety auditor is that he or she fails to identify an issue that later leads to a crash, which leads to litigation. There may be several reasonable explanations for this:

- The safety problem was identified and discussed in the audit team but not included in the safety audit report because it had been rejected in a previous Audit Response report,
- The safety problem affected part of the project that was outside the scope of the road safety audit brief,

- Road safety knowledge has changed since the road safety audit had been carried out. At the time of the audit, it would have been unreasonable to foresee that type of problem,
- The safety problem was considered by the audit team, but not included in the road safety audit report because it was not a real problem at that time or one with a very small chance to cause an accident,
- The accident that took place may have resulted from human error or from a vehicle fault.

The road authority as client of the road safety audit may also have certain concerns after an accident occurred on a new or improved road project:

- No road safety audit was undertaken, despite procedures being in place recommending road safety audits, or common practice demonstrating that others would have conducted road safety audits under similar circumstances,
- The road safety audit identified the possibility of a similar type of accident and made recommendations for improvement. However, no evidence exists of any response to the audit and no changes were made to the design in response to the recommendations,
- The road safety audit identified the possibility of a similar type of accident, but the road authority rejected the findings of the audit team or rejected the recommendation of the audit team without implementing reasonable alternative mitigating measures,
- The road safety audit was carried out by untrained road safety auditors, or auditors undertaking an audit beyond their level of competence or experience.

### Minimising the risk of litigation

To minimise not only the potential for successful litigation, but also to reduce the possibility of a claim being made in the first instance, the following steps may be taken:

- Road authorities should ensure that road safety audits are undertaken. If resources are constrained then road safety audits should be conducted on a prioritised basis, where the prioritisation should be done in accordance with a policy accepted by the authority.
- The draft policy in this regard should have been cleared by legal counsel for the road authority.
- The road safety audit process should be well documented and road safety auditors should be able to show that the audits have been done and that notes have been kept of deliberations and team discussions, especially of those “findings” that had not been included in a road safety audit report.
- Road safety auditors should ensure that safety concerns raised as issues in previous audits should be repeated in subsequent stages of a road safety audit if still relevant.

- Road safety auditors should be careful in their choice of language in a report. The words “must” and “shall” could be construed as an instruction implying that the road safety auditor assumed a line function responsibility for the project, rather than an advisory role.
- Clients should ensure that they commission road safety audits from competent road safety auditors who can demonstrate that they are suitably experienced to undertake the task.
- Authorities should decide how long to retain records of a road safety audit and to keep such records accessible in the case of a late claim.
- Clients should ensure that they consider the findings and recommendations of a road safety audit report and the preparation of an audit response report. The court may take greater cognisance of what was said and done at the time of responding to an audit, rather than the justifications developed after an accident has taken place.

## Conclusion

Notwithstanding the possibility of litigation, road safety auditors should keep the objective of reducing the risk of crashes or the reduction of severity of crashes as their prime motivation.

By padding road safety audit reports with risk averse or unreasonable findings merely to “cover your back” the road safety auditor just adds to the cost of road safety auditing and the cost of a project, without contributing in a reasonable way to the true objective of the road safety audit.

## Decided Cases

The following cases are examples of the way the courts review cases which could be linked to road safety audit principles:

1. *Cape Town Municipality v Bakkerud* 1997 (4) SA 356 (C)
2. *McIntosh v Premier, KwaZulu-Natal (632/07) [2008] ZASCA 62 (29 May 2008)*
3. *Graham v Cape Metropolitan Council 1999 (3) SA 356 (C)*
4. *Esterhuizen e.a. v Die Lid van die Uitvoerende Raad vir Openbare Werke, Paaie en Vervoer van die Vrystaat Provinsie, Case 1673/2004; Unreported Case; 23 June 2005; G van Coppenhagen J*

# APPENDIX V3-A2: PRO-FORMA: TERMS OF REFERENCE FOR ROAD SAFETY AUDIT

## B1 TERMS OF REFERENCE

### B1.1 DEFINITIONS

1. The following definitions will apply to these Terms of Reference:

a) "South African Road Safety Audit Manual "(RSA Manual) means –

i. the Draft 3rd edition of the guidelines manual developed as part of the TRH/TMH series of guidelines and standard methods published by the Committee of Transport Officials (COTO) to describe the principles, policies and procedures to manage and conduct road safety audits, road safety investigations and supporting road safety assessments or reviews, together with all the appendices forming part of TRH 29 Volume 3: Road Safety Audit, or

ii. the South African Road Safety Audit Manual or TRH 29 Volume 3: Road Safety Audit, (latest edition) sourced from the following website: - http://www.rtmc.co.za/index.php/publications/rs-audit-manual

iii. And/or: a road safety audit manual identified in Schedule 1 herewith to be used for specifically identified road safety audit aspects.

b) "Auditor" means a Road Safety Auditor authorized by the service provider or client organization to conduct a road safety audit in terms of the South African Road Safety Audit Manual.

c) "Independent" means –

i. that the Auditor has no business, financial, personal, or other interest in the activity or application of which that Auditor is authorized to conduct in terms of the South African Road Safety Audit Manual other than fair remuneration for work performed in connection with that activity or application; or

ii. that there are no circumstances that may compromise the objectivity of the Auditor performing such work.

d) "Service Provider" means –

i. The design organization commissioned by the client organization to review the conditions related to the proposed project and to develop the necessary designs and reports to meet the objectives of the project,

e) "Sub-Service Provider" means –

i. The organization commissioned to conduct the road safety audit using key personnel as Auditors.

## B1.2 RESPONSIBILITIES OF THE SUB-SERVICE PROVIDER

1. The Sub-Service Provider shall conduct a road safety audit or road safety audits on the project in accordance with the South African Road Safety Audit Manual.
2. The road safety audit/ audits and any supporting road safety investigations are to be undertaken as per the guidelines and specifications outlined in the South African Road Safety Audit Manual.
3. The road safety audit/ audits shall be conducted for the stages as indicated in Schedule 1 herewith.
4. The Sub-Service Provider shall act as Independent Road Safety Auditor to ascertain the acceptability or not of the proposed design being considered. The audit opinion will be submitted to the Client Organization to inform the finalization of the current stage of the design of the project.

5 The Sub-Service Provider shall submit a full disclosure of their independence as Road Safety Auditor. Any links (shareholding with directorship, both executive and non-executive) with the Client Organization or the Service Provider or a party contracted to execute construction work on the project or any other entity that may influence its independence as an auditor shall be disclosed in full at the onset of the project. Should conditions change affecting the disclosure after such disclosure the Sub-service Provider shall forthwith update the disclosure with the relevant information.

6 The Sub-Service Provider shall carry out his work, which is focused entirely on the identification of safety concerns and recommended remedial measures and submit his findings independent of the preferences expressed by the Client organization, the Project Engineers, the Design Organization or any other role player or interested or affected party.

7 The Sub-Service Provider shall submit his findings and recommendations for mitigation of safety concerns in a road safety audit report as indicated in the South African Road Safety Audit Manual

8 The findings and recommendations made by the Sub-Service Provider shall also be summarized in the prescribed format in a Decision Tracking Record (DTR). The DTR shall be used by the Design organization to accept, reject or partially accept the findings and recommendations made by the Sub-Service Provider.

9 The Sub-Service Provider shall consider all comments received from the Design Organization by means of the DTR and use the DTR in an interactive manner to recommend acceptance or rejection of any or all responses received from the Design Organization as a safety advisor to the Client Organization.

10 The Sub-Service Provider shall refrain from conducting a road safety audit by only providing comments as per detailed audit checklist and the completion of such checklist template sheets unless specifically instructed by the Client Organization in Schedule 1 or in the Road Safety Audit Brief. In such case the completed safety audit checklist sheets shall be supplemented by a geo-referenced video recording of the project which may be viewed on a public accessible video viewing platform. The completed safety audit template sheets and video recording shall be appended to the road safety audit report in a readily accessible electronic format.

### B1.3 DESCRIPTION OF THE PROJECT

1. The location, length, size and characteristics of the project to be road safety audited are described in Schedule 1. This description agrees with the location and relevant information of the scope of works for which the Service Provider as Design Organization has been commissioned.
2. The description of the project shall include a description of the functionality of the proposed project and describe the anticipated development strategy which would be followed in the construction to enable the Auditor an improved understanding of the sequential development of the project schedule.
3. The description of the project shall also include any facilities that would be decommissioned as part of the development of the new project in order for the Auditor to better understand possible changes which road users may need to become accustomed to.
4. Should the Contractor propose a significantly different development strategy, the Service Provider shall advise the Auditor of such changes forthwith to determine if the proposed changes would influence the scope of the road safety audit.

### B1.4 PROJECT BACKGROUND

1. The role and objectives of the project to be road safety audited are described in a local, regional or national socio-economic context in Schedule 1. This description may be described in more detail in design reports that the Auditor may receive in accordance with the Road Safety Audit Brief.
2. The road safety background to the project may also be described in more detail in the Road Safety Audit Brief or in copies of earlier stage road safety audit reports to be provided to the Auditor if conducted and available.

### B1.5 SCOPE OF THE ROAD SAFETY AUDIT

1. The scope of the audit shall be described in Schedule 1 as one (or more) of the standard road safety audit stages as referenced in South African Road Safety Audit Manual and any other specific road safety tasks included in the scope of the audit.
2. The subject of the audit is the Contract Scope as reflected in Schedule 1 and the latest design or tender drawings that have been prepared. In case of any

discrepancy between the two sources, the drawings shall take precedence.

3. The road safety findings and recommendations to be made by the Auditor, are expected to take account of the ultimate solution, and express a view on the implementation schedule.
4. If partial occupation of the works would be taken as part of the temporary traffic management during construction the Auditor may be required to conduct one or more Stage 5: Pre-opening audit(s) as Interim audit(s) to allow possible remedial road safety works to be agreed and implemented prior to the partial opening of the works to public traffic.
5. In the case of a Conceptual Design Stage Audit (Stage 1 RSA) the scope of the audit shall clearly indicate if an audit would be required for different options or alignments developed by the Design Organization. If more than one scheme or alignment would be subjected to an audit, the Client's Representative may, in Schedule 1, instruct the Auditor to conduct a full audit with road safety audit report on the primary scheme to be recommended by the Design Organization, and audits at a more macro level conducted to assess the safety of possible local alternative options, provided that the scheme which eventually progresses to subsequent design stages would be fully audited and closed-out.
6. The Auditor shall not be required to state an opinion comparing schemes or alignments to be more or less safe than the other(s).
7. A specialist road safety engineer may be engaged on the design team. Whereas the Auditor should propose possible remedial measures for identified road safety concerns, it is not the responsibility of the Auditor to develop design solutions for such remedial measures. If so provided in Schedule 1 and specifically approved by the Client's Representative, the Design Team may request the Auditor to express a road safety opinion on an aspect of the design that may result in delays or the design becoming locked into less safe conditions which could constrain the implementation of remedial measures at a later stage. Such an opinion shall be expressed in the form of an Interim Audit that addresses only that aspect. Nothing precludes the Auditor to revise such an interim audit opinion once the full audit is conducted and that particular road safety concern is reviewed in broader context.
8. The scope of the audit shall cover the master listing of aspects to be audited as described in the master audit listing contained in South African Road Safety Audit Manual. Individual projects may not require all the aspects to be audited. Any aspect which the Client's representative wishes to be audited in-depth and/or accident analysis to be done for a road safety investigation on an existing road, should be identified in Schedule 1.

## B1.6 METHODOLOGY FOR THE ROAD SAFETY AUDIT

1. The road safety audit shall be conducted in accordance with the methodology described in the South African Road Safety Audit Manual.
2. The Service Provider, in consultation with the Client's Representative shall agree on the scope of the audit, any specific aspects that need to be emphasized and prepare an Audit Brief for the Sub-Service Provider.
3. A Commencement meeting shall be held where the scope shall be discussed, as well as schedule, program of daytime and nighttime site visits, need for de-brief or completion meeting, submittal of RSA report and the close-out process.
4. Any deviation of the agreed methodology shall be raised as soon as the need for the deviation become known. An alternative methodology shall only be accepted upon proper motivation by the Service Provider and/or the Sub-Service Provider. Any deviation from the agreed methodology shall clearly show that the road safety audit findings would not be compromised compared with results expected from the agreed methodology.
5. The Service Provider and Sub-Service Provider shall take specific notice of the close-out process described in the South African Road Safety Audit Manual. Deviation from the close-out process will only be considered in extraordinary cases.
6. The function of the Auditor in the close-out process, should be clearly understood. The Auditor is not in the line function and shall not give any instruction or comment on designer responses in a manner which may indicate a position any other than that of a road safety advisor

## B1.7 REPORTING

1. The Sub-Service Provider shall prepare the RSA report in accordance with the South African Road Safety Audit Manual. Road safety concerns shall be identified individually unless a particular concern occurs generally, which would then be referenced as general, with the appropriate remedial measure also applicable generally.
2. Each road safety concern shall be risk assessed in accordance with the risk assessment methodology described in the South African Road Safety Audit Manual. The risk assessment shall be recorded in the RSA report.
3. The Sub-Service Provider shall submit the audit report/ draft audit report to the Client Representative who shall facilitate responses from the Service Provider/ or Design Organization in the form of Designer's Response on the Decision Tracking Form.
4. Unless the Designer's Responses agree fully with the findings and recommendations of the Auditor, the Decision Tracking Form shall be returned to the Auditor for consideration of the Designer's Response. The Auditor's reply should be succinct and indicate if the Designer responded to a concern that was properly understood and record if the responses contribute to improvement of safety.
5. The Auditor shall return the Decision Tracking Form to the Client's Representative for consideration, decision, and relevant instruction to the Design Organization.
6. In developing the RSA report, identifying safety concerns and remedial measures, or replying to Designer's Responses, the Auditor shall not be influenced by the

Employer, Client's Representative or Project Engineer regarding the improvement of the scheme plan, and shall not be interfered with in the execution of his duties, save for when the Project Engineer is required to make submissions or provide clarifications.

## B1.8 PERSONNEL REQUIREMENTS

1. The Sub-Service provider shall recognize that information regarding key persons such as the proposed road safety audit team leader and supporting personnel who will be involved in the audit forms part of the adjudication for the assignment and shall be provided using the prescribed forms.
2. The Sub-Service Provider's proposal of key persons becomes a contractual commitment upon award. However, the Employer recognizes that key persons may for some, or other reason is not available for the full duration of the project and any changes to those listed are, to all intents and purposes, a change or variation to the contract. Any proposed change shall be handled formally by way of written request and approval but does not require a variation order to be submitted. Replacement personnel shall be of same or better competence and experience as those initially accepted. Re-evaluation by the Employer's Agent of any replacement key personnel shall be paid for by the Sub-Service Provider unless the circumstances dictating the changes are completely outside of the control of the Sub-Service Provider's.
3. The Auditor performing the duties of the Road Safety Audit Team Leader shall be permanently employed staff of the Sub-Service Provider and shall be a professional engineer or professional technologist duly registered with the Engineering Council South Africa. Other Auditors on the audit team may be subcontracted to the Sub-Service Provider.
4. Auditors shall comply with the minimum qualifications and experience levels as indicated in the South African Road Safety Audit Manual. The Road Safety Audit Team Leader shall have at least 10 years post-graduate experience in road safety engineering and/or traffic engineering and/or geometric design. Road Safety Audit team members shall have at least three years of experience in road safety engineering and/or traffic engineering and/or geometric design.
5. If specified in Schedule 1, it is compulsory for the Sub-Service Provider to engage one additional Road Safety Audit team member from QSE/EME companies/firms for capacity building. Such a member should at least comply with the requirements for a RSA Observer/ Audit trainee as indicated in the South African Road Safety Audit Manual.
6. The Sub-Service Provider may be required to sign a declaration of independence to be submitted when required.

## B1.9 TIMEFRAME FOR ROAD SAFETY AUDIT

1 The envisaged timeframe to conduct the audit, present the findings and the road safety audit report and complete the close-out procedures are recorded in Schedule 1.

## B2.1 MEASUREMENT AND PAYMENT

Item

1 PROFESSIONAL SERVICES WORK BREAKDOWN

| Item No | Item description | Unit |
|---|---|---|
| (a) | Road safety audit brief by Project Engineers and/or Commencement meeting and/or preparatory works regarding entire future road scheme and implementation schedule via Video Conferencing facilities (e.g. MS Teams) | Hour |
| (b) | On-site inspection; daytime and/or nighttime, including photographing or videographing and hosting the video on a platform available for viewing by the Client or Client representative | Hour |
| (c) | Conducting Road Safety Audit of the project at the audit stage(s) as indicated in Schedule 1, including review of drawings, analyses of site inspection information, identification of safety concerns and remedial measures, compiling road safety audit report, and engagement with the Client Representative for completion of remedial measures | Hour |
| (d) | Stage 5 Pre-opening Road Safety Audits of road scheme prior to partial or final opening to road users, identification of safety concerns and remedial works, preparation of Interim and/or final Safety Audit Report, and engagement with Client Representative for completion of remedial measures | Hour |
| (e) | Interim road safety audits on an as and when required basis for road safety engineering liaison with Design Team providing road safety opinion, or as approved by the Client . | Prov. sum |

| | | |
|---|---|---|
| (f) | Issuing the above reports (2 x hardcopies) and discussing the findings with the Service Provider and the Client Representative via Video Conferencing facilities (e.g. MS Teams) | Hour |

| | | |
|---|---|---|
| (g) | Initiating and conducting a completion meeting including finalization of the report and submission of 2 x hardcopies and 1 x digital version | Hour |

| | | |
|---|---|---|
| (h) | Cost for managing, mentoring, and guiding the QSE/EME | Hour |

The tendered unit of measurement for sub-items 1(a) to 1(g) shall be the number of hours required to perform all the tasks as listed and sub-divided per category of the audit team personnel as well as the hourly rate for each category of the audit team personnel, as well as the hourly rate for the Audit team Member sourced from the QSE/EME company.

The tendered unit of measurement for sub-item 1(h) shall be the number of hours required to manage, mentor and guide the QSE/EME company in connection with sub-items 1(a) to (g)

## 2. DISBURSEMENTS (incl. for QSE/EME member)

| Item No. | Item description | Unit |
|---|---|---|
| (a) | Handling costs i.r.o sub-item 1(h)) | Lump Sum |
| (b) | Travel | km |
| (c) | Accommodation | day |
| (d) | Other (meetings, venues, photographs, printing of reports, etc.) | Lump Sum |
| (e) | Allowance for additional Requirements by Employer | Prov Sum |

The tendered unit of measurement for sub-item 2(a) shall be a Lump Sum and shall cover all additional costs associated with managing, mentoring and guiding the QSE/EME company during the execution of the RSA contract not covered in sub-item 1(g).

The tendered unit of measurement for sub-item 2(b) shall be kilometers (km) and shall cover all costs associated with all travel by the Service Provider's team and the QSE/EME companies audit team member during the execution of the RSA contract.

The tendered unit of measurement for sub-item 2(c) shall be in days and shall cover all costs associated with all accommodating the Service Provider's team and the QSE/EME companies audit team member during the execution of the RSA contract.

The tendered unit of measurement for sub-item 2(d) shall be a Lump Sum and shall cover all disbursement costs associated with meetings, venues, photographs, printing of reports and all other costs required by the Service Provider's team and the QSE/EME companies audit team member during the execution of the RSA contract.

The tendered unit of measurement for sub-item 2(e) shall be a Provisional Sum and shall cover any other additional requirements or services required by the Employer and not covered elsewhere.

### B3.1 SCHEDULE 1 TO THE TERMS OF REFERENCE FOR ROAD SAFETY AUDIT

| TOR Ref | SUBJECT | CONDITION |
|---|---|---|
| • B1.1.1(a) | • Road Safety Audit Manual | South African Road Safety Audit Manual (COTO) 3rd edition *[Indicate Draft/ Final] [And/ or]*<br>*[Indicate an additional road safety audit manual, if required*<br>to be used for the following specific aspects:<br>*Indicate aspects to be subjected to the additional road safety audit manual]* |
| B1.1d | Service Provider | *[Indicate the name and contact details of the design organization]* |
| B1.2.3 | Road safety audit stages | *[Indicate the RSA stages to be conducted:*<br>*Stage 1: Conceptual Stage RSA/ Feasibility Study*<br>*Stage 2: Preliminary Design Stage RSA*<br>*Stage 3: Detail design Stage RSA*<br>*Stage 2/3: Combined Design Stage RSA*<br>*Stage 4: Accommodation of Traffic Stage RSA*<br>*Stage 5: Pre-opening Stage RSA*<br>*Thematic RSA: ..........................................................]*<br>And/or<br>*[Indicated if Interim RSA are allowed or required]* |
| B1.2.10 | RSA Checklists | *[Indicate if the RSA Report shall be supplemented by detail completed RSA checklist templates; Indicate the density or distance interval for which the checklists shall be prepared and submitted]* |

| TOR Ref | SUBJECT | CONDITION |
|---|---|---|
| B1.3-1 | Description of the Project | *[Provide summarized detail of the location, size and particular components of the project. Provide details of possible staged implementation. Describe elements of the current situation which road-users are accustomed to which would become obsolete under the new project.]* |
| B1.4-1 | Background to the Project | *[Describe the rationale supporting the new project, the goals and objectives and the strategy to develop the project. Describe any previous RSA reviews and main concerns accepted or rejected/ delayed]* |
| B1.5-1 | • Scope of the Audit | *[Describe any specific aspects that should be addressed as part of the standard stages of RSA or as a specific requirement.]* |
| B1.5-5 | Multiple Stage 1 RSAs | *[Describe the need to conduct multiple Stage 1 road safety audits for more than one options; Clarify which, if any, should be done in full, or which should be done partially.]* |
| B1.5-7 | Road safety opinion or Interim Audits | *[Indicate if the sub-service provider may be requested to conduct an Interim audit to express a road safety opinion to the design team to avoid locking in designs with potential safety concerns]* |
| B1.5-8 | Aspects to be reviewed in depth | *[Identify specific items which the road safety audit team should address in detail and/or accident analysis to be conducted as part of a RSINV.]* |
| B1.8-5 | Personnel requirements | *[Indicate if it is compulsory to expand the RSA Team by inclusion of a RSA Team member or observer from a QSE/EME company]* |
| B1.9 | Timeframe | *[Indicate the dates for the start and end of the road safety audit and any specific intermediate deadline for submittal of reports]* |

# APPENDIX V3-A3: PRO-FORMA: NOMINATION FORM FOR RSA TEAM MEMBERS

| | |
|---|---|
| Name | |
| Audit Team Position: | Team Leader □ Team Member □ Other ……………………… |
| Organisation / Employer: | |
| Date / e-mail | Date: e-mail |
| Contract number / Project/ | Contract No. Project |

| Continued Professional Development Record | | | |
|---|---|---|---|
| Course/ Presenting Organisation/ Type of Course (Example: Road Safety Audit/ SARF/ Residential – theory and practical) | Date | Course/ CPD | Duration (days) |
| | | | |
| | | | |

| Qualifications / Accreditation | | |
|---|---|---|
| Accreditation/ Qualification Name / Awarding Body | Post Nominal | Date |
| RSA Accreditation: | | |
| Professional registration | | |
| Professional qualifications | | |
| | | |
| | | |

| Record of Recent Road Safety Audits (Previous 2 to 3 years only; Specialist audits < 5years) | | |
|---|---|---|
| Scheme / Details | Date | Role |
| Audit Name / Stage: | | |
| Brief Description: | | |
| Audit Name / Stage: | | |
| Brief Description: | | |

| Record of Recent Safety Engineering, Crash Analysis or Collision Investigations (Previous 2 - 3 years only) | | |
|---|---|---|
| Project / Details | Date | Role |
| Type. Name and Location of Project: | | |
| Description: | | |
| Type. Name and Location of Project: | | |
| Description: | | |
| | | |
| Name | | |
| Project | | |

| Career Summary (500 words max) including RSA experience and key dates<br>(Show experience in safety engineering, accident investigation and road safety audit/ role and relevancy to current project) |
|---|
| Brief Description |

| Record of Other relevant information wrt road safety audit/ crash investigation / road safety engineering offered for information of the client. |
|---|
| Brief Description: |

| Statement –<br>I confirm that the information given above is a true and accurate reflection of my training and experience as a road safety auditor and that I meet the requirements contained in the SA Road Safety Audit Manual for the nominated RSA Team position on this project | |
|---|---|
| Name | Signature:<br><br>Date: |

# APPENDIX V3-A4: PRO-FORMA CHECKLIST: ROAD SAFETY AUDIT BRIEF

| Relevant Stakeholder contact details | |
|---|---|
| *Client Organisation Contact* | |
| *Project Name:* | |
| *Project Manager Contact:* | |
| *Design Team Contact:* | |
| *Road Maintenance Contact* | |
| *SAPS/ Metro Police Contact* | |
| *Road/ Metro Local Authority* | |

| Road Safety Audit Stage Required: | | | |
|---|---|---|---|
| | *Contract Start Date:* | | *End Date:* |
| | *Required RSA Stage* | | |
| *1.* | *Conceptual Design* | | Required date: RSA Report |
| *2.* | *End of Preliminary Design* | | Required date: RSA Report: |
| *3.* | *End of Detailed Design* | | Required date: RSA Report: |
| *2/3* | *End of Detailed Design* | | Required date: RSA Report: |
| *4* | *Work Zone Traffic Management* | | Required date: RSA Report: |
| *5.* | *Pre-Opening* | | Required date: RSA Report: |

| Liaison and RSA Requirements | | | | |
|---|---|---|---|---|
| | | | | Comments |
| | RSA Team approval meeting | | | |
| | Commencement meeting | | | |
| | De-brief meeting | | | |
| | Completion meeting | | | |
| | Nighttime site visit | | | |
| | Video record of site drive-through | | | |
| | Append checklists to RSA report | | | |

| **Data Submitted for Road Safety Audit**<br>**Brief description of site and objectives for the project** (Attach location plan if possible): |
|---|
| |

| Data Item | Supplied (✓)<br>Not Available (×) | Method of Supply *<br>Disk/ e-mail/ Hard Copy | Reference (Drawing Nos/ Report Nos) |
|---|---|---|---|
| Road Safety Audit Brief | | | |
| Details of Exemptions or Relaxations from Design Standards | vi. | | |
| Project Drawings including: | | | |
| Layout | | | |
| Road Signs and Markings | | | |
| Long Sections | | | |
| Cross Sections | | | |
| Fencing | | | |
| Lighting | | | |
| Drainage | | | |
| Landscape Detail | | | |
| Other: | | | |
| Plans for inclusion in Road Safety Audit Report (A3 or A4): | | | |
| Electronic copies | | | |
| Hard copies | | | |
| General Details including: | | | |
| Design Speeds | | | |
| Speed Limits | | | |
| Traffic Flows: Existing & Forecast | | | |
| Capacity Calculations | | | |
| Queue Lengths | | | |
| Traffic Signal Phasing/ Timing | | | |
| Non-motorised User Flows | | | |

| Data Item | Supplied (✓) Not Available (×) | Method of Supply * Disk/ e-mail/ Hard Copy | Reference (Drawing Nos/ Report Nos) |
|---|---|---|---|
| Desire Lines | | | |
| Environmental Constraints | | | |
| Other relevant factors including: | | | |
| Adjacent development (proposed/existing) | | | |
| Proximity of schools, hospitals, retirement homes/ etc (Land-use plan) | | | |
| Emergency vehicle access | | | |
| Public Transport routes | | | |
| Accident data 24/ 36/ 48/ months | | | |
| Reports: | | | |
| Design reports | | | |
| Previous RSA Reports | | | |
| Details of any changes since last RSA | | | |
| Previous Designers' Response Reports | | | |
| Previous Client Decision Reports | | | |
| Other Data | | | |

| Comments/ Special Requirements: |
|---|
| |

| Signed by/ for Client: | | Date: | |
|---|---|---|---|

# APPENDIX V3-A5: TYPICAL LIST OF CONTENTS FOR THE RSA REPORT

**Cover page**

*[Title and stage of report; Client organisation and Road authority; Date and revision of the report]*

**Document control sheet**

**Executive Summary**

*[Optional when the RSA report is particularly long, or conditions are complex or require specialists]*

**Table of Contents**

**1 Introduction**

1.1 Title of the Road Safety Audit

*[Identify the road safety audit project and stage of the RSA.]*

1.2 Commissioning Authority

*[Identify the relevant role players such as client, project managers, design team contractor and any other relevant party of significance]*

1.3 Terms of Reference

*[Identify contractual issues and salient aspects from the RSA Brief; describe how the TOR had been complied with]*

1.4 Road Safety Audit Team

*[Record the members of the RSA team, indicating their affiliation, specialists and observers. Also record the names of significant representatives from the client organisation, design team and contracts manager if they attended the site inspection]*

**2 Background**

2.1 Site description and scope of the audit

*[Describe the site and conditions that may have an influence on the safety of road-users on or adjacent the project]*

2.2 Findings resulting from previous road safety audits

*[Describe information related to earlier road safety audits and the close-out of these earlier audits, particularly those findings that had either not been closed or had been postponed to the current audit.]*

**3 Road Safety Concerns from the current Road Safety Audit**

*[Sequential listing of safety concerns and recommendations, including photos (use of which is to be encouraged), annotating findings on a suitable set of plans, where emphasis is desirable. Rate concerns in accordance with the risk assessment methodology - to aid designers and client organisation]*

**4 Road safety audit team statement**

*[In accordance with prescribed format, recording possible deviation from the standard set in the Manual.]*

**APPENDICES**

| | |
|---|---|
| A | Marked-up drawing with indicative location of safety concerns |
| B | Road Safety Audit Brief |
| C | List of reviewed drawings |
| D | Risk Assessment methodology |
| E | RSA Decision Tracking Form (To be included upon finalization of RSA) |

# APPENDIX V3-A6: PRO-FORMA: DECISION TRACKING FORM

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | DECISION TRACKING FORM | | | | | | | | | |
| | Contract Number: | TRD XX/ CCYY | | | Client: | Progressive Metro Municipality | | | | Status |
| | Project | Project Name | | | RSA Stage & Description: | | | | | |
| | Road Safety Auditors: | RSA Consultants | SUM Body AN Other | | Design Consultant: | DTC Consultants Inc | | | | |
| | Audit Team Findings | | Designer Responses | | | Audit Team Replies | | Road Authority Disposition | | |
| | Identified Risk (of a casualty) | Audit Team Mitigating Recommendation | Response (to risk) | Response (to recommend) | Comment | Reply (to designer) | Comment and Status | Decision | Comment | |
| Example | **Pedestrian accident at median crossing**<br>Insufficient separation<br>Risk rating: Medium<br>Location: Avenue 1 & 2<br>Limited lateral distance between crossing points in the median. leading to poor pedestrian behaviour diagonally shortcut between crossings and increasing the risk of vehicle-pedestrian crashes. | Horizontal distance between crossings should be extended and fenced in median/ pedestrian fence. | Agree | Agree | Horizontal distance for Avenue 1 is sufficient; Median fence to be done under Landscape contract/ Out of scope for this contract. | Accept as noted | Response for Avenue 2 outstanding | | | |
| 1 | | | | | | | | | | |
| 2 | | | | | | | | | | |
| ... | | | | | | | | | | |
| | RSA Team Findings | Sign | Designer Responses | | Sign | Reply | Sign | Client | Sign | |
| | | | | | | | | | | |
| | Date Completed | Name | Date of Response | | Name | Replied | Name | Date | Name | |
| | | | | | | | | | | |

TRH 30: 2022

# South African Road Safety Assessment Methods (SARSAM)

## Volume 3

## Road Safety Audit manual

## Part B: Conducting Road Safety Audits

Volume 1: Network screening

Volume 2: Network level assessment

**Volume 3: Road Safety Audit Manual**

Part A: Policy and Procedures

**Part B: Conducting Road Safety Audits**

Draft Standard (CDS) Version 1.0

March 2022
(Draft 1)

# FOREWORD

## Compiled under the auspices of the:

Road Traffic Management Corporation (RTMC)
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## Published by:

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## Existing publication:

This document forms part of the update of the South African Road Safety Audit manual, 2nd Edition, May 2012 (SARSAM 2012)

## Document versions:

**Draft Standard:** This draft of Volume 3, Road Safety Audit: Part A has been prepared to address RSA Management Policies and Procedures and should be read with Volume 3, Part B describing the execution of road safety audits. They have been prepared for the Update of the South African Road Safety Assessment Methods manual and remains the intellectual property of the RTMC.

The contents of the report may only be used for the Update of the South African Road Safety Assessment Methods manual study for which it was commissioned under licence and shall not be reproduced or used in full or in part outside of this application without the authorisation of the RTMC.

## Comments:

Comments on this working draft should be provided in writing and e-mailed to the developers of the document, Messrs CSIR for attention of the Project Manager, Mr Michael Roux at mproux@csir.co.za.

This document and its various parts will only be published in electronic format.

# PREFACE

TRH 29 consists of three mutually supporting volumes related to successive diagnostic practices to improve road safety on the South African road network. These volumes are:

- Volume 1: Network screening
- Volume 2: Road Safety Assessment
- **Volume 3: Road Safety Audit (This volume)**

The South African National Road Safety Strategy 2016-2030 (NRSS) accepted the vision of "Safe and Secure Roads". South Africa aims to contribute towards the reduction of an unacceptable global road safety problem that claims the lives of some 1,3 million people annually. NRSS aims to address this problem on a national scale across different subject areas. This document will fall under the Safer Roads and Mobility theme of the United Nations' 2nd Decade of Action for Road Safety, 2021–2030. One of the strategic themes adopted for achieving Safer Roads is the implementation of a Road Safety Audit Programme on new and upgrade road infrastructure projects.

Volumes 1 and 2 of TRH 29 provides guidelines on applying curative methods for the identification and improvement of hazardous locations, roads, and routes. They also provide proactive assessment methods for the identification and treatment of road safety deficiencies.

**Network screening (Volume 1)** is a process for reviewing a transport or road traffic network with the objective of identifying and ranking sites from most likely to least likely to realise a reduction in accident frequency following the implementation of appropriate safety improvement measures.

**Road Safety Assessment** (Volume 2) is a two-tiered process, namely:

1) **Network Level Assessment (NLA)** which is a routine, programmed and systematic field survey on existing roads to identify risk factors that can be mitigated against to achieve enhanced safety, and
2) **Road Safety Inspection (RSI**) is an expert assessment of the road environment conducted in response to an identified road safety issue on a section of the road network. RSI involves an expert and in-depth review of the safety of existing roads. Apart from identifying safety problems, the assessment team should be looking out to identify and recommend viable and cost-effective measures which will improve safety.

**Road Safety Audit** (Volume 3) provides guidelines on Road Safety Audit - a systematic assessment of plans for new road schemes (including on existing roads), intended to ensure that new roads have the lowest attainable accident potential across all road users.

Road safety auditing can be traced back to the mid-1980's when accident investigators in the United Kingdom (UK) became concerned that even newly built road projects were included on the country's black spot listings. This led to the development of a policy requiring that the design of road projects should be reviewed by a departmental road safety engineering team prior to the construction thereof. It was found that this review process improved the road safety performance of road projects. Through formalization of this process the principle of road safety audits was established. The success of this process was replicated by parallel developments in road safety auditing in Australia.

Road Safety Audit is a proactive road safety engineering tool based on the philosophy that road authorities do not have to wait for the accumulation of serious injury and fatal accidents statistics before positive steps can be taken to reduce the risks of such. It plays a significant role in ensuring that the road environment is forgiving, self-explaining and provides for the needs of all road users while being aligned with the principles of

Road safety audits may be conducted at all stages of the life cycle of a roads or traffic related project (on existing roads, from conception to the final constructed project, as well as after opening to traffic). Given that South Africa is currently in a process of road safety audit capacity development, road authorities should endeavour to introduce road safety audits at the earliest possible stages of specific projects – this will provide the highest road safety return on such investment.

A road safety audit is conducted by a qualified and experienced road safety audit team led by a road safety audit team leader recognized as a specialist road safety engineer and accredited such by the Engineering Council of South Africa (ECSA). The size of the road safety audit team is determined by the size, complexity, and stage(s) of the project to be audited. The audit team leader is the lead auditor that is responsible for compiling the road safety audit report and representing the audit team in engaging with the client (the road authority or project owner). The audit team members assist, collaborate, and contribute to the road safety audit.

The successful implementation of the entire road safety audit process and the implementation of the remedial measures recommended by the road safety audit team would make a meaningful contribution to ensure that road safety problems are not repeatedly introduced on the road network.

It is our firm belief that the South African Road Safety Assessment Methods 2022 manual, (this TRH 29) would pave the way for our real contribution to meeting the objectives of the NRSS and of the UNDoA2.

# OVERVIEW OF VOLUME 3: ROAD SAFETY AUDITS PART B

TRH 29 Volume 3: South African Road Safety Audit Manual (SARSAM2022) consists of two mutually supportive parts, Part A, and Part B.

**PART A: POLICY AND PROCEDURES**

Part A addresses road safety audit policy for utilization on the South African public road network and describes the management procedures associated with road safety audit in South Africa.

Part A introduces road safety auditing including a short background to the Safe System Approach which is industry best practice at the time of writing, and which underpins the road safety audit process described in SARSAM2022. Part A also describes the management process for the appointment of the road safety audit team, the oversight required and the receipt of the road safety audit report from the audit team. It recognizes the need to consider recommendations made in the road safety audit report and to respond to the recommendations in the road safety audit report in a clear and unambiguous manner and to identify remedial measures to be implemented or the reasoning why deviation from the recommended remedial measures was deemed necessary.

**PART B: CONDUCTING ROAD SAFETY AUDITS**

Part B is a continuation of Part A and describes the road safety audit process from the viewpoint of the road safety auditor – focusing on what needs to be done at each stage of the process.

Part B describes the responsibilities of the different parties to the road safety audit process with emphasis on the responsibilities of the road safety audit team. It introduces the Safe System Approach as the basis for conducting road safety audits in contrast with the system that had been described in the 2nd edition of the Road Safety Audit Manual (SARSAM2012). Part B also describes the risk assessment procedure which in SARSAM2022 becomes the responsibility of the road safety audit team.

Part B describes the different types and stages of road safety audits in more detail and the different reports that result from road safety audit. It indicates how these different road safety audit reports lead to the final client disposition report that records the acceptance of remedial measures for individual road safety concerns.

Part B also includes a case study for a design stage road safety audit as well as a typical road safety audit report and prompt lists as guidance to the road safety audit team.

Part B includes an appendix containing typical road safety concerns intended to sensitise the road safety audit team on concerns that can be observed regularly, and which may have been considered appropriate prior to the implementation of the Safe System.

# ACKNOWLEDGEMENTS

A road safety audit manual is a comprehensive guide for the formal road safety audit of road and traffic designs before they are built, and for the road safety investigation of existing roads.

This Manual describes the road safety audit process, together with practical guidance for road safety practitioners. It is recommended reading for all practitioners and decision makers who are responsible for road safety, for designing new road projects and for managing roads.

As the science of road safety auditing is constantly developing, this Manual recognises the benefits of standardising road safety audit procedures and practices and has drawn extensively on the experiences of countries or organisations where road safety auditing is being done and, on the guidelines and procedures in use in these countries.

The RTMC would like to recognise and acknowledge the references that had been made to the following international road safety audit manuals:

- African Development Bank, Transport and ICT Department, Road Safety Manuals for Africa, July 2014
- Asian Development Bank, Road Safety Audit, CAREC Road safety engineering manual 1, March 2018
- AUSTROADS, Guide to Road Safety Part 6: Managing Road Safety Audits, Austroads publication No. AGRS06/19, Edition 1.2, February 2019
- AUSTROADS, Guide to Road Safety Part 6A: Implementation of Road Safety Audits, Austroads publication No. AGRS06A/19, Edition 1.0, February 2019
- FHWA, Road Safety Audit Guidelines, Publication No. FHWA-SA-06-06, 2006
- Highways England, UK Design Manual for Roads and Bridges: Road Safety Audit, GG 119, October 2018
- Indian Roads Congress, Manual on Road Safety Audit (First revision), August 2019
- Institution of Highways and Transportation, Road Safety Audit, October 2008
- National Roads Authority Ireland, Road Safety Audit Series: GE-STY-01024–01027, 2017
- New Zealand, Interim RSA procedures for projects, 2013
- PIARC Technical Committee on Road Safety (C13), Road Safety Manual, 2018
- United Nations Economic Commission for Europe, Road Safety Audit and Road Safety Inspection on the TEM network, 2018

# ABBREVIATIONS

| | |
|---|---|
| BRT | Bus Rapid Transit |
| COTO | Committee of Transport Officials |
| CPD | Continuous Professional Development |
| CWZ | Construction Work Zone |
| DoRA | Division of Revenue Act, 2017 |
| ECSA | Engineering Council of South Africa |
| FSI | Fatal and serious injury accidents |
| MAIS | Maximum Abbreviated Injury Scale |
| NLA | Network Level Assessment |
| NMT | Non-Motorised Transport |
| NRSS | National Road Safety Strategy |
| PRMG | Provincial Road Maintenance Grant |
| QSE/EME | Qualifying Small Enterprise/ Exempt Micro Enterprise |
| RSA | Road Safety Audit |
| RSINV | Road Safety Investigation(s) |
| RSI | Road Safety Inspection(s) |
| RTMC | Road Traffic Management Corporation |
| SARSAM2012 | South African Road Safety Audit Manual, 2nd edition, 2012 |
| SARSAM2022 | South African Road Safety Assessment Methods 2022 |
| SARSM | South African Road Safety Manual |
| SARTSM | South African Road Traffic Signs Manual |
| SADC RTSM | Southern African Development Community Road Traffic Signs Manual |
| SSA | Safe System / Safe System Approach |
| TMH | Technical Methods for Highways (COTO) |
| TTM | Temporary Traffic Management |
| TRH | Technical Recommendations for Highways (COTO) |
| UK | United Kingdom |

| | |
|---|---|
| UNDoA | United Nations Decade of Action for Road Safety. 2011–2020 |
| UNDoA2 | United Nations 2nd Decade of Action for Road Safety, 2021–2030 |
| UNGA | United Nations General Assembly |
| VRUs | Vulnerable Road Users |
| WB | World Bank |
| WHO | World Health Organization |

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# PART B: CONDUCTING ROAD SAFETY AUDITS

# 6 Principles for conducting road safety audits

## 6.1 Safe System Approach

South Africa adopted the National Road Safety Strategy 2016 to 2030 (NRSS) with the vision of "***Safe and Secure Roads***". This strategy emphasises the fact that road safety is everybody's shared responsibility, individually and collectively. This principle is embodied in the Safe Systems Approach.

The Safe System Approach recognizes that road users are human beings that inevitably make errors which may lead to accidents. The human body can only withstand a certain level of change in kinetic energy during an accident before the active forces will result in serious injury or death. This system comprises five essential components which together reflect a holistic view of road safety, namely:

- Safe roads and roadsides
- Safe speeds
- Safe vehicles
- Safe road users
- Safe Post-crash responses

It is against this background that SARSAM2022 has been developed. The strategic themes relevant to road safety audit as a road safety intervention, are:

- Identify and address high road safety risk locations,
- Provide a self-explaining and forgiving road environment, and
- Implement a road safety audit programme on new infrastructure and upgrades.

**Table 6-1: Traditional and safe system approaches to road safety review**

| | Traditional | Safe System Approach |
|---|---|---|
| 1 | Human error is the cause of most accidents; focus on education as a solution | Accidents are multifactor events |
| 2 | Individual responsibility | Shared responsibility |
| 3 | Accidents are the problems to be solved | Casualties are the problems to be solved (the restricted tolerance of the human body to external violence) |
| 4 | The 3 E's road safety model can be separated into unrelated Engineering, Enforcement and Education policy thrusts | The road safety problem should be addressed holistically with a systems approach. |
| 5 | There is an optimum point where it becomes uneconomical to reduce fatalities and injuries further | Loss of life is never an acceptable outcome |
| 6 | Design is based upon road users obeying the rules | Road users make mistakes and should not be punished with their lives for this |
| 7 | Design to standards ensures safety | Safety requires a broader design appreciation |

The fundamental basis for conducting road safety audits within the Safe System Approach has changed compared to a more traditional approach and requires specific attention by road safety auditors. Table 6.1 compares important differences between the traditional approach and the Safe System Approach.

Fundamental to the Safe System Approach is designing a road or traffic scheme that contributes towards the tolerance of the body to sudden changes of momentum or kinetic energy to avoid fatal and serious injury (FSI) accidents (and in fact, all injury accidents) based on the following concepts:

- *Functionality*: roads should be physically and visually different to demonstrate their differing functions,
- *Homogeneity*: there should be limited interaction between road users travelling at different speeds, in different directions and between vehicles and road users of different mass or type,
- *Predictability:* roads should be "self-explaining", and the function and road rules should be clear and evident to road users,
- *Forgivingness:* roads and roadsides should be forgiving in the event of an accident and accommodate driver error,
- *Status awareness:* road users should be able to assess their own capability of performing the driving task.

The challenge to the road safety audit team is therefore to review the design of the road or traffic project to identify the extent to which these concepts are violated at the expense of increasing the risk of casualties.

By the acceptance of the Safe System Approach the integration of the principles described above into the road safety audit process (as advanced in this manual), is now required by means of:

- Comparing possible accident forces to tolerable levels regardless of the likelihood when identifying road safety concerns and assessing casualty risks,
- Categorizing road safety concerns and remedial measures by their respective alignment with the Safe System Approach.

## 6.2 The role of safe speeds in road safety audit

One of the primary concepts in the Safe System Approach is '*safe speeds*'. The tolerance of the human body to changes in momentum or kinetic energy to reduce casualties is specifically correlated with the speed of the different vehicles during an accident. The management of speed may be used to achieve rapid or significant safety improvement.

The core philosophy underpinning the success of the Safe System Approach as proven in the Swedish Vision Zero strategy is termed "*Survivable Speed*." Survivable speeds refer to the speed threshold above which the risk of a fatal or serious injury rapidly increases. These differ depending on the type of accident. These speeds have been postulated by Wramborg as impact speed-fatality probability relationships as shown in Figure 6.1.

The focus of the road safety audit process will be to consider key accident types (as shown in the Wramborg curves) that may lead to fatal and serious injury accidents and kinetic energy generation and their management.

The following key questions should be raised:

- Is it possible to have a head-on accident . . . greater than 70km/h?
- Is it possible to have a side-impact accident . . . greater than 50km/h?
- Is it possible to have a run-off road accident . . . greater than 40km/h?
- Is it possible to have a pedestrian/ cyclist accident . . . greater than 30km/h?

A risk of fatality level of 10% has been adopted as a threshold level of risk of fatality in countries using the survivable speed principle.

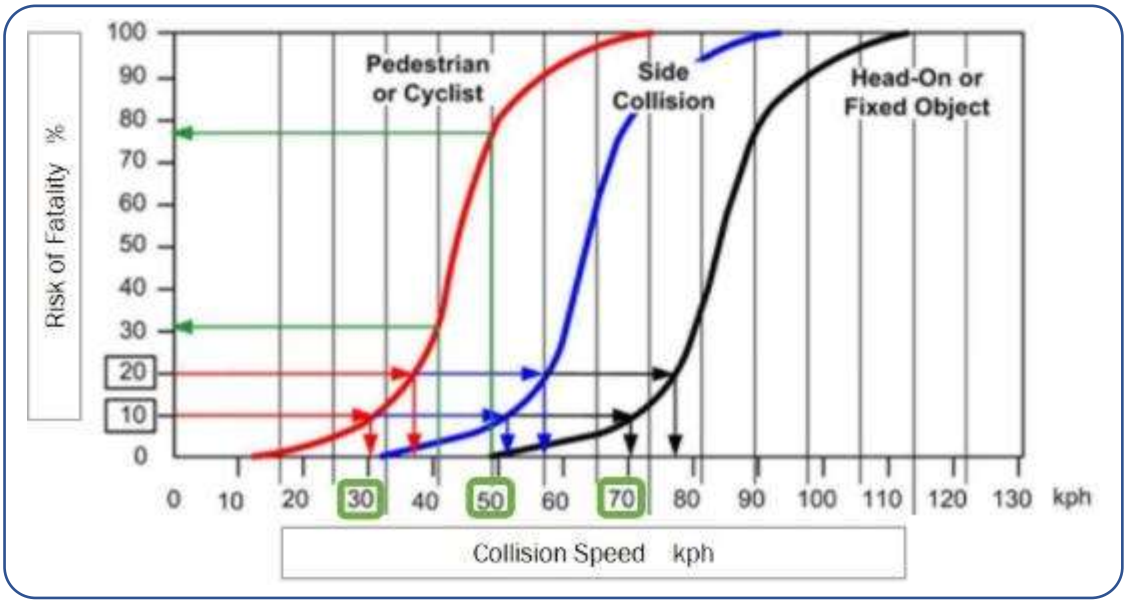



*Figure 6-1: Survivable speeds – Risk of Fatality* (Wramborg, 2005)

Although various studies challenged the quantum of the survivable speeds indicated by Wramborg, the principle of the survivable speeds remains accepted.

The speeds shown in Table 6.2 should be used as the indicative survivable speeds for road safety audits conducted in accordance with this manual

*Table 6-2: Safe System Speeds*

| Accident Type | Impact Speed |
|---|---|
| Car/ pedestrian/ cyclist | 20–30 km/h |
| Car/ Motorcyclist | 20–30 km/h |
| Car/Tree or pole (Run-off road) | 30–40 km/h |
| Car/ Car (side impact/ intersections) | 50 km/h |
| Car/ Car (Head-on/ Fixed object) | 70 km/h |

Various studies have also been done to correlate the effect of changes in mean speeds to the resulting changes in casualties. In Australian studies by Kloeden *et al* (2002) it was found that the risk of being involved in a casualty accident doubles for every increase of 5km/h in travelling speed. Figure 6.3 indicates the relationship between the change in casualties compared to the change in mean speeds as postulated by Nilsson (2004).

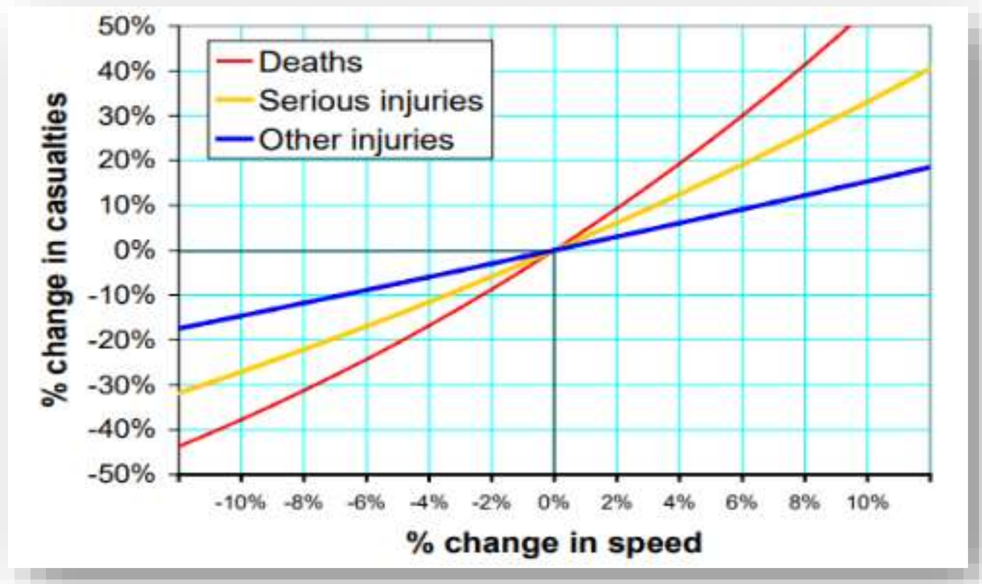



*Figure 6-2: Relationship of speed changes to casualty rate changes*

It is important that the road safety audit team keeps in mind the effect even small changes in speed may have on the risk of casualty accidents on a road due to the non-linear relationship between the speed prior to an accident and the consequent injury level. (This relationship may be explained at the hand of Figure 6.3)

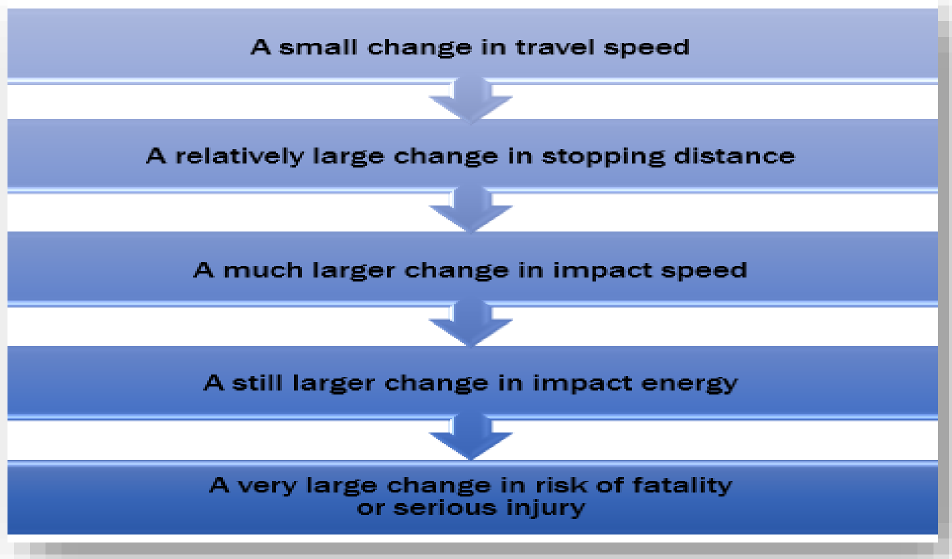



*Figure 6-3: Effect of small travelling speed change on injury*

The review by the road safety audit team of the speed on the proposed project should confirm that the speed should be credible to most drivers so that they drive in compliance with the posted speed limit without endangering other road-users yet retain the principles of survivable speeds.

## 6.3 Risk assessment in road safety audit – The 6–step process

When applying Safe System principles to the RSA process and findings, Australian guidelines suggest that road safety auditors shall focus on three key elements, namely Accident severity, Road user exposure and Accident likelihood. These elements deviate significantly from the risk assessment principles described in SARSAM2012.

In risk engineering, the risk level is a product of the likelihood that an event will occur and the expected outcome of such an event. Risk assessment of individual safety concerns in SARSAM2012 was based on this principle, expressed as the following equation:

$$\boldsymbol{Risk\ Level} = \boldsymbol{Likelihood\ of\ occurrence} \times \boldsymbol{Consequence}$$

In SARSAM2022 this principle is extended to a multi-step process that determines the level of personal risk of injury which the road user would be exposed to, in addition to the level of risk which the safety concern represents. The level of risk represented by the safety concern is measured essentially by the degree and extent of the concern and is identified in this manual as the *intrinsic risk* of the road safety concern.)

The road safety audit team shall identify potential road safety concerns and correlate these with possible accident types and perceived speeds influencing the accident. The risk associated with these safety concerns and the potential negative effect thereof on the road user shall be assessed. The multi-step process shown in Figure 6.4 outlines the risk assessment process for all road safety concerns identified in the road safety audit:

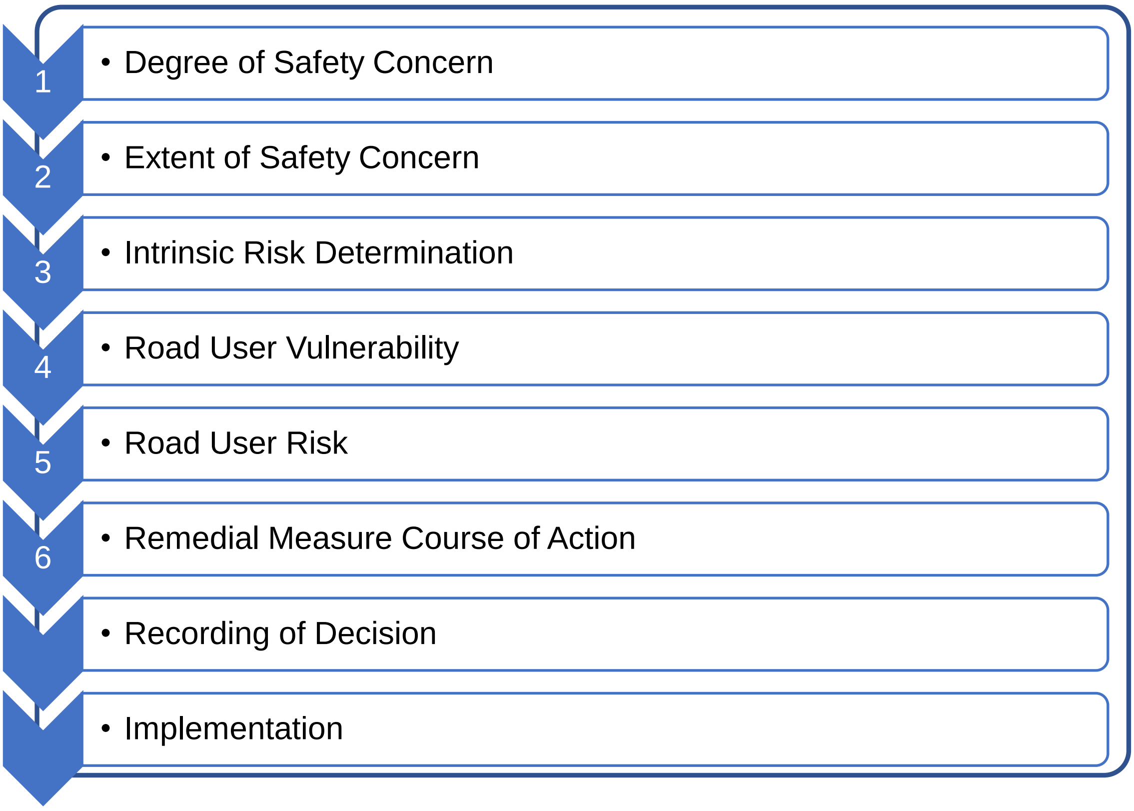



*Figure 6-4: Multi-step risk assessment process*

### *Step 1: Estimate the Degree of Safety Concern*

The *degree* of an identified safety concern is given by the *severity of the injuries* that could be sustained should the road-user be involved in an accident that can be contributed to the safety concern. This requires an assessment of the injury that may be caused when the road user is exposed to conditions leading to an accident while the road user was using the road within reasonable compliance with operational restrictions or within reasonable driver expectation – *i.e.* not excessively over-speeding or driving recklessly, but not excluding the possibility of reasonably exceeding operational conditions.

The degree of safety concern should be assessed in a design stage road safety audit against foreseeable mistakes that the road user may make, rather than measuring the degree against extraordinary or improbable usage scenarios. The degree of the road safety concern is measured against the consequences of an accident involving the safety concern in-use and not based on the degree of distress that a physical hazard may show due to deterioration over time or poor maintenance, although this may play a role in the safety of use.

The degree of safety concern is described in Table 6.3 in terms of the level of injury that exposure to the safety concern could lead to.

(Please refer to Appendix V3B8 for description of the MAIS injury classification.)

*Table 6-3:* Degree of Safety Concern

| DEGREE | DEFINITION |
|---|---|
| **Negligible** | Concern is potentially dangerous or located in a potentially dangerous location but is likely to cause property damage only or trivial or superficial injury remediable by first aid responders. |
| **Minor** | Concern is potentially dangerous or located in a potentially dangerous location and likely leading to minor injury which may require emergency room attendance but not hospitalization (Typical injury level MAIS 2) |
| **Moderate** | The safety concern would cause temporary and remediable injuries requiring hospitalization. Injuries may not be life threatening and would be reversible. (Typical injury level MAIS 3) |
| **Significant** | The safety concern would lead to injury or consequences that would require hospitalization in excess of 24h and would affect the functioning of the injured road-user for a period of some six months or lead to permanent disability (Typical injury level MAIS 4) |
| **Severe** | The safety concern would lead to injury or consequences that is or could be fatal, severe loss of limbs or other long-term or permanent disabilities. (Typical injury level >= MAIS 5) |

### Step 2: Estimate the Extent of the Safety Concern

The level of risk which is represented by the road safety concern does not only depend on the degree of the concern, but also on the extent of the problem situation. It is postulated that the more widespread a problem the greater the likelihood of a road-user to experience the problem and the greater the ensuing risk.

Assessment of the extent of the safety concern should be done in accordance with the definitions described in Table 6.4.

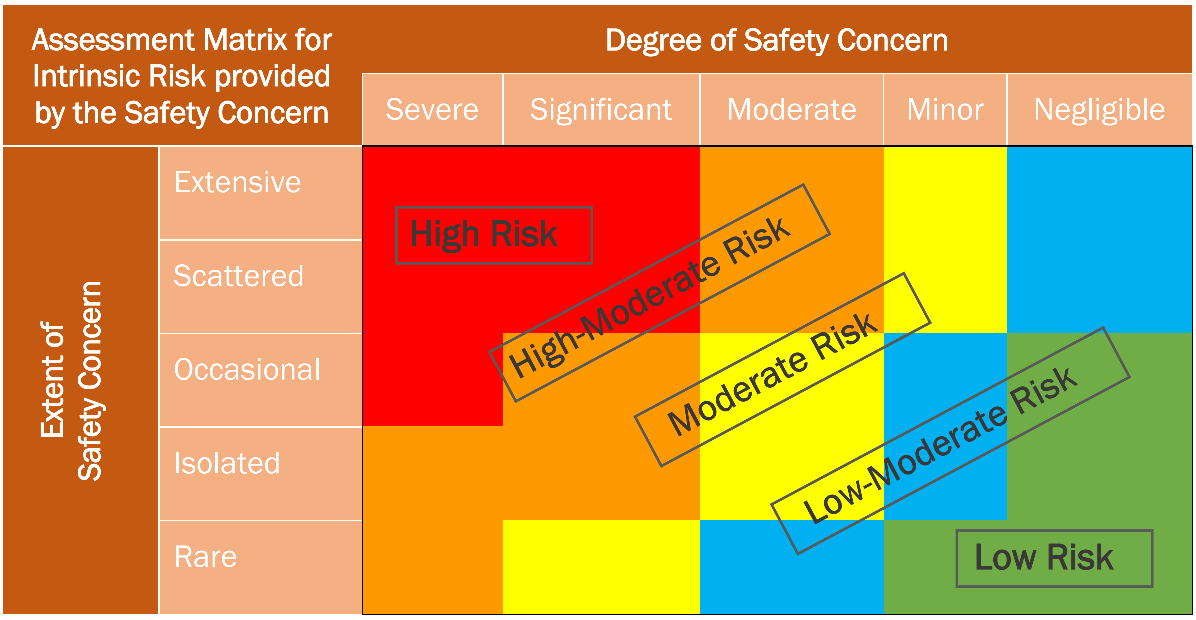
Table 6-4: *Extent of Safety Concern*

| EXTENT | DEFINITION |
|---|---|
| Rare | The safety concern has been identified as limited in size or occurrence and located where conflict with road-users would be unlikely. |
| Isolated | The safety concern is reflected in locations where conflict is likely but found as an exceptional occurrence, *i.e.,* isolated application of a potentially dangerous design situation. |
| Occasional | The safety concern occurs more than merely in isolation but may still be considered as limited in extent, as shown on the design. |
| Scattered | The safety concern may be identified generally over limited areas of the area being audited or intermittently over the greatest part of the area being audited. |
| Extensive | The safety concern occurs extensively over the area being audited, *i.e.*, the safety concern may be included in typical construction standards used in the project. |

### Step 3: Determine the Intrinsic Risk represented by the Safety Concern

The basic level of risk provided by the safety concern is determined by the matrix combination of the degree of the safety concern with the extent of the safety concern. This level of risk is perceived to be the intrinsic or 'natural' level of risk of the safety concern as found in the scheme being road safety audited. This level of risk does not provide for the exposure of the road-user to the safety concern within the Safe System Approach and is shown in Table 6.5.

Table 6-5: *Intrinsic Risk of the Safety Concern*



### Step 4: Estimate the Road-user Vulnerability

Step 4 estimates the road-user vulnerability associated with the Safe System concept of survivable speeds when the road-user is exposed to a potential accident represented by the identified road safety concern. This step is a significant departure from the risk assessment procedure used in SARSAM2012, because it introduces the kinetic energy restrictions that forms the core principle of human body tolerance to traumatic accidents

Risk bands have been introduced on the Wramborg curves and are shown in Figure 6.5.

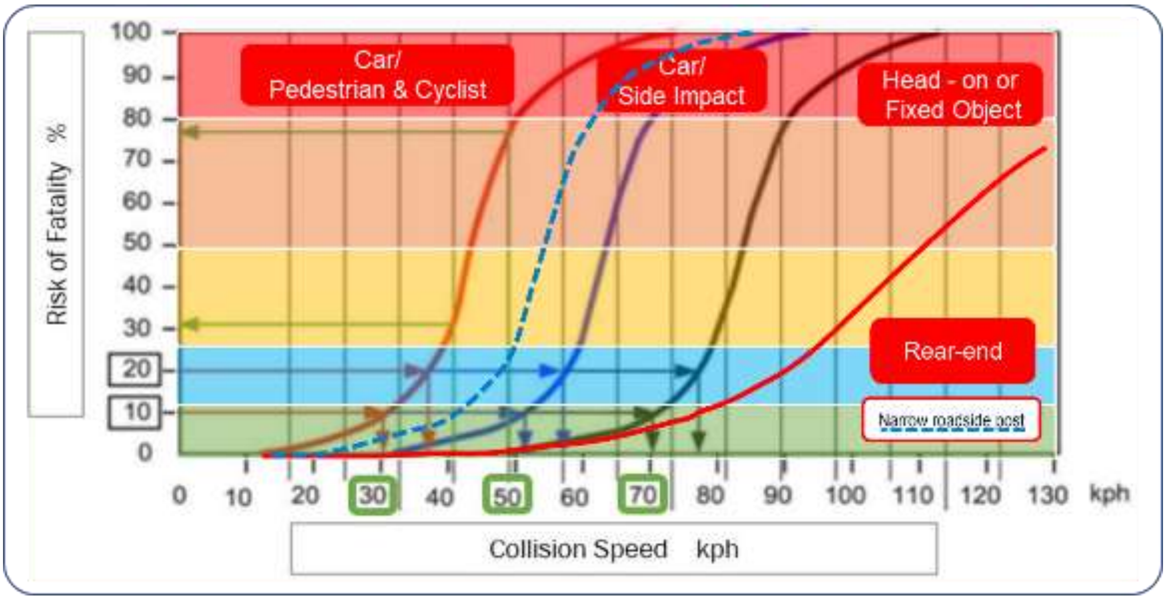



*Figure 6-5 Safe System Road-user Vulnerability*

It is recognised that speed on its own may represent a simplified approach and that various other aspects influence the risk of fatality in an accident, such as:

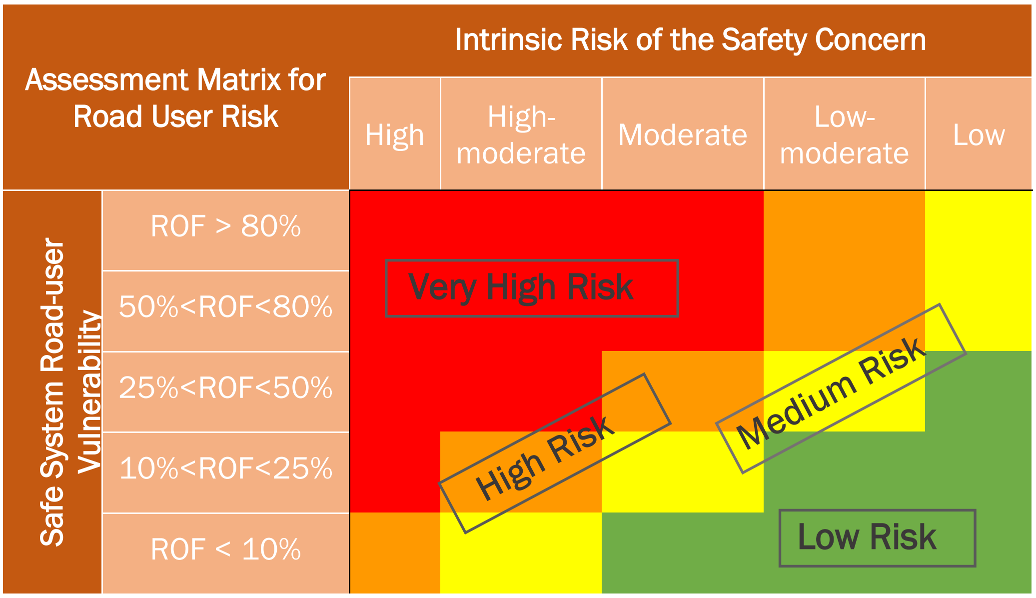
- Age and gender of the road-user victim
- The location and type of impact
- The relative seating location of a victim
- The size shape and stiffness of the victim
- The presence of airbags and other restraint systems such as seatbelts
- The delay in time before emergency medical attention can be given.

Whereas speed is under the direct control of a person involved in the accident and the source of the energy levels in the accident, it is accepted that the survivable speed-concept as indicated in Figure 6-5 should be used in determining the vulnerability of a victim in an accident.

### Step 5: Determine the Level of Road User Risk

Step 5 estimates the road-user risk level represented by the combination of the intrinsic risk of the road safety concern combined with the level of road-user vulnerability within the safe system environment. This adjusted risk level is shown in Table 6.6 and represents the combination of the degree and the extent of occurrence of the road safety concern as well as the exposure of the road-user to conditions not aligned with the Safe System Approach.

*Table 6-6: Road-user risk (Adjusted Risk Level)*




*ROF = Risk of Fatality as indicated in Figure 6.5 or extrapolated from Table 6.2*

Whereas Figure 6.5 provides for the road-user vulnerability based on the survivable speed concept, the Safe System Approach is not only defined by the survivable speed concept. It may therefore be necessary for the road safety audit team to adjust the intrinsic risk of the road safety concern upwards (or downwards) depending on the extent to which road-users would be exposed to situations that are aligned to the Safe System to a greater or lesser extent.

### Step 6: Determine a Course of Action

Upon conclusion of the risk assessment process, the road safety audit team shall prepare appropriate remedial measures to counter the road safety concerns. The suggested treatment actions shown in Table 6.7 below are indicative only. It is acknowledged that the level of development adjacent the reviewed road may differ significantly depending on the location and on traditional practices. Road authorities should review the levels of risk that they would be prepared to accept and develop particular policies pertaining to the risk assessment indicated in the road safety audit and adjust the suggested treatment actions to fit such policies. These policies should then be implemented consistently to strengthen road user expectancy.

Table 6-7: *Suggested remedial treatment action*

| ROAD USER RISK | SUGGESTED TREATMENT ACTION |
|---|---|
| Very High | In Design stage road safety audits, the primary cause of the identified risk should be eliminated if possible, or significantly reduced.<br>In Pre-opening stage road safety audits, the risk should be reduced as far as possible and alternative options be considered to reduce the exposure level of the road-users at risk or the likelihood of accidents. |
| High | In Design stage road safety audits, the risk should be reduced to a lower level. In Pre-opening stage road safety audits, the risk should be reduced by implementing possible accident reduction measures. |
| Medium | Remedial measures addressing the degree or extent of the safety concern should be addressed in Design stage audits and at least warning measures be implemented in Pre-opening stage road safety audits. |
| Low | The design team should identify measures to be implemented which could reduce accident likelihood. |

## 6.4 The Role of the RSA Team

The role of the client and the design team in any new or upgrading road or traffic related project has been well defined over the years. These two parties have the responsibility to review all the conditions related to such a project with the objective of implementing a project that balances the needs of the different road users or affected communities within economic and environmental constraints, whilst retaining constructability of the project.

The role of the road safety audit team is much more a case of reviewing the project through the eyes of different road-users to identify areas where the road-user may be exposed to increased levels of risk of being involved in an accident which could cause death or injury.

The road safety audit team should work within the framework of the Safe System Approach to identify road safety concerns which could contribute to an increased risk of fatalities or serious injuries. These safety concerns should be included in the road safety audit report together with appropriate recommendations to reduce this risk.

Because of the biased opinion expressed by the road safety audit team, the road safety audit team does not give any *instruction* to modify designs to reduce the exposure to incidents or accidents. The road safety audit team submits a road-user safety viewpoint for consideration by the design team or client organization, improving the degree of informed decision-making. The road safety audit team shall also suggest possible measures to improve the safety performance of the project, or all road safety concerns associated with design aspects, to which the design team and client need to respond.

The decision to accept or reject road safety audit recommendations rests with the client in coordination with the design team. It is quite possible that these parties may disagree with the road safety audit team on the likelihood of an accident or on the severity of the accident. It is also possible that the design team may suggest a different remedial measure for implementation. This procedure allows for the implementation of a scheme that would be more sensitive to the possible risks experienced by road-users. It is, however, essential that the decision process and the finally agreed decision be properly recorded.

## 6.5 Responsibilities of different stakeholders

Part A of SARSAM2022 describes the Administration and Management of road safety audits. This includes the responsibilities of the different stakeholders, as indicated in Figure 5.1 which is repeated herewith as Figure 6.7.

### 6.5.1 The client organization

The client organization is responsible for the management and administration of the road safety audit in accordance with the statutory or organization-specific procurement processes from inception to close-out.

It is also responsible for the following aspects related to the technical aspects of the road safety audit:

- Determining with the design team whether the proposed project should be subjected to a road safety audit, and, if so, at which stages of the design process,
- Remaining informed of the design development by means of regular design progress meetings at which the design team presents their design progress with due consideration of allowing adequate time to provide for the road safety audit and close-out procedures,
- Establishing the terms of reference for the identified project to be road safety audited,
- Confirming the road safety audit brief,
- Chairing the commencement meeting, de-briefing meeting and any additional project meetings to be held for the project
- Reviewing the road safety audit report and reviewing the designers' report.
- Deciding on the remedial measures advanced for close-out of the project.

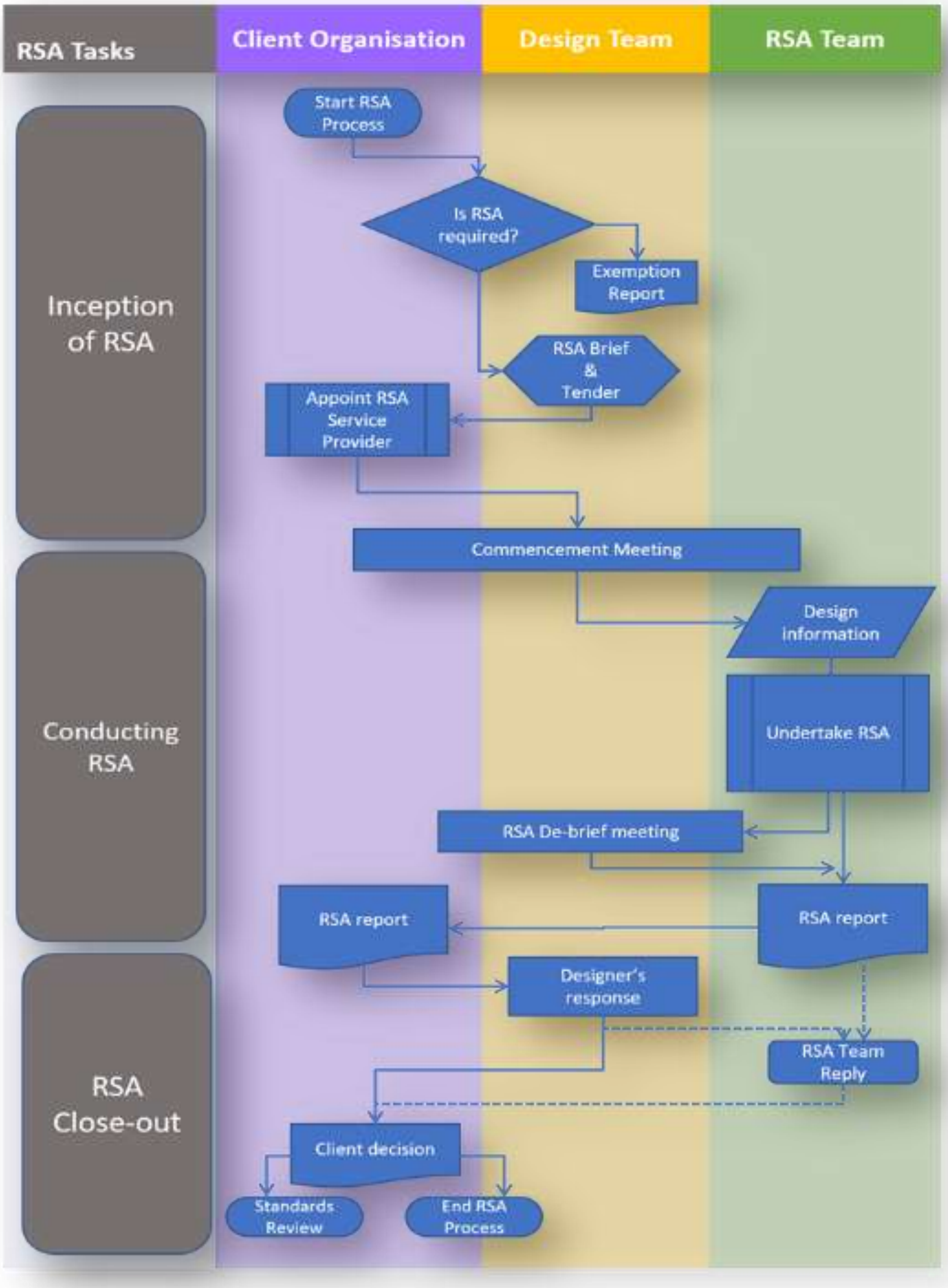



*Figure 6-6: RSA Process and responsibility matrix*

### 6.5.2 The design team

The design team is responsible for the following aspects related to the road safety audit:

- Advising the client on the need for a road safety audit.
- Preparing an exemption report addressing the road safety basis if it was decided not to conduct a road safety audit. This exemption report is in effect a self-assessment road safety review discussing the evidence upon which the design team depends to prove that a road safety audit may be excluded from the scope of the project.
- Developing the road safety audit brief for each stage of the road safety audit process (if a road safety audit was deemed necessary).
- Leading the commencement meeting by sharing project details which the road safety audit team would need to conduct the audit.
- Participating in the site inspections of the road safety audit to provide context and additional background information (but not by influence), should the road safety audit team require such information.
- Responding to all the findings made by the road safety audit team.
- Supporting the client in deciding on remedial measures.

### 6.5.3 The road safety audit team

*The road safety audit team reviews the project through the eyes of all road-users, identifying areas of increased personal risk of injury or fatality or of perceived potential risk.*

Although the responsibilities of the RSA team start officially from the commencement meeting, in practice it already starts its role with reviewing the tender specifications, the audit brief, the site where the audit is located and submitting RSA team information and personnel experience profiles.

The formal responsibilities of the road safety audit team are as follows:

- Attending the commencement meeting.
- Reviewing the audit brief and the design information for completeness and appropriateness.
- Undertaking a desktop review of all the design drawings and/or three-dimensional rendering related to road user interaction.
- Conducting a site visit of the intended location of the Works.
    - Assessing all interaction between road usage on the proposed project and the transitioning between the existing and the new facilities,

    - Identifying potentially hazardous road user behaviour as a result of violation of road user expectation.
    - Identifying potentially hazardous conditions based on incompatibility between different road users as a result of differential speeds or the lack of segregation between different users.
    - Identifying potentially hazardous conditions related to the limited alignment of the design with Safe System principles applied to the project or the lack of a design that complies with the principles of self-explanatory roads or a forgiving roadside.
- Comparing desktop review with on-site observations at suitable time of day or night, not only of road conditions but also taking cognizance of different usage scenarios by all road users, including possible road-user mistakes.
- Assessing the risk of potentially hazardous situations.
- Identifying appropriate remedial measures to reduce the risk associated with the expected conflict and reducing the severity of an expected accident.
- Leading a completion or de-brief meeting with the client and the design team.
- Finalizing the road safety audit report for submittal to the client and copied to the design team for response.
- Advising the client of the soundness of the designer’s responses from a road safety perspective.

# 7 Conducting Road Safety Audits

## 7.1 Definition of Road Safety Audit

*A Road Safety Audit is a formal technical assessment process of a new or upgrading road or traffic project, in which an independent and qualified team pro-actively identifies potential road safety concerns that may lead to injuries or fatalities of any road-users and suggests measures to mitigate such risks by applying the principles of the Safe System Approach.*

The RSA process results in a report describing potential safety concerns and an assessment of their associated risks and measures to mitigate such risks. This risk mitigation should be considered prior to advancing to the next stage of the design process or to physical construction or taking over completed construction works.

## 7.2 Objectives of RSA

The objective of a road safety audit is to identify aspects of engineering interventions that could give rise to road safety concerns and to suggest modifications that could improve road safety. A road safety audit is not a check on the compliance of a project to design standards. It is against this background that road safety audit should be considered. Even with the careful application of design standards by competent professionals, the design process might not remove all hazards for road users.

The road safety audit is initiated to identify aspects that may potentially contribute to incidents or accidents on the project or potentially increase the severity of such accidents. The road safety audit is therefore a biased review of project details.

The primary objective of the RSA process on new or upgrading road and traffic projects is to deliver completed projects that minimize the risk of death and serious injury resulting from road traffic accidents by identifying and grading potential road safety concerns for all road users and others that may be influenced by the road facility or adjacent environment.

Secondary objectives of the RSA process include the following:

- To minimise the need for remedial measures after the opening of a new road project,
- Recognize the importance of safety in road planning, design and implementation for all road users,
- Improve the standards of road design to ensure that all road users are given adequate protection and information with special focus on Vulnerable Road Users (VRUs), especially pedestrians.
- Improve the awareness of road safety engineering principles,

- Improve the awareness of, and contribute to, improvement in safe design practices.
- Ensure that road design is forgiving, thus allowing motorists to recover from error, or to incur least harm when an accident is inevitable.
- To reduce the full life-cycle cost of a road project by reducing its accident cost.
- Develop a culture of road safety among those responsible for the delivery and maintenance of road infrastructure.

## 7.3 Essential elements

The key elements of any road safety audit (RSA) on a project encompass the following aspects:

- The RSA focuses solely on safety aspects of the project,
- The RSA is carried out by a team that is independent of the client or road authority, design team or the contractor,
- The RSA is completed by applying Safe System principles to eliminate or reduce the potential for serious injury or fatal accidents,
- The RSA is carried out by a team with appropriate experience and training, and which understands the Safe System Approach to improve road safety,
- The RSA considers all road users,
- The RSA is a formal documented process,
- The RSA requires a formal close-out response by the road authority or client of all identified road safety concerns.

The RSA is NOT:

- A quality control review, a design review, or a peer review,
- A judgement of the quality of a project,
- A compliance check on standards, guidelines or drawings and specifications,
- An opportunity to redesign or to suggest changes to aspects not directly related to a safety issue.
- An informal check, inspection, or consultation,
- A means of comparing one project or option with another.

In conducting the road safety audit, the road safety audit team shall consistently try to answer the following questions:

- "Who can be hurt in an accident on this part of the road/ project and how might that happen?" and
- "What can be done to reduce the potential for that accident, or to limit its consequences?"

Both these questions need to be answered with reference to the principles of the Safe System Approach and the relevant speed regime.

# 8 The Road Safety Audit process

## 8.1 Summary

PART A of SARSAM2022 describes the different stages of conducting road safety audits. The stages differ based on the phase of the design of the project, on the one hand, and the extent of road safety impact that may be affected as a result of the road safety audit, on the other. All the stages require a similar process of reviewing, which in the responsibility matrix (Figure 6.7) is summarized as "Undertake RSA". This section describes the stages of road safety audits and the process which the road safety audit team should undertake in assessing the road safety concerns in the project being audited.

## 8.2 Components of the road safety audit process

### 8.2.1 Commencement meeting

A commencement meeting shall be convened with the client, design team and the road safety audit team at the onset of the audit. The commencement meeting provides the opportunity for all parties to discuss the scope of the audit and available information and for the RSA team to request further information or clarification of previously provided information. It also allows the RSA Team to better understand the objectives leading to the project and share the programme for the Audit with other parties, especially if on-site safety or security support would be required for the audit.

### 8.2.2 Road safety audit brief

The Client Organisation, in conjunction with the design team, prepares a brief for the Road Safety Audit Team detailing the rationale for the project and the background information. This should also indicate the expectations of the client as far as compliance with the audit procedures is concerned. The road safety audit team should be provided an opportunity to review the audit brief and request further information if needed.

The information in the Audit Brief is road safety audit stage dependant and may include the elements shown in Table 8.1 (or additional relevant information).

*Table 8-1: Information to be included in the RSA Brief*

| RSA Stage | Information to be provided |
|---|---|
| Stage 1<br>Conceptual Design | Extent and timeframe of the road safety audit<br>Scope of and Rationale for the project<br>Relevant land use where the project would be undertaken<br>Continuity of routes<br>Traffic information<br>Proposed speed regime and design standards<br>Other appropriate information, including development proposals, bridge types, phasing and accident information if available. |
| Stage 2:<br>Preliminary Design | Extent and timeframe of the road safety audit<br>Scope of and Rationale for the project<br>Relevant land use where the project would be undertaken<br>Design speed regime<br>Geometric standards and rationale for possible departure from standards,<br>Preliminary design stage drawings – Horizontal & vertical alignment, cross sections, proposed access to properties and typical intersection layout.<br>Traffic flow information, relevant intersection layouts and traffic control proposals<br>Bridge types and cross sections<br>Facilities for pedestrians or other special road user groups<br>Local circumstances, including underground conditions affecting general layout<br>Accommodation of traffic concept<br>Other appropriate information including design report if available |
| Stage 3<br>Detail design | Scope, extent, and timeframe of the Road Safety Audit<br>Copy of previous Road Safety Audit reports and client decisions where available<br>Detailed design drawings, including full details of the scheme including signing, road markings, lighting, safety fences, road and pedestrian restraint systems, drainage gullies, manholes, service chambers<br>Proposed accommodation of traffic scheme<br>Departures from design standards and the rationale thereof,<br>Design speeds, speed limit, speed survey data<br>Copies of standard details of the project including sign faces and mounting/ lighting proposals<br>Traffic and pedestrian data where applicable<br>Details of any traffic signal and / or pedestrian crossing design including capacity and timing calculations, operating modes etc.<br>Local feature information,<br>Lay-by and accesses and provision for heavy or abnormal vehicles or service vehicles<br>Underground and overhead services apparatus including surface features, manholes |

### 8.2.3 Desktop Study

The desktop study of the drawings and other information shall be conducted by the road safety audit team prior to the site visit.

The review of design drawings and model view is crucial to gain an understanding of the proposed interaction between road users and how they may interpret the proposed project. The desktop review should also identify safety issues for verification during the site visit. The drawings may be reviewed using checklists or prompt lists. These lists should not be considered as part of the road safety audit report, nor as a suggested outline or structure of the road safety audit report. The design drawings should be supplemented by the supporting information which the road safety audit team can use to assess the safety of the project against prevailing conditions and use.

Comments should be limited to those which have a bearing on the safety of road users and operators.

### 8.2.4 Site visit

The Road Safety Audit Team shall visit the site to confirm concerns that have been identified in the desktop review and to identify other possible concerns that were not apparent from the drawings. The site visit shall be conducted also as a night-time visit for a Stage 3 Detail design stage road safety audit and a Stage 5 Pre-opening stage road safety audit. In areas of complex interaction with existing facilities a night-time visit at the Preliminary design stage is recommended.

Issues identified in the desktop study should be verified during the site visit, and additional issues recorded. Photographic or video evidence is useful for writing the road safety audit report and performing the road safety audit debrief.

The nature of the site visit will differ depending on the stage of the road safety audit. During concept and design stages the road safety audit team will need to visualize features including the kerb lines, street furniture and the tie-in with existing infrastructure. Construction stages afford the opportunity to comment on the actual layout and road user interaction.

Peak hour visits may be required for all road safety audits to view the layout under the heaviest traffic conditions. Similarly, off-peak observations would reveal higher traffic speeds.

Upon undertaking a site visit the Road Safety Audit Team Members should complete a site visit risk assessment to identify the potential risks of working in the environment necessitated by the road safety audit and identify measures to mitigate those risks as far as practically possible. It is mandatory that appropriate personal protection equipment be worn by all participants attending the site visit.

### 8.2.5 Completion or de-brief meeting

Using the information recorded during the desktop study and site visit(s), the road safety audit team should finalise their findings, assess the risks associated with the findings and identify opportunities for improving safety.

A meeting should be held with the client representative and design team to discuss these findings. This allows the road safety audit team to present the findings, including photographs and video (if available) to the other parties, giving them insight into the issues likely to be included in the road safety audit report and provide feedback where appropriate.

The design team may identify actions already being addressed and discuss recommendations. It is also an opportunity for the client representative to question or seek clarification on road safety audit findings.

Minutes of the meeting should be recorded for inclusion in the road safety audit report, along with digital media used to portray the road safety concerns.

### 8.2.6 Road safety audit report

Once the findings and recommendations are finalised, the Road Safety Audit Team Leader is responsible for preparing the Road Safety Audit Report which may be written with the support of the Audit Team as necessary. The Road Safety Audit Report should be completed within the timeframe specified in the Road Safety Audit Brief.

The road safety audit report should comply with the following:

- The report should be concise and focused on those issues that generate road safety concerns.
- Road safety issues should be described from the road safety concern perspective, rather than from the possible remedial measure or design standard perspective. For example, it would be more appropriate to describe an issue as “*The driver at the skew T-junction would not be able to safely enter the main road in the face of oncoming traffic approaching at a possible operating speed of 80km/h, increasing the risk of a severe injury or fatal side impact accident*” rather than “*Shoulder sight distance to the South is insufficient and/or does not comply with the design standards for 80km/h*.”

- Each issue should be clearly numbered and defined as specifically as possible and referenced to the principles of the Safe System Approach where needed.
- Issues should be supported by photographs, illustrations or extracts from the design drawings as appropriate.
- Where appropriate, relevant standards, guidance or reports should be referenced within each issue to comply with the definition of the road safety audit as a technical assessment process, without such reference being used as a design check for the identified safety concern.
- Each issue should be accompanied by an assessment of the associated risk in accordance with the risk assessment procedure described in this Manual.
- Each issue should have a recommendation for addressing the safety risk. Whilst noting that some risks would be difficult to eliminate at the level where the road safety audit is being conducted, a recommendation to reduce the potential for harm may be made.
- It is important to keep the road safety audit report objective; for example, terms such as "unsafe", "unacceptable", "consider" etc should be used with care to ensure that the objectivity of the Road Safety Audit Team is not compromised.
- Recommendations should be aligned with the stage of road safety audit being undertaken. For example, it would not be appropriate to suggest vertical alignment changes in a Stage 3 Road Safety Audit once a road project is all but completed. In contrast during a Stage 1 Road Safety Audit suggesting the installation of vehicle restraints on the outside of reduced radii curves would normally not be appropriate, rather the alignment could be altered at such an early stage.

The road safety audit report should follow a standardized tabulated format which would support clear coordination with the designer's response report and the client decision report. An example layout of the report is shown in Appendix V3B2 of this Part of SARSAM2022.

The Road Safety Audit report should be submitted to the Client representative and copied to the design team. If road safety issues are identified which are outside the scope of the project as identified in the Audit Brief, they should be listed in a covering letter to the client organization and accompany the road safety audit report.

### 8.2.7 Designer's Response Report

The designer's response is intended to recognize that an alternative road safety viewpoint may exist which should be considered to improve the safety of all or some road-users. It offers the opportunity for refining a design to reduce the exposure to hazardous conditions by balancing them with the current design proposals. The designer's response report is not intended as a defence of the design. It should provide a fundamental assessment of the identified road safety concern and not a mere "*designed to standards*" response.

The design team should refrain from motivating why a specific approach has been taken unless such response would show that the original design provides a greater degree of risk mitigation than the RSA team's recommendation.

For each road safety concern raised in the RSA report, the Designer's Response report makes provision for the design team to agree or disagree with the audit team as to the assessment of such safety concern. It also provides the opportunity for the design team to accept, reject or to propose revised mitigation measures. In formulating its response, the design team shall consider the following aspects:

- Is the defined issue within the scope of the project as identified in the RSA Brief?
- Would the recommendation made in the RSA report mitigate the safety issue, reducing the probability of occurrence and/or its severity?
- Will the recommendation lead to other non-safety issues, for example mobility or environmental issues?
- What is the cost implication of implementing the recommendation or could a different more cost-effective solution be used?

The designer's response report is not intended to critique the RSA Team's recommendations but should have as objective the recognition that a potential road safety concern may exist, and that the designer's response may identify an alternative feasible solution.

The designer's response report shall address each individual concern identified by the road safety audit team and should form part of the tracking sheet used for the Client decision report.

### 8.2.8 RSA Team reply

Provision is made in the close-out process of the road safety audit for the RSA team to reply to each of the designer's responses. This is not intended as a means to enter into discussion on the merits of the designer's responses, but rather to minute whether the RSA Team agrees that possible revised mitigation measures suggested by the design team would contribute to the improvement of the safety concern without compromising other aspects of the project.

### 8.2.9 Client Decision Report

The Client Decision Report is a summary report used to record the decision by the client on each identified and recorded road safety concern. A template in the format of a decision tracking form is proposed which would record the safety concerns identified and the recommendations made by the RSA team, provide for the designer's response and the RSA team reply as well as the decision by the client. If a safety issue is to be only partly accepted or implementation delayed, the client's decision should outline which actions are agreed upon to be taken to reduce the level of risk. In the event that a mitigating proposal is rejected, justification for the rejection should be documented and an alternative action be recorded where possible.

### 8.2.10 Close-out

The format of the decision tracking form (DTF) is included as Appendix B5 to this Part of the Manual. This sheet provides for a status indication for the close-out decision by the client for each of the road safety concerns and for the sign-off by each of the parties to the RSA process.

It is recommended that a copy of the completed and signed off decision tracking form be bound into the Road Safety Audit report.

Whereas the Client Decision Report is a summary report, it is conceivable that this is based on design adjustments or explanations by the design team. Any design revisions that have been accepted as well as exemptions from the road safety audit team replies should be clearly described in the close-out process and supporting documentation appended to the records.

# 9 Road Safety Audit Stages

## 9.1 Conceptual Design Stage Road Safety Audit: (Stage 1 RSA):

This RSA assesses road safety concerns at a higher or broader level where the types of road safety concerns are restricted to the broader road safety principles associated with the project. It addresses different road-user groups in a wide approach and is the opportunity to influence fundamental aspects such as design criteria (including design speeds), possible changes in route choice, impact on the surrounding road network and developments, appreciation of road usage scenarios, etc.

In adopting the basic principle of a Safe System (to create a safer road system that minimises the total number of casualty accidents) a conceptual design stage road safety audit provides the opportunity for the Road Safety Audit Team to not only identify potential road safety issues at planning and inception stages, but also to ‘challenge’ the Client Organisation and Design Team on the nature and type of project being proposed.

For example:

- Will the proposed project generate conflicting traffic movements that cannot be reconciled from a safety perspective?
- Will potential conflicts occur at unacceptably high impact speeds?
- Will the project planning and design create unacceptable differential speeds between road users?
- Will the project be of a type where road users will comfortably comply with the rules of the road?
- Will the proposed design speed and posted speed limits be appropriate for the surrounding environment?

A conceptual stage design (or Route location/ Route determination stage design) is often conducted to identify different alternative design options. It is therefore possible that the road safety audit brief may determine that certain options, such as route alignment, cross sections or access patterns, etc, be audited at different levels of detail or that a Conceptual stage road safety audit may be undertaken on multiple options for particular aspects of a project. The issues identified should be given due consideration by the Design Team prior to the development of the Preliminary Design of the proposed road project.

For improvements or upgrading of the existing road network a road safety inspection of the existing network at the location of the proposed project is recommended in addition to a formal Road Safety Audit of the proposed project. This ensures that any inherent safety problems on the existing road network are not carried forward into road improvements or upgrades or that possible road safety concerns addressed in the project do not just migrate into adjacent sections of the network.

The Stage 1 RSA often needs to be conducted with limited design information while considering broad contextual issues recognising existing patterns that would directly or indirectly influence different groups of road users and their practices.

A Stage 1 Road Safety Audit has the following objectives:

- To identify the potential safety problems that can have an influence on survivable speeds for the following aspects:
  - Project scope
  - Choice of route, layout and/or treatment
  - Design standard selection
  - Impact on the adjacent road network and land-use
  - Impact on pedestrians or vulnerable road user movement patterns
  - Access Control: Provision of accesses/ intersections/ interchanges
  - Continuity of routes
- To consider the design and operating speed regime,
- To assess the relative safety performance of various alternatives for the road project noting that the road safety audit only addresses possible safety concerns and does not rank alternatives on the basis of potential road safety concerns.

## 9.2 Preliminary Design Stage Road Safety Audit: (Stage 2 RSA):

As the design progresses the alignment, junction types and typical cross-sections have usually been determined at this stage. This RSA is conducted towards the end of the preliminary design process when the horizontal and vertical alignment as well as junction designs have been completed.

A Stage 2: Preliminary Design Stage Road Safety Audit has the following objectives:

- To address the design standards utilised for the preliminary design,
- To consider, among others, how the survivable speeds would be influenced by the following:
  - Alignment – horizontal and vertical alignment and their interrelation,
  - Sight distances,
  - Layout of intersections and configuration of interchanges,
  - Widths of lanes and shoulders,
  - Cross-section and superelevation,
  - Location of accesses,
  - Provision for different road user groups: Pedestrians, cyclists, heavy vehicles, etc
- To evaluate whether any deviation from guidelines and design standards would impact safety negatively, seen from the perspectives of all potential road users,

- To determine how possible staged implementation of the project could influence road safety. If staging is proposed, then the safety of each stage should be considered as well as the transition from one stage to the next. This staging should be considered both from a short-term or from a long-term perspective with due consideration of the safety implications, should follow-up works be delayed for some reason.

- To consider the issues carried over from a Stage 1 Road safety audit, or to review issues normally part of a Stage 1 Road safety audit if the Stage 2 Road safety audit is the first audit of the project.

At this stage of the design process, fundamental decisions regarding route choice, the overall design and layout of the project have already been decided. The road safety audit team should take care to not redesign the project at this stage – it is expected that the design team and the client have already resolved fundamental design principles balancing relevant planning, design and affordability issues at this stage. Nevertheless, the audit team may still suggest changes to horizontal or vertical alignment, provision of a median, lane and shoulder width, provision of cycle lanes or sidewalks or channelization, if deemed necessary to comply with the Safe System principles.

Accesses provided should be reviewed for upstream and downstream effects, possible conflicting movements, sight distance and the possible consolidation of access points.

The road project presented for road safety audit at this stage may still be under development with several viable options being worked on by the design team, especially if the project is reasonably complex. As such, design work will be ongoing and certain individual elements may not be progressed sufficiently at the time of the road safety audit. It may therefore be necessary to consider the use of Interim Road safety audits as the project develops. Interim Road safety audits (if approved by the client organization) allow the project cycle to continue without materially affecting the programme.

Conducting an interim stage road safety audit does not negate the requirement for a formal Road safety audit to be undertaken on the completed design elements. Specific issues such as traffic signals, pedestrian facilities or intersections can be brought into play. All issues identified in the Interim Road safety audits should be incorporated at the formal Road safety audit stage.

Any such recommendations should be based on the consideration of safety issues only and should be supported by justifiable Safe System background reasoning. The reasoning need not necessarily be included in the road safety audit report.

The ability of the design to safely accommodate future widening, expansion or extension should also be considered, unless they have been excluded in the road safety audit brief. Specific attention needs to be given to assess the safety of different usage scenarios.

At this stage the client's decisions pertaining to a completed Stage 1 Road safety audit should also be reviewed for acceptance and implementation of any remedial actions in the design. Any issues that have not been satisfactorily resolved from the Stage 1 Road safety audit should be brought forward for inclusion into the Stage 2 Road safety audit.

If the project options are relatively straightforward and the client decides to proceed to a Preliminary Stage design without conducting a Conceptual Stage design, or the client decides not to conduct a Stage 1 road safety audit, then the road safety audit team should conduct the Stage 2 road safety audit as a Combined Stage 1/2 road safety audit. In such case the road safety audit team should make the client aware of this and it should be described thus in the road safety audit brief and the road safety audit report.

The scope of a Combined Stage 1/2 road safety audit also includes the components typically addressed in a Stage 1 road safety audit, acknowledging that potential remedial measures may be more restrictive on the one hand, or could cause interruption of the design process if deemed irreconcilable with the proposed preliminary design.

## 9.3 Detailed Design Stage Road Safety Audit: (Stage 3 RSA)

This RSA takes place close to the completion of the detailed design but before the contract documents are finalized. At this stage, the design drawings should be completed to such a level of detail that they can be used in the preparation of contract documentation. Further to alignment and cross sections, the following design elements should be available for assessment: drainage, kerbs and edge details, street lighting and electricity feeder pillar positions, signing and markings, barriers, intersection traffic control and any potentially fixed objects located in the clear zone.

If the audit team are concerned about a lack of details, they may request such additional details from the client or design team to allow the audit to be completed without conditional findings. This stage is the last opportunity to influence the safety of a design before construction work details are commissioned.

The Stage 3 road safety audit is focused on aspects of detail as to how the road layout, traffic arrangements and information transfer to the proposed road user groups would influence survivable speeds. It is also the stage where the influence of the violation of driver expectation on Safe System principles such as self-explanatory or forgiving road design would be identified best. It is important that any issues that have not been satisfactorily resolved from earlier audits be reiterated in the Stage 3 audit. It may well happen that the proposed remedial measures for such an outstanding issue be different in this stage than an earlier stage, because the flexibility to influence the design would be less.

A Stage 3: Detailed Design Road Safety Audit has the following objectives:

- To consider, among others, how safe and survivable speeds and the forgiving road may be influenced by the following:
  - Any changes since the Stage 2 Audit,
  - Road traffic signs and markings.
  - Road lighting and electrical reticulation
  - Intersection detail,
  - Roadside hazard management issues (clear zones, vehicle or pedestrian restraints, fixed objects etc.),
  - Needs and requirements for Vulnerable Road Users (pedestrians, cyclists, individuals with disabilities) or special classes of vehicles (heavy vehicles, buses, service vehicles, etc.),
  - Drainage,
  - Landscaping,
  - Cross-section, side-slopes, road furniture, etc.
- To review the safety of the proposed construction phasing prepared by the design team in establishing the constructability of the project, if this had been a requirement of the design team and included in the audit brief,
- To review those findings from earlier stages and the implementation of mitigating measures,
- To consider the issues listed in the Stage 1 and Stage 2 Road Safety Audit if the Stage 3 Road Safety Audit is the first audit of the road project.

If the project is to be implemented in separate phases, which may or may not be implemented at significant time intervals, each phase and its interim end condition should be considered as stand-alone final designs subject to road safety audits. The road safety audit of a subsequent phase should take cognisance of the transition between phases and the expectation of road users.

## 9.4 Work Zone Traffic Management Stage Road Safety Audit (Stage 4 RSA)

This RSA reviews the accommodation of traffic scheme advanced by the contractor and the implementation thereof to ensure safe usage by all possible road users. The audit team should recognize the guidance given to contractors in the SA Road Traffic Signs Manual, Volume 2, Chapter 13: Road Works Signing, as well as COTO Standard Specifications for Road and Bridge Works.

Recognizing that work zones pose challenges as far as design criteria for safe travel are concerned, the Stage 4 RSA reviews the project against the Safe System principles in terms of survivable speeds and forgiving roadsides. The road safety audit team shall realize that speeds should be lower because of lower design standards on deviations and of generally greater restrictions placed on road users.

Particular attention should be given to the following aspects:

- Compliance with driver expectation principles in an environment that will be dynamically changing.
- Appropriateness of the proposed traffic management scheme, especially conditions in transition areas,
- Adequacy and consistency of advance warning areas,
- Proposed and actual speed limits,
- Conflicts between permanent and temporary features,
- Any aspects of the layout that could be misread by road users leading to the violation of driver expectancy,
- Likelihood of mud or dust obscuring traffic control devices,
- Appropriateness of vehicle restraint systems or barriers including the correct installation and the safety level criteria of such systems, including the appropriate application and installation of energy absorbing approach end treatments or terminals,
- Adequate provision for pedestrians, vulnerable road users and public transport vehicles like minibus taxis,
- Conflict points between construction-related traffic and the general public,
- The effect of congestion during peak periods,
- The effect of an incident within the detour/ deviation/ diversion areas.
- Provision for safe conditions during both daytime and nighttime utilization of deviations.

The RSA Team shall be particularly careful in reviewing the safety of road users during the change-over between different phases of the construction process.

A Work Zone Traffic Management road safety audit should be conducted as a combination of a themed detail design stage road safety audit followed by a pre-opening road safety audit of the diversions to confirm that the implementation of the traffic accommodation proposals has been properly implemented and that potential road safety concerns have been correctly addressed in the Accommodation of Traffic design.

In complex projects it is customary to complete the works in multiple phases. A Work Zone Traffic Management road safety audit should be conducted for each of the distinctly different accommodation of traffic phases including the transition from one phase to the next. The pre-opening audit part of subsequent phases should be conducted as Interim Road Safety Audits specifically focusing on the changes that occur from one phase to the next and which may surprise road users that may have grown accustomed to earlier phases.

If a specific phase of the accommodation of traffic allows the beneficial use of a section of road that may be substantially completed, the pre-opening part of the Work Zone Traffic Management road safety audit should be conducted against the background of the final design, rather than accommodation of traffic proposals. This is essential if access to such a section of the works would be difficult or would compromise the safety of road users or construction teams to carry out remedial measures of the final works.

The regular inspection of diversions or the accommodation of traffic scheme is not to be considered a road safety audit nor the responsibility of the road safety audit team. This should be considered as the responsibility of the Contractor and the construction monitoring team in terms of the conditions of contract and the specifications for such project.

## 9.5 Pre-opening Stage Road Safety Audit (Stage 5 RSA)

A Stage 5 RSA should be conducted before the opening to traffic of a road or traffic project but not before substantial completion of the project; enabling the audit team to review conditions as they would be experienced by different road user groups under typical operational conditions.

Pre-opening stage road safety audits represent the last opportunity that the audit team has to identify potential road safety concerns before the road is opened to the travelling public. The team should have the opportunity to conduct a site visit of the whole project, especially intersections and tie-ins with the existing network in a manner similar to which road-users would use the project once opened to traffic.

It is particularly important to also conduct a night-time site visit to review the site under conditions when the road user cannot be assisted by wider perception of the road environment to safely use the facility.

The potential for making significant changes to the road safety situation on-site during a Pre-opening stage road safety audit is limited and the audit team may have to accept that the mitigating measures that may be recommended at this stage would similarly be limited in scope. (Such mitigation would be best received when identified in a Stage 3 road safety audit.)

If it is not possible to audit the project before the road is opened to traffic, the Stage 5 audit may be conducted after the opening of the road, but within one month after such opening and with the approval of the client.

The Road Safety Audit Team may need to walk, drive and/or possibly cycle across the project to assess whether:

- Sufficient provision is made for the different road users of the road project,
- There is adequate protection or mitigating treatment of roadside hazards,
- There is no undue effect on safety as a result of variations between actual construction and detail design, (The road safety audit team conducting the Stage 5 RSA, should take care that only stage-appropriate remedial measures are recommended, but that earlier agreed remedial measures have been implemented.)
- Road signs and markings, lighting and other night-time related issues are appropriately addressed,
- The issues listed in the Stages 1, 2 and 3 Road Safety Audits are considered if the Stage 5 Road Safety Audit is the first audit of the road project.

In the Stage 5 RSA it is also important that the audit team confirm that temporary signage, markings, construction equipment, barriers, fencing, materials and debris that may constitute a hazard, either as a physical entity or as the causal factor for road user confusion, are removed from the newly constructed road facility to ensure that the site as perceived by the road-user would present as a forgiving road.

The implementation of the mitigating factors agreed upon in a Stage 3 Detail Design RSA, should also be assessed in a Stage 5 RSA. If these issues had not been resolved satisfactorily, they should be re-iterated in the road safety audit report.

The traffic management scheme in large projects often calls for certain sections of the project to be completed and partially taken over or to be made available for beneficial use by road users, whilst another part of the project is being constructed. The ability to gain access to such a partially opened section of the project to conduct a pre-opening stage RSA or for the contractor to access that section under traffic, may be restricted or subject to increased risk. Under these conditions it is possible to conduct an interim road safety audit on the section of road to be taken over / partially taken over. This would allow the RSA team and the contractor safer access to the site to conduct the road safety audit and to implement mitigation measures before beneficial occupation.

## 9.6 Other road safety audits

### 9.6.1 Interim Stage road safety audit

The Interim Stage road safety audit forms an integral part of the Road Safety Audit process in working towards a Safe System. An Interim Road Safety Audit can be undertaken on any aspect of the Road Project and at any stage, allowing focused attention to a specific aspect. It is recommended that the client organization allows for interim stage audits in the road safety audit brief such that the results of the interim road safety audit supports progress with the project. Because the scope of interim road safety audits cannot be fully pre-determined, conducting an interim road safety audit should be subject to the approval of the client representative as far as scope and remuneration are concerned.

Interim road safety audits should be conducted in the same procedural manner as other road safety audits in the project development process and be undertaken by the road safety audit team together with specialist advisors pertinent to the type and nature of the required interim road safety audit.

Interim road safety audits are a professional service that is additional to the design and the construction stage road safety audits and should only be undertaken under special circumstances and at the request of and after procurement process approval by the client organization.

All information contained in the interim road safety audits must be gathered and assessed as would be done under any other road safety audit, as part of the full and final road safety audit process.

### 9.6.2 Monitoring Stage road safety audit

The Monitoring Stage audit is conducted after the implementation of road safety remedial measures and is intended to identify and rectify possible road safety concerns that are encountered in the first year after the opening of the project. A Monitoring Stage road safety audit is a mandatory audit in the UK road safety audit process[14].

A Monitoring Stage audit differs from the ordinary process of a road safety audit in the sense that it is based on an in-depth study of 12 months of traffic accident data after the opening of the project. (A monitoring stage road safety audit would not be required if no accidents had occurred in the vicinity of the project in the 12 months after opening, or if the client organization decides not to proceed with such an audit.)

If the client organization decides to proceed with the monitoring stage road safety audit, a road safety audit brief should be prepared, and a road safety audit be conducted in broad terms similar to the audit process described in Figures 5.1 and 6.7. The monitoring stage road safety audit should be directed by the location and nature of accidents. Accident trends or observed changes in accident trends need to be incorporated, especially if migration of accident locations is anticipated.

The road safety audit team shall pay specific attention to possible changes that may have been implemented during the construction stage and the altered effect that the project may have had on the safety of vulnerable road users.

The monitoring stage road safety audit report shall be prepared in reasonable compliance with the layout and contents of the typical road safety audit report.

### 9.6.3 Existing Facility Road Safety Audits

TRH 29 advances that the road safety audit process may be applied on the whole life cycle of a road or traffic project, therefore also on the operational phase of the road. The terminology used internationally to refer to a road safety audit which is conducted on an existing road differs from country to country. In TRH 29 (Volume 1) the road safety assessment process referring to the road safety audit of an existing road is designated as a Road Safety Investigation and is defined very similarly as a road safety audit.

A Road Safety Investigation (RSInv) is a formal systematic examination of an existing road location, in which an independent and qualified team reviews on-site conditions and historical evidence to identify existing or potential road safety problems and suggest measures to mitigate those problems. Because the Safe

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System Approach underpins all road safety assessment methods in TRH 29, it is also important that RSInvs be conducted against the same supporting philosophy.

The aim is to identify problem features which are not yet apparent from the accident history, or new problems introduced by engineering changes to the road or by modifications in the way it is used. RSInvs are therefore performed according to the same procedures as road safety audits.

The selection of roads for RSINV can either be based on the results of network screening or a programme of periodic inspection, e.g., Network Level Assessments (NLA), in which all sections of the road network are inspected at fixed intervals.

RSInv is applied during the normal operation of a road, i.e., when the road is open to traffic and no major maintenance or upgrading works are in progress. It is recommended that RSInv be conducted whenever periodic maintenance is planned, including like-for-like replacement such as re-surfacing. This would allow the identification of remedial measures that could be implemented when construction equipment would be on-site and when provision may be made for funding of road safety remedial measures in combination with maintenance budgets.

A RSInv report follows practically the same layout and administrative review and close-out process as a RSA Report, with the exception that the RSInv should also include an analysis of the accident statistics on such section of road, unless specifically excluded by the client organization in the road safety audit brief.

# 10 Thematic road safety audits

## 10.1 General

The principles underpinning the road safety audit concept allows road safety audit to be applied at all stages of the life cycle of a road or of a transport related project. Depending on the audit brief issued by the client organisation, it is also possible to conduct a road safety audit assessing only certain aspects. In this section the following atypical audits are described:

- Specialist road safety audits for specific road user groups
    - Pedestrians and vulnerable road users
    - Road users with disabilities and special needs
- Specialist road safety audit for integrated transportation hubs
- Land-use development project road safety audit

Thematic road safety audits are audits focusing on specific road users, rather than reviewing the safety of a facility for all road-users. Road safety audits typically require that the audit considers all road-users affected by the proposed project. To an increasing extent, specialized facilities are being developed for non-motorised transport such as jogging tracks and/or cycle tracks which would be used outside of the typical road environment. The need to assess the safety of animal-drawn vehicles in the rural environment is another concern worthy of review in rural areas. Road safety audits that focus specifically on the safety of a particular group of road users are referred to as Thematic Road Safety Audits.

It is also recognized that in certain areas an increased concentration of road-users with specific needs can be identified, such as older pedestrians or those that are hearing or visually impaired. Areas around schools and routes towards schools are also examples where thematic road safety audits may prove particularly beneficial, given the behavioural patterns of young children. Other examples may be found in areas such as public transport hubs, rest-and service areas along freeways, and major shopping malls or sports venues.

It is prudent for a shift in emphasis in areas such as these to specifically address the needs of the prevalent special interest road-user groups.

A thematic road safety audit should be conducted when facilities for specific road-users are developed in such a manner that they would be open for public access or use, rather than a facility with access restricted to an isolated group. The subject matter incorporated in a proposed thematic RSA should be clearly set out in the audit brief to the auditors.

The thematic road safety audit brief and the RSA team should recognize the need for design elements to prioritise the road-user group with the highest degree of vulnerability and proceed stepwise to groups with lesser vulnerability.

In a thematic road safety audit, the audit team should pay particular attention to the following:

- The traffic zones applicable to the road user group under review, such as streets, street crossings, parking areas or transit areas,

- The aspects specifically related to the type of facility, such as pedestrian facilities, traffic exposure or traffic control devices,
- Design elements such as differential speeds, continuity or connectivity with reduced exposure to safety concerns, placement or obstructions of utilities, inter-visibility with vehicular traffic, etc.
- The risk that pedestrians may disobey design elements such as pedestrian channelization or restrictive conditions.
- The possible violation of road-user expectancy, for example the risk of using a marked pedestrian crossing under the impression that the painted crossing reduces the risk of driver ignorance.

Thematic road safety audits may be conducted at any stage in the planning and design process but would have the greatest benefit when done at the planning, detail design and pre-opening stages. It is also important to address the exposure of such vulnerable groups in construction work zones.

## 10.2 Road Safety Audits for specific road-user groups

### 10.2.1 Pedestrians and Cyclists

Pedestrians (and cyclists) are particularly vulnerable to serious injury. In a vehicle-pedestrian accident, the probability of survival for the pedestrian decreases dramatically at impact speeds above about 30 km/h. Management of the speed environment where pedestrians and vehicles interact is therefore a critical consideration. This '*survivable*' differential speed between NMT-users on one side and vehicles in a conflict situation in mixed traffic would be near impossible to achieve.

For this reason, increased focus is given to the separation of vehicles and bicycles, where dedicated cycle lanes are provided at-grade adjacent to vehicle lanes or separated cycle tracks constructed. In the ordinary road environment, it is unlikely that full separation of vehicles and cycles can be achieved by physical separation and or operational separation using traffic control devices at all locations. The increase in risk associated with these type of conflicts forms the basis of a Pedestrian/ Cyclist Thematic road safety audit.

In these thematic road safety audits, the audit brief should clarify the extent to which the road safety audit team should address at least the following possible road safety concerns in terms of speeds, visibility, and road-user expectation conflicts:

- Interaction with bus stop locations and bus rapid transit in terms of waiting areas and entering or exiting the bus
- The location of bus stops, or BRT stops in relation to the possible pedestrian crossings to ensure sufficient forward visibility to crossing pedestrians, without being obscured by a stationary bus.
- The design of bus stop facilities creating continuity with pedestrian walkways, kerb ramps and pedestrian crossings, encouraging the effective interaction with the existing pedestrian network.
- The safety of bus access to bus stops where shared or on-street cycle lanes need to be crossed to use the bus stop

- Access of pedestrians to bus rapid transit stations including pedestrian refuge areas and pedestrian traffic signals when BRT stations are in the median.
- Pedestrian exposure to increasing the number of vehicle lanes and pedestrian crossing distance
- Pedestrian demographics in terms of age and possible mobility restrictions.
- Traffic mix with greater exposure to truck traffic.
- Possible nighttime pedestrian movements

The RSA Team for a thematic pedestrian/ cyclist road safety audit should include at least one member with a good understanding of the principles of pedestrian and cyclist safety. These principles would include reasons why a pedestrian may be influenced to walk, such as:

- The lack of choice between different modes of travel or lack of access to vehicles.
- The distance to a desired destination.
- Characteristics which encourage or discourage walking and the commensurate increase in risk.
- Perception of safety, security and or comfort

The principles of conducting a Pedestrian and Cyclist Thematic Road Safety Audit are the same as any other Road Safety Audit, only with the road-user being restricted to vulnerable road users and the facility possibly restricted to a dedicated facility to the exclusion of other facilities.

The site visit for such a pedestrian or cyclist road safety audit should include:

- A walk-through or ride-through of the audit site
- Assessing conditions against the background of road users with wide ranging but potentially restricted, physical or mental abilities,
- Reviewing the possible lack of visibility of pedestrians at night,
- Reviewing the safety treatment of pedestrian-specific facilities.
- Assessing the behaviour of drivers, pedestrians and cyclists in the adjacent areas and the effect thereof within the audit area.In the South African context, the role of walking even long distances in rural areas is a regular occurrence. The position of the pedestrian in the rural context and on a vehicle-priority network, should be carefully reviewed in any road safety audit in such an environment

A master list of aspects to be considered when assessing the safety of pedestrians in the rural context is included in Appendix V3B7 to this report. The aspects that can cause road safety concerns and which should be addressed in a thematic road safety audit pertaining to pedestrians in rural areas include the following:

- Higher order roads cutting through informal settlements,
- The cross section of these roads is often rural in character and does not suggest that the road is considered as semi-urban,
- Ribbon development of rural settlements along the road,
- Crossing of the main road is required to access schools, shops and houses on opposite sides of the road,
- High vehicle speeds on the major roads with no or limited traffic reducing incentives contributing to high differential speeds,
- Speed traffic calming measures,
- Predominant transport mode in the adjacent developments offers no alternative to walking or cycling,
- Due to the lack of designated transit areas, taxis and buses stop anywhere,
- Un-classified road users such as trollies or animals are vulnerable to motor vehicles,
- Crossing of pedestrians over multiple high-speed lanes,
- Pedestrian bridge or tunnel crossings that are unsafe due to crime or violence,
- No formal walkways other than using shoulders or the roadway itself,

- Lack of roadway lighting increasing the perception of poor security and road safety,
- Non-maintained vegetation,
- Wide range of vehicles making use of the areas,
- Road condition is often poor and suffers from poor maintenance with respect to insufficient road markings and signage and a lack of road furniture such as restraint systems, signs, etc,
- Paved road intersected primarily with gravel roads with little maintenance,
- Lack of road traffic safety awareness and education.

#### 10.2.2 Road users with disabilities and special needs

The United Nations General Assembly adopted Standard Rules on the Equalization of Opportunities for Persons with Disabilities on 20 December 1993. The Constitution of the Republic of South Africa, 1996 protects the rights of all people in South Africa. No person, including the State and private companies may unfairly discriminate directly or indirectly against any person on one or more grounds including race, gender, colour, age or disability. It is against this background that the South African Cabinet approved a White Paper on the Rights of Persons with Disabilities. The White Paper is supported by nine strategic pillars of which Strategic Pillar 1 recognizes the need for Removing Barriers to Access and Participation.

It is incumbent on the road safety audit team to specifically assess the needs of persons with disabilities whenever a road safety audit is conducted in areas close to facilities frequented by persons with disabilities. Whereas various issues emerge generally whenever pedestrian audits are conducted, these become even more important when the facilities are to be used by persons with disabilities. Furthermore, the type of disability must be taken into account when the road safety audit is conducted.

Strategic Pillar 1 of the White Paper addresses the importance of accessibility for persons with special needs. This is a specialized field requiring in-depth analysis to be able to resolve universal accessibility issues for people with a wide range of special needs. Some of these areas of concern (which should be addressed in the context of a road safety audit), include the following:

- Provision should be made for continuous and barrier-free movement by road-users, avoiding the risk of mixed traffic,
- Provision should be made for independent approach, entry and exit of transportation facilities and transitioning between road crossing, sidewalk and adjacent facilities,
- Path of travel should be accessible in terms of width, be linear and continuous and limited in direction changes between pedestrian crossings,
- Pedestrian crossings should be clearly distinguished from the road by applying contrasting road markings, clearly visible and provided with appropriate signs or traffic control devices,

- Sloped transitions should be provided in case of height differences at pedestrian crossings with due consideration of space to turn a wheelchair, for example,
- Kerb ramps towards pedestrian crossings should preferably be aligned perpendicular to the kerb to facilitate direct transition from sidewalk to pedestrian crossing. A single depressed kerb aimed at 45 degrees towards the center of an intersection, instead of directly on to the pedestrian crossing should be avoided,

- Accessible paths should not have dangerous unprotected edges, gaps or openings and should be free of protruding or obstructing objects that may be considered hazardous such as signs or lamp posts, for example,
- Bollards, planters and other roadside furniture should not reduce the accessible travel path to less than 1200mm (or those limits published in relevant regulations or bylaws),
- Appropriate tactile surfaces should be installed in areas where visually impaired persons would require directional guidance,
- Accessible parking spaces for persons with special needs should comply with local regulations or bylaws but should be located as close as possible to the facilities being served. They should be provided with lateral access aisles connecting to accessible pathways and marked with standardized signs and markings,
- Pick-up and drop-off areas should include kerb ramps similar to those at accessible parking spaces in such a way that possible confusion with the roadway and the sidewalk area would be avoided,
- If construction works would impinge on the accessibility of travel paths, irrespective of narrowing of the path or trenching across the path, protection should be provided to prevent road-users from injury, or an alternative and unobstructed accessible path should be provided,
- Pedestrian signals in areas where visually impaired may be expected should be provided with pedestrian buttons at a standard height and supplemented with audible output.

## 10.3 Road Safety Audits for specific types of conditions

### 10.3.1 Road safety audit for integrated transportation hubs

Integrated transportation hubs create complex movement patterns for pedestrians, passenger vehicles and public transport vehicles.

Due to the commercial activity mostly being driven by the increased number of patrons to the area, a significant attraction value exists for small and medium businesses, along with informal business development.

The existence of such formal and informal businesses in an urban or peri-urban environment also requires meaningful access and circulation arrangements for public service vehicles such as waste removal.

The complex movement patterns together with the undisciplined driving characteristics that may be encountered in a less formalised area, require a particularly robust review of potential road safety concerns. The implications of changing scenarios at such a transportation hub, should also be considered when reviewing road safety conditions for such a proposed development.

The figures below indicate the extent to which such a hub influences road safety:

- With developments that initially occurred at Denneboom train station in the Mamelodi area in Tshwane (station currently closed), combined with taxi ranks, a shopping center was developed in support of this hub as well as facilities for informal commercial activities on the other side of a major dual carriageway arterial.

Similar conditions occur regularly, as the figure below indicates in the Mdantsane area, where an even greater utilisation of informal business development is evident.

### 10.3.2 Land use development projects

Land-use development projects can be found in industrial, commercial, or residential environments. They often have their own car parks, driveways or footpaths and therefore have traffic interactions in much the same way as roads and streets. Since these projects have great potential to change the traffic volumes, traffic patterns, vehicle mix, road environment or user perception of the area, they match the type of project envisaged for road safety auditing as contemplated in the definition of a road safety audit.

The inclusion of road safety engineers in the design process would be beneficial in the case of land-use developments. Such an approach:

- saves the developer time and money, because arguments about potential safety concerns are removed from decisions and planning inquiries or appeals.
- avoids last minute re-designs,
- allows developers to use safety as a positive selling feature.

### 10.3.3 Temporary Traffic Management Road Safety Audits

In the case of special events of a significant size or in a potentially hazardous environment, or in areas where such events would result in major variations of traffic flow, it would be particularly advantageous to assess the road safety conditions that would be expected during such events. The road safety concerns that could be identified during these events, would be similar to special cases of work zone traffic management. It would therefore be particularly advantageous if the temporary traffic management would be road safety audited to identify potential road safety concerns to be remedied. Such Temporary Traffic Management Road Safety Audits should be treated as special cases of the Work Zone Traffic Management Road Safety Audits.

Typical situations where these types of events would occur, may be found in the temporary traffic management proposals for events such as the 2010 FIFA World Cup and the annual Comrades ultra-marathon or cycling events (such as the annual Cape Town Cycle Tour).

Similar conditions also exist in coastal towns where the traffic conditions during summer holiday periods are significantly more complex than during the rest of the year. During these holiday periods the general level of road safety awareness deteriorates against the background of a more relaxed and careless attitude by road-users.

These road safety audits can also be applied with great advantage on incident management plans when a freeway needs to be closed due to natural phenomena (such as sinkholes), accidents causing major disruption or even uncontrolled lawlessness.

# 11 Road Safety Audit Reporting

## 11.1 General Requirements

The road safety audit report is intended to guide the decision-making process. However, it is the responsibility of the project manager (client) and designers (consulting engineers) to make the final decisions about what advice to accept, and how best to proceed to implement changes in the design and positively influence the road project as a whole. It is therefore incumbent on the road safety audit team that the report be written in an advisory style rather than instructional style.

Writing the report is the responsibility of the road safety audit team leader. The team leader may delegate sections to be written by team members, but most reports are prepared by one auditor. The draft report should then be circulated among team members, for each person to provide inputs, comments and correct where necessary.

Audit reports are succinct reports with brief, but technically clear descriptions of each of the safety concerns identified by the audit team.

The RSA Report should be brief, accurate, and technically complete. It should contain:

- a title page with the name of the road project and its location; a brief description of the road project: what type of project, why it has been proposed, and the stage of the audit,
- names of the road safety audit team members,
- dates of the audit inspections and the weather conditions on-site at those times,
- a table of all the safety concerns found from the desktop audit as well as from the site inspection(s),
- a practical and clear recommendation for corrective action for each safety concern,
- digital photographs of important safety concerns or extracts from the drawings showing the identified concerns,
- a statement signed and dated by the team leader on behalf of the team, indicating that the team has audited the drawings, inspected the site, and identified the road safety concerns noted in the report; and
- a list of all drawings, reports, and documents reviewed as part of the audit, including drawing numbers and revisions. This may be useful for reference later as large road projects often have several generations of drawings. It may prove necessary, at a later time, to be quite specific about the actual drawing audited.

## 11.2 Road Safety Audit Report Format

### 11.2.1 Background to report format

Road safety audit manuals are consistent in requiring the RSA report to be concise yet summarising each road safety concern, describing the concerns and the associated risks as well as recommending appropriate remedial measures. It is also evident from reviewing RSA Manuals that the report format covers various aspects as standard items in the layout of the report. This typical format is described hereafter as well as shown in Appendix B6.

The actual layout of the report in portrait or landscape format is less prescriptive and different options are shown in the report templates used in different manuals. The use of photographs or extracts from design drawings is advocated as a means of clarification of the identified concern. Review of actual RSA reports indicate the extent to which aspects from the RSA manual are often used in the body of the RSA Report to pad up the report. This is not an acceptable practice and conflicts with the objective of the report to be concise. Should it be necessary to duplicate contents from the RSA Manual, this should be relegated to an appendix, like the suggestion below that the risk assessment matrices be copied into Appendix C.

Published RSA report templates normally do not include the close-out items associated with the designers' response or exception reports. These aspects often form part of an additional report, resulting in these close-out items becoming cryptic references to the RSA report and not conducive to understanding the context of those parts of the report. Review of the layout of the different templates shows the ease (or not) which these aspects forming part of the RSA close-out process can be appended to the RSA Report, making certain that all findings are closed out meaningfully.

In SARSAM 2022 it is a requirement that all road safety concerns shall be responded to by the design team, the response replied to by the RSA team and a decision for implementation or close-out recorded on behalf of the client organization. To achieve these objectives the template in which the road safety concerns need to be reported and how the close-out process needs to be done, has been recommended to be in a tabular format in landscape layout. This allows the findings and recommendations of the RSA team to be recorded in a manner that also supports the continuation thereof for the rest of the close-out process. Examples of the RSA report and of the Decision Tracking Form are included in the appendices to this part.

### 11.2.2 Report Format

The proposed report format should record the road safety audit using at least the following sub-sections:

**1 Introduction**
- 1.1 Road Safety Audit
- 1.2 Commissioning Authority
- 1.3 Terms of Reference
- 1.4 Road Safety Audit Team

**2 Background**
- 2.1 Site description and scope of the audit
- 2.2 Items resulting from previous road safety audits

**3 Road Safety Concerns from this Road Safety Audit**

**4 Road safety audit team statement**

**APPENDICES**
- A Marked-up drawing with indicative location of safety concerns
- B Road Safety Audit Brief (Including list or reviewed drawings)
- C Risk Assessment matrix
- D RSA Decision Tracking Form (To be included upon finalization)

# APPENDICES

V3B-1: Glossary

V3B-2: Example:  RSA Report Example

V3B-3: Example: RSA DTF

V3B-4: Example: Risk Assessment

V3B-5: Model Audit Brief

V3B-6: Model: RSA Report Layout

V3B-7: Model: Prompt List

V3B-8: Illustrative Examples of Road Safety Concerns

# APPENDIX V3-B1: GLOSSARY

| TERM | DESCRIPTION |
|---|---|
| Client Organization | The client organization is responsible for the management and administration of the road safety audit in accordance with the statutory or organization-specific procurement processes from inception to close-out. |
| Client Decision Report | The Client Decision Report is a summary report recording the decision by the client on each identified and recorded road safety concern. |
| Completion or de-brief meeting | A meeting that may be held on conclusion of the road safety audit site visit with the client representative and design team to discuss road safety audit findings. |
| Decision Tracking Form (DTF) (Close-out sheet) | A form to record in iterative manner the close-out process and status of completion of each individual road safety concern for each of the identified road safety concerns and for the sign-off by each of the parties to the RSA process. Upon final close-out the DTF is bound into the RSA report as the Client Decision Report. |
| Design team (Also Service Providers) | Consulting engineers appointed by the client organisation to perform the professional services related to the planning and design of the works. |
| Designers' response report | Report by the design team in response to the road safety concerns and remedial measures identified by the road safety audit team in the road safety audit report. |
| Forgiving Roads | A road safety engineering concept which recognises that road-users make mistakes on the road but that the road designer should design the road in such a way that the ensuing injuries should be minimised. |
| Interim RSA | The application of the road safety audit process to the whole or a part of the works at any time during its design or construction to assess a specific aspect subject to the approval of the client representative. The interim road safety audit is neither mandatory nor a substitute for the road safety audit stage during which it is conducted. |

| TERM | DESCRIPTION |
|---|---|
| Level of Road User Risk | Risk level represented by the combination of the intrinsic risk of the road safety concern combined with the level of road-user vulnerability within the safe system environment. |
| Risk Assessment | A prescribed six-step procedure to determine the level of road-user risk. |
| Road Safety Audit | A formal technical assessment process of a new or upgrading road or traffic project, in which an independent and qualified team pro-actively identifies potential road safety concerns that may lead to injuries or fatalities of any road-users and suggests measures to mitigate such risks by applying the principles of the Safe System Approach. |
| Road safety audit brief | The instructions to the road safety audit team describing the scope and details of the project to be road safety audited, including sufficient information for the stage of road safety audit to be undertaken. |
| Road safety audit recommendation | A proportionate and viable suggestion to reduce the risk of injury or fatality in mitigating an identified safety concern. |
| Road safety audit report | The report produced by the road safety audit team describing any road safety concerns identified by the road safety audit team, risk assessment and the associated road safety recommendations. |
| Road safety audit site visit | A visit to the location of the proposed or completed project by the road safety audit team to assess on-site conditions and identify aspects related to safety concerns. |
| Road safety audit team | A that works together on all aspects of the road safety audit, independent of the road or traffic project conception, design, construction or operation. |
| Road safety audit team leader | A person with the necessary training, skills and experience who is approved for a specific road safety audit by the client organisation. |
| Road safety audit team member | A member of the road safety audit team with the appropriate training, skills and experience necessary for a particular project and road safety audit stage, working with the road safety audit team leader. |
| Road Safety Audit Team reply | Formal response to the design teams’ response report on the road safety audit findings. |

| TERM | DESCRIPTION |
|---|---|
| Road Safety Investigation (RSInv) | A formal systematic examination of an existing road location, in which an independent and qualified team reviews on-site conditions and historical evidence to identify existing or potential road safety problems and suggest measures to mitigate those problems. |
| Safety concern | An identified road safety matter together with the potential road traffic accident, location, summarised description and risk assessment. |
| Safe System Approach/ Safe System | A road safety approach which recognizes that road users will continue to make mistakes and that roads, vehicles and speeds should be designed to reduce the risk of accidents and to limit their exposure to impact forces to a level that the human body can tolerate. |
| Specialist advisor | A person approved by the client organisation to provide specialist independent advice to the road safety audit team where the project includes features outside the experience of the road safety audit team. |
| Stage 1 RSA<br>Conceptual Design Stage Road Safety Audit | A road safety audit conducted at the onset of the design process |
| Stage 2 RSA<br>Preliminary Design Stage Road Safety Audit | A road safety audit conducted towards the end of the preliminary design process when the horizontal and vertical alignment as well as junction designs have been completed. |
| Stage 3 RSA<br>Detailed Design Stage Road Safety Audit | A road safety audit conducted close to the completion of the detailed design but before the contract documents are finalized. |
| Stage 4 RSA<br>Work Zone Traffic Management Stage Road Safety Audit | A road safety audit conducted on the proposed accommodation of traffic scheme proposed by the contractor in terms of the specifications of the construction contract. |
| Stage 5 RSA: Pre-opening Stage Road Safety Audit | A road safety audit conducted before the opening to traffic of a road or traffic project but not before substantial completion of the project; enabling the audit team to review conditions as they would be experienced by different road user groups under typical operational conditions. |

| TERM | DESCRIPTION |
|---|---|
| Survivable (Safe) Speed | The speed at which the tolerance of the human body to changes in momentum or kinetic energy during a specific type of accident is not normally exceeded sufficiently to increase the risk of fatality to more than 10%. |
| Thematic road safety audits | Road safety audits focusing on specific road-users or conditions, rather than reviewing the safety of a facility for all road-users and considering all road-users affected by the proposed project. |

# APPENDIX V3-B2: EXAMPLE RSA REPORT

ROAD AUTHORITY
or METRO/ LOCAL
ORGANISATION

CLIENT ORGANISATION

# Road Safety Audit

## Preliminary Design Stage (Stage 2)

# Project Name

*Project number*

Date
Version 00



Prepared for

**DTC CONSULTANTS**

Address

Prepared by

**RSA CONSULTANTS**

Address

**REVISION AND ISSUE CONTROL SHEET**

| Rev | Status | Purpose of Issue | Originated | Checked | Authorized | Date |
|---|---|---|---|---|---|---|
| 00 | Draft Final | For Designer's Response | | | | |
| 01 | Final | For Submittal | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

## TABLE OF CONTENTS

# 1 INTRODUCTION

## 1.1 Road Safety Audit

Preliminary Design Stage Road Safety Audit for dualling of Main Street, Industrial Area 1, Cityscape:

## 1.2 Commissioning Authority

This report results from Preliminary Design Stage Road Safety Audit carried out for the client, INDUSTRIAL AREA DEVELOPMENTS, upon instruction from the client's design consultant, Messrs. DTC CONSULTANTS.

## 1.3 Terms of Reference

No formal road safety audit brief had been submitted to the RSA Team. The Terms of Reference for this audit was therefore taken from the guidelines as contained in the (*draft*) South African Road Safety Audit Manual, 2022 and the Specifications contained in the Terms of Reference for the project. The RSA team applied the guidance given for road safety audit site visits during the pandemic period as indicated by Highways England, allowing multiple party site visits for design stage audits to be replaced by video recording where possible.

A video conference commencement meeting attended by the client representative, geometric design staff from DTC Consultants and the RSA team was held on [*Date, 2020*]. This virtual meeting confirmed guidance given during the conceptual stage road safety audit. The design team also confirmed the submittal of preliminary design drawings for the project, as well as the comments received from City Council Safety Engineer on the conceptual design stage road safety audit conducted in [*Date1,* 2020]. The client representative confirmed that the video recording submitted to the RSA Team was acceptable in support of the desktop review of the drawings.

No relaxation of design standards was raised in the commencement meeting

This report describes the road safety concerns identified during the review of the preliminary design drawings.

The desktop review of the City Council Safety Engineer's comments, and of the design drawings was done between [*Date 2, 2020]* and [*Date 4, 2020]*. The site visit was conducted on [*Date 3, 2020]* by the road safety audit team leader accompanied by the design team geometric engineer.

The weather conditions and traffic conditions during the site visit did not negatively impact upon the ability of the RSA Team to review the site, its surrounding areas, and their tie-in with existing network and factory accesses. The conditions were also similar to the conditions captured on the earlier video recording. No infrastructure changes exist compared with the video recording.

In this report, the audit team only identifies issues specifically relating to road safety and does not examine or verify the compliance of the design to any other criteria, nor comments on aspects that could reflect on alternative design options that might have been available to the design team.

Road user risk assessments were done in accordance with the SARSAM2022 procedure utilizing the risk assessment procedure indicated in Appendix B of this report.

Recommendations with respect to possible remedial measures that should be considered to reduce the likelihood of road safety incidents, or the severity thereof are made for each concern identified. The locations of the identified road safety concerns are shown in Appendix C to this report.

## 1.4 Road Safety Audit Team

The road safety audit was conducted by:

**RSA Team Leader:**

S.U.M. Body, Pr Eng, MBA, B.Eng Hons (Civil)
RSA CONSULTANTS Inc, Cityscape, South Africa

**RSA Team Member:**
A.N. Other, Pr Tech MTech(Transportation)
RSA CONSULTANTS Inc. Cityscape, South Africa

**The road safety audit report was independently reviewed by:**
Eng D.B.L Checker Pr Eng, MEng (Transportation) MRoSPA
Independent Road Safety Engineering Specialist, Cityscape, South Africa.

## 2. BACKGROUND

### 2.1 Site description and scope of the audit

1. The proposed improvement to Main Street comprises the dualling of the existing two-way street for a distance of 700m between the roundabout access to Grandiose Development and an at-grade left in-left out junction with Arterial Street just west of the interchange with A1 Expressway. The proposed dual carriageway will tie in with existing dual carriageway section of Main Street. The project also provides for formalizing parking arrangements and upgrading the roadway cross-section to provide Fig 3 barrier kerbs and 2m buffer zone adjacent all existing kerbs.

2. The audited site is shown in Figure 1.


*Figure 1: Location of Audit Area along Main Street*

3. The current road layout provides for a single carriageway two-way traffic street with half-batter kerbs only at the intersection bell-mouths. The available ROW allows for extensive width on both sides of Main Street which is being utilized for non-formal parking by passenger cars and trucks on the eastern side of the road, and passenger cars on the western side. The western side of Main Street is adjacent a no-access boundary of Grandiose private access development. The eastern side of the road provides access to a section of industrial development.
4. The proposed road layout provides for the duplication of the street as a new fully kerbed carriageway with angled car parking and reconfiguring the existing Main Street as one carriageway with parallel truck parking. All parking is directly on Main Street.
5. The speed limit has been agreed at 60km/h with road authority and local traffic police.
6. Due to pandemic travel restrictions individual site visit has been conducted by the road safety audit team leader and the design team engineer on [Date 3, 2020] under daylight conditions. The accuracy of the video recording received from the client was also confirmed. Traffic volumes during the recording were low and weather conditions fine with no negative effect on the recording or influencing the review.
7. The video recording, general layout drawing, existing and proposed cross sections, profiles, road signs and marking drawings and street lighting drawings were assessed off-site by the road safety audit team which has a good knowledge of the area and the traffic patterns on this section of the road network.
8. The audit team in this report only identified issues specifically relating to road safety and did not examine or verify the compliance of the design to any other criteria, nor commented on aspects that could reflect on alternative design options that might have been available to the design team, but which have no direct bearing on road safety.

## 2.2 Items resulting from previous road safety audits

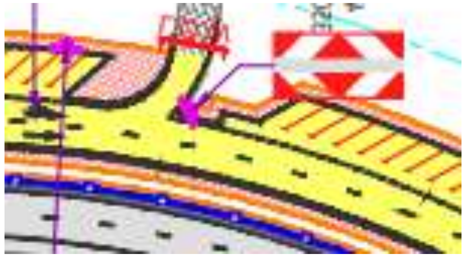
A Conceptual stage road safety audit of limited scope was conducted by the same RSA team and submitted to the client and design team for consideration and revision of the proposed design.

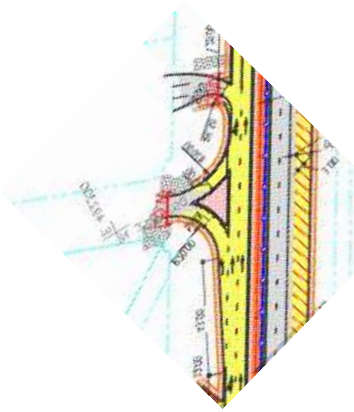
The City Council road safety engineer also commented on the conceptual design drawings. These summarized comments are included herewith together with the road safety audit team responses made during the current road safety audit.

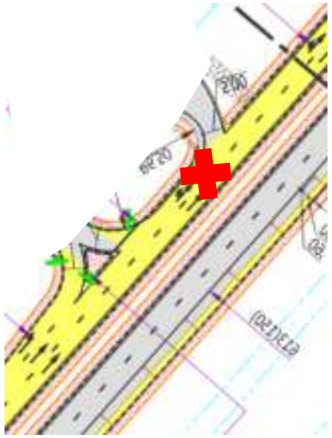
Unresolved road safety findings raised in the Conceptual Design Stage RSA are repeated in this Preliminary Design Stage RSA

| No. | Council's Safety engineer comments | ACTION (as indicated by Design Team) | RSA Team Response |
|---|---|---|---|
| 1 | Show the existing pedestrian markings for the existing roundabout and provide the missing pedestrian crossing for others approaches, also check the continuity of footpath *(Conceptual Design stage audit; Item 1.3)* | The layout has been updated showing the existing and proposed pedestrian marking and footpath | Supported |
| 2 | Show petrol station access on Main Street (plot No. 3650) | The future petrol station access is shown on the road layout | Revised layout will be reviewed in Final Design Stage RSA. when design has been completed and submitted for rights application |
| 3 | Raised pedestrian crossing/s should be provided along the scheme to allow pedestrian crossings and to reduce potential over-speeding on this section of the road. *(Conceptual Design stage audit; Item 1.5)* | Noted: one more speed table has been added on the middle of the road | Supported, subject to appropriate signs and markings |
| 4 | Continuous Footpath of 2m shall be provided clear from all obstructions and street lighting poles in some locations should be studied again | Noted. Footpath 2m has been provided without any obstructions. | Supported |

## 3 . FINDINGS RESULTING FROM THIS PRELIMINARY DESIGN STAGE ROAD SAFETY AUDIT

| Ref | Identified Risk (of a casualty) | Safety Concern | Recommendation (to mitigate risk of a casualty) |
|---|---|---|---|
| 3.1 | **Angled parking on dual carriageway street**<br>Risk of side impact crashes upon exiting from angled parking<br><br>Risk rating: Minor/Scattered/ ROF<25%<br>User Risk: Medium<br> | Location: General along Main Street<br><br>Parking for passenger vehicles is provided as angled parking for a number of parking bay clusters along the street and on both sides of the street.<br>With the driver located on the front right of the parked vehicle, all movements to return the vehicle into the main traffic vehicle would require reversing into the main road under restricted visibility conditions with traffic on the main road not expecting such reversing vehicles. Notwithstanding the fact that the posted speed limit is 40km/h the expected operational speed will be higher. (The designers indicated in design report that 70km/h standards have been applied.)<br><br>Reversing under the expected higher operating speed would increase the risk of side impact crashes. | The use of angled parking directly on to this dual carriageway road should be reconsidered from a driver expectancy and sight distance perspective.<br><br>A service road for parking and access to the adjacent lots should be provided, failing which parking should be revised as parallel parking. |
| 3.2 | **Limited turning width**<br>Restricted turning conditions for trucks – possible head on crashes<br>Risk rating: Significant/Isolated/ROF<25%<br>Road user risk: High | Location: Access to dead-end local road<br>The intersection into the dead-end local road some 280 m from Arterial Road does not allow for safe turning movements by heavy vehicles. Turning into the local road from Main Street will require encroaching into opposing traffic flow on the local road.<br>Designer response for Conceptual Design Stage RSA confirmed that the turning radius allows for the turning of an SU truck. Observations on-site confirms the large | Turning radii for this junction should be revised to allow for tractor/trailer truck turning geometries without encroaching opposing flow lane. |

| Ref | Identified Risk (of a casualty) | Safety Concern | Recommendation (to mitigate risk of a casualty) |
|---|---|---|---|
| |   | number of tractor/trailer combination trucks that require larger turning radii. Review of existing aerial images indicates that the proposed left-in-left-out junction is significantly smaller than the existing junction.<br><br>Wide turning trucks increase the risk of head-on crashes in violation of driver expectancy on the local road. | |
| 3.3 | **Poor visibility for corner lot access**<br><br>Visibility for access to corner lot is poor.<br><br>Risk rating: Moderate/Occasional/ROF<25%<br>Road user risk: Medium Risk | Location: Corner lot just north of local road junction.<br><br>It is acknowledged that the access to the corner lot is designated as an exit only from Main Street. The distance available between the junction to the local road and the access to the corner lot in the north-eastern corner does not allow for safe stopping distance along Main Street.<br><br>Vehicles entering from the local road will tend to look towards approaching traffic when entering Main Street and run the risk of crashing into a vehicle slowing down to access the corner lot; close spacing between entry/exit locations.<br><br>Increased risk of rear-end or sideswipe crashes | Access to the corner lot should be relocated as far as possible from the junction of the local road. |

| Ref | Identified Risk (of a casualty) | Safety Concern | Recommendation (to mitigate risk of a casualty) |
|---|---|---|---|
| |  | | |
| 3.4 | **U-turn too tight for trucks**<br>U turn of limited radius restricts use by trucks increasing risk of entering passenger cars<br>Risk rating: Minor/Occasional/ROF<50%<br>Road user Risk: Medium | Location: Southern end of scheme at Arterial Street<br><br>The radius of the turning loop at the end of the scheme is 20m measured to the inner edge line of the curve and is too small for the type of trucks observed on-site.<br><br>Trucks which need to U-turn to use the proposed truck parking on the eastern side of Main Street run the risk of damaging kerbs and tyres, contributing to later damage by either truck or car. Trucks may turn wide to improve line and risk turning into adjacent lane (Side impact crashes on higher speed traffic entering Main Street) | Roadway should be widened to meet tracking characteristics and inside kerbs be made mountable. |

| Ref | Identified Risk (of a casualty) | Safety Concern | Recommendation (to mitigate risk of a casualty) |
|---|---|---|---|
| 3.5 | **Location of lamp posts**<br><br>Physical objects within the clear zone<br><br>Risk rating: Minor/Scattered/ROF<50%<br>Road user risk: Medium | Location: Along the eastern boundary of Main Street<br><br>Posted speed limit is 60km/h on dual carriageway with potential speeding. The proposed cross section of the new road indicates the location of the lamp posts to be retained on the eastern side of the road and that no additional lamp posts are provided along the duplicated section or in the median.<br><br>The proposed location in Cross section AA is 3 m from the nearest running lane, placing it within the clear zone. (Clear zone for 60km/h design speed is 4.5m in undeveloped roadside conditions) No lamp posts are indicated in Cross section BB although posts have been observed in the current situation.<br><br>The lack of lamp posts on the western side of the road will furthermore keep that part of the road in a darker environment increasing the risk of pedestrian crashes or compromising sight distance under nighttime driving conditions.<br><br>Risk of narrow diameter fixed object crashes | Lighting should be provided in accordance with the illumination standards in Cityscape to ensure improved night-time driving conditions.<br><br>Kerbs should be transitioned from semi mountable to barrier (Fig 2 Barrier kerbs) on the approach to the light posts |
| 3.6 | **Lack of longitudinal pedestrian facilities**<br><br>Lack of pedestrian facilities along Main Street.<br><br>Risk rating: Moderate/Scattered/ROF<80%<br>Road user risk: Very High | Location: Along Main Street on both sides<br><br>The typical services reservation cross sections in the design indicate the provision of pedestrian sidewalks as an integral part of the cross section.<br><br>The existing cross section of the road does not have such facilities and the proposed cross sections only make partial provision for a 2 m buffer zone of interlocking tiles | Continuous pedestrian sidewalks should be provided on both sides of the main road and should be tied into existing facilities, where needed. |

| Ref | Identified Risk (of a casualty) | Safety Concern | Recommendation (to mitigate risk of a casualty) |
|---|---|---|---|
| | | along the road which may be used as pedestrian walkway. This is not a continuous walkway, however.<br>Lack of pedestrian sidewalks encourages pedestrians to walk in the roadway itself, leading to increased risk of pedestrian crashes at speed limit of 60+km/h. | |

## 4 ROAD SAFETY AUDIT TEAM STATEMENT

We certify that we have examined the drawings, video recordings and traffic information related to the dual carriageway design of Main Street. This examination has been carried out with the sole purpose of identifying any features of the design that could be removed or modified to improve the safety of the scheme. The concerns that we have identified have been noted in the report, together with suggestions for improvement which we recommend should be considered for implementation.

**Name:**
S.U.M. Body Pr Eng

**Position:**
Road Safety Audit Team Leader

**Organization:**
RSA CONSULTANTS Inc
Cityscape, South Africa

***RSA Team Member:***
A.N. Other, Pr Tech MTech(Transportation)
RSA CONSULTANTS Inc. Cityscape, South Africa

**Signed**: *S.U.M. Body.*

**Date** Day*, Month, Year*

# APPENDIX AROAD SAFETY AUDIT BRIEF AND LIST OF REVIEWED DRAWINGS

Not included

## APPENDIX B: RISK ASSESSMENT MATRICES

The risks associated with this road safety audit were assessed in accordance with SARSAM2022 utilising the following risk assessment procedure:

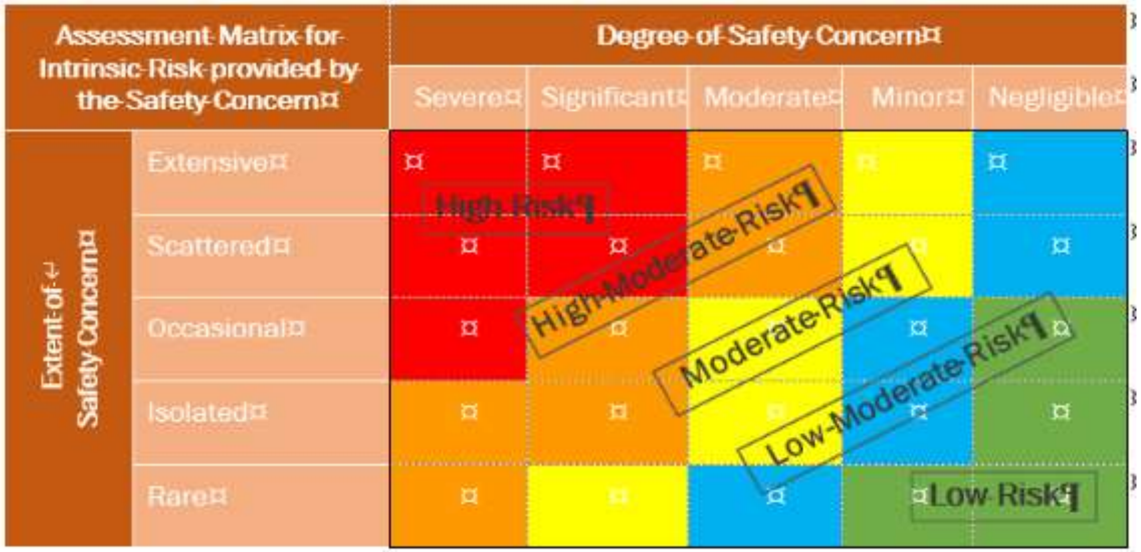
### Step 1: Estimate the Degree of Safety Concern

| DEGREE | DEFINITION |
|---|---|
| **Negligible** | Concern is potentially dangerous or located in a potentially dangerous location but is only likely to cause property damage only or trivial or superficial injury remediable by first aid responders. |
| **Minor** | Concern is potentially dangerous or located in a potentially dangerous location and likely leading to minor injury which may require emergency room attendance but not hospitalization (Typical injury level MAIS 2) |
| **Moderate** | The safety concern would cause temporary and remediable injuries requiring hospitalization. Injuries may not be life threatening and would be reversible. (Typical injury level MAIS 3) |
| **Significant** | The safety concern would lead to injury or consequences that would require hospitalization in excess of 24h and would affect the functioning of the injured road-user for a period of some six months or lead to permanent disability (Typical injury level MAIS 4) |
| **Severe** | The safety concern would lead to injury or consequences that is or could be fatal, severe loss of limbs or other disabilities. (Typical injury level >= MAIS 5) |

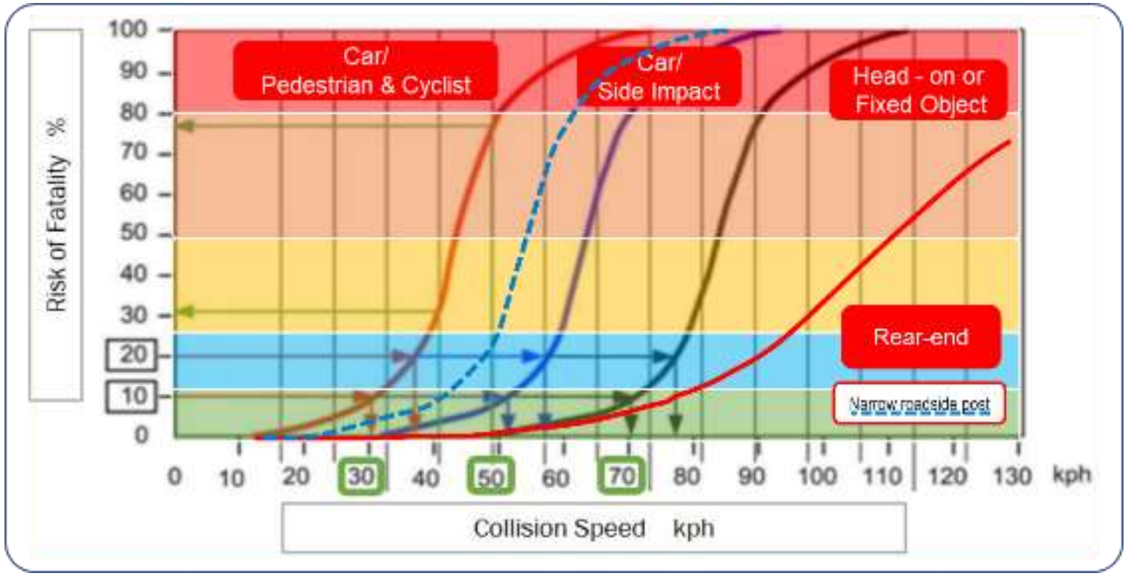
## Step 2: Estimate the Extent of the Safety Concern

| EXTENT | DEFINITION |
|---|---|
| **Rare** | The safety concern has been identified as limited in size or occurrence and located where conflict with road-users would be unlikely. |
| **Isolated** | The safety concern is reflected in locations where conflict is likely but found as an exceptional occurrence, *i.e.*, isolated application of a potentially dangerous design situation. |
| **Occasional** | The safety concern occurs more than merely in isolation but may still be considered as limited in extent, as shown on the design. |
| **Scattered** | The safety concern may be identified generally over limited areas of the area being audited or intermittently over the greatest part of the area being audited. |
| **Extensive** | The safety concern occurs extensively over the area being audited, *i.e.*, the safety concern may be included in typical construction standards used in the project. |

## Step 3: Determine the Intrinsic Risk represented by the Safety Concern



**Step 4: Estimate the Road-user Vulnerability**




**Step 5: Determine the Level of Road User Risk**

| Assessment Matrix for Road User Risk | | Intrinsic Risk of the Safety Concern | | | | |
|---|---|---|---|---|---|---|
| | | High | High-moderate | Moderate | Low-moderate | Low |
| Safe System Road-user Vulnerability | ROF > 80% | | | | | |
| | 50%<ROF<80% | | | | | |
| | 25%<ROF<50% | | | | | |
| | 10%<ROF<25% | | | | | |
| | ROF < 10% | | | | | |

Very High Risk
High Risk
Medium Risk
Low Risk

## APPENDIX C MARKED UP DRAWING WITH INDICATIVE LOCATION OF SAFETY CONCERNS

[Marked up drawing with cross referenced safety concern number to be inserted as Appendix]

## APPENDIX D DECISION TRACKING FORM

[Fully signed off DTF to be included in Final RSA Report]

**End of RSA Report**

# APPENDIX V3-B3: MODEL: DECISION TRACKING REPORT

[Fully signed off DTR should be included in Final RSA Report]

## RSA Feedback and Decision Tracking Record

| | | | |
|---|---|---|---|
| **Project:** | **Revisions to Access Interchange** | **Document Number:** | DN 2021-12345 |
| **Project Number:** | | **Road Safety Audit Stage:** | Stage 1 |
| **Contract Number:** | | | |
| **Client or Project Manager:** | PMC Consultants | **Designer:** | DTC Consultants |
| **Road Safety Auditors:** | AD (RSA T-L) XyZ | | |

| | **Road Safety Audit** | | | **Designer Response** | | **RSA Team Reply** | | **Road Authority Decision** | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Identified Risk of a casualty** | **Risk Rating** | **Recommendation (to mitigate risk of a casualty)** | **Response (to risk) (to remedy)** | **Comment** | **Reply wrt Designer** | **Comment** | **Response (to designer)** | **Comment** | **Status** |
| 1 | The speed limit on the expressway is 120km/h leading into egress ramps A and C which are posted for 60km/h. Sudden transitioning creates large differential speed with risk of rear-end whiplash accidents. | Significant Isolated ROF<50% VERY HIGH | Early speed reduction should be actively encouraged. | Agree Not agree | Auxiliary deceleration lane would be added with tactile transverse markings (rumble strips) Diagrammatic signs with reduced speed limit will be added to auxiliary lane | Accepted | | Proceed | Use thermoplastic marking material | Closed |
| 2 | The steel guard rail on outside of Ramp A transitions into a short concrete safety barrier at the abutment of the MSE wall. An impact on concrete barrier near the MSE wall by a closed delivery vehicle, would encroach in the Zone of Intrusion and impact the abutment. | Moderate Isolated ROF<25% MEDIUM | The concrete barrier should be extended and a height and shape transition provided to reduce the risk of intrusion. | Not agree Not agree | The MSE wall and abutment are behind the safety barrier. Hence this concern does not exist. | Not accepted | Refer to AASHTO LRFD Bridge design specifications for impact loading and AASHTO Roadside Design Guide for protection conditions and width of the Zone of Intrusion. | Not accepted | Assess implications of RSA Team recommendations. | Carried to next stage |
| 3 | Roundabout 1 is close to the end of the bridge. Vertical profile of the bridge reduces visibility to splitter islandat the roundabout starts for more than 80m away. The risk exists that a driver approaching the crest will not realize that the road curves away from straight ahead, Risk of crashing into the nose of the splitter. | Moderate Isolated ROF<25% MEDIUM | The median barrier along the bridge centre line should be curved to follow the median edge line south of the overbridge to provide continuous directional guidance for the driver and should be terminated closer to the Yield line at Roundabout 1. | Not agree Not agree | The median barrier is already proposed to be extended to the R/A splitter island. Moreover, the Design speed of the bridge is 70 kph. The crest curve provided has a K value of 30 which provides a stopping sight distance of 140m design manual. This is more than required for design speed of 80 Kph. | Not accepted | Design condition should be for decision sight distance criteria, rather than stopping sight distance | Not accepted | Designer shall confirm that forward visibility to the road surface is not interrupted at any time upon approaching Roundabout 1 | Open |
| | | [Date] | *RSA Team Leader* | [Date] | *Designer* | [Date] | *RSA Team Leader* | [Date] | *Road Authority Manager* | |
| | | [Date] | Name | [Date] | Name | [Date] | Name | [Date] | Name | |

# APPENDIX V3-B4:
# EXAMPLE: APPLICATION OF RISK ASSESSMENT PROCEDURE

## IDENTIFIED ROAD SAFETY CONCERN:

Deep V-drain adjacent to narrow shoulder on inside of a curve on a surfaced district road in rural environment with limited development.

### ASSESSMENT:

| CONSIDERATION | COMMENTS |
|---|---|
| Posted speed limit | 80km/h |
| Clear zone | 3-4m |
| Traffic volume | Low |
| Typical traffic pattern | Familiar drivers; low seasonal inflow towards holiday village;<br>subsistence farming; |
| Accident type | Run-off-road accident due to lack of edge line guidance; Indirect head-on impact/ skew angled; low risk of overturning |
| Environmental conditions | Night-time or poor visibility |
| Primary hazard | Steep and non-recoverable backslope; located within clear zone<br>In reverse direction the hazard is located outside the clear zone. |
| Possible driver mistakes | Over-speeding; Not wearing safety belts; possible passengers on open LDV (used at lower speeds) |

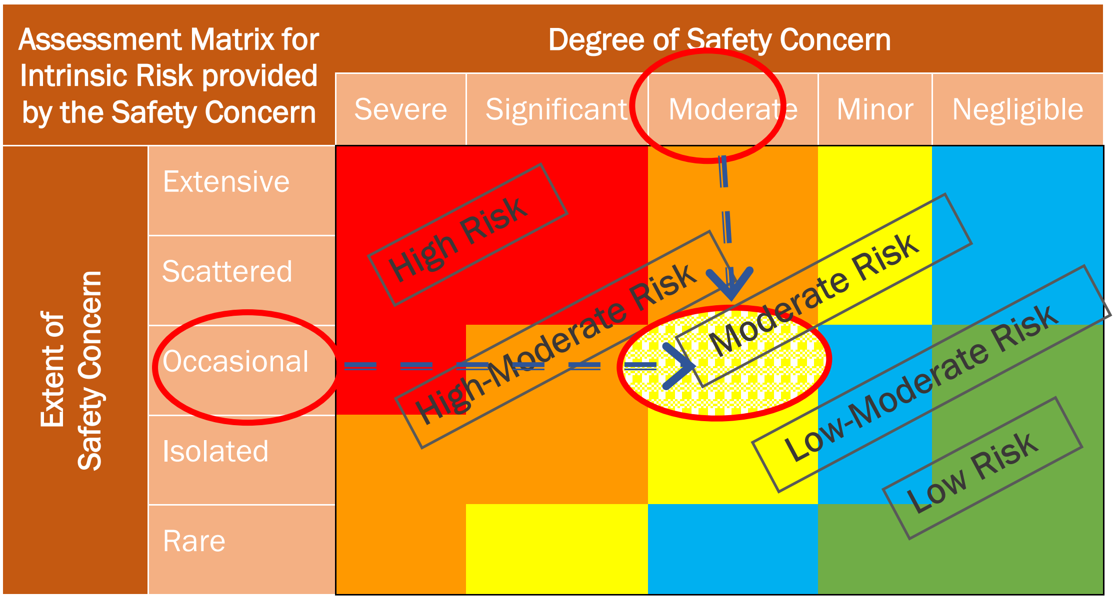
**Step 1: Expected severity of injuries:**

| DEGREE | DEFINITION |
|---|---|
| **Negligible** | Concern is potentially dangerous or located in a potentially dangerous location but is only likely to cause property damage only or trivial or superficial injury remediable by first aid responders. |
| **Minor** | Concern is potentially dangerous or located in a potentially dangerous location and likely leading to minor injury which may require emergency room attendance but not hospitalization (Typical injury level MAIS 2) |
| **Moderate** | The safety concern would cause temporary and remediable injuries requiring hospitalization. Injuries may not be life threatening and would be reversible. (Typical injury level MAIS 3) |
| **Significant** | The safety concern would lead to injury or consequences that would require hospitalization in excess of 24h and would affect the functioning of the injured road-user for a period of some six months or lead to permanent disability (Typical injury level MAIS 4) |
| **Severe** | The safety concern would lead to injury or consequences that is or could be fatal, severe loss of limbs or other disabilities. (Typical injury level >= MAIS 5) |

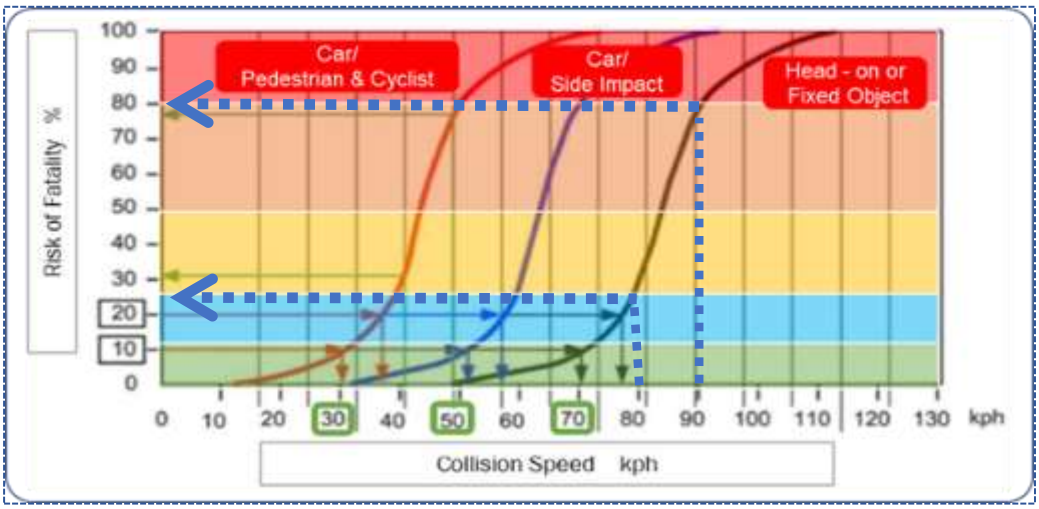
**Step 2: Extent of safety concern:**

| EXTENT | DEFINITION |
|---|---|
| Rare | The safety concern has been identified as limited in size or occurrence and located where conflict with road-users would be unlikely. |
| Isolated | The safety concern is reflected in locations where conflict is likely but found as an exceptional occurrence, *i.e.,* isolated application of a potentially dangerous design situation. |
| Occasional | The safety concern occurs more than merely in isolation but may still be considered as limited in extent, as shown on the design. |
| Scattered | The safety concern may be identified generally over limited areas of the area being audited or intermittently over the greatest part of the area being audited. |
| Extensive | The safety concern occurs extensively over the area being audited, *i.e.*, the safety concern may be included in typical construction standards used in the project. |

**Step 3: Intrinsic Risk of Safety Concern:**

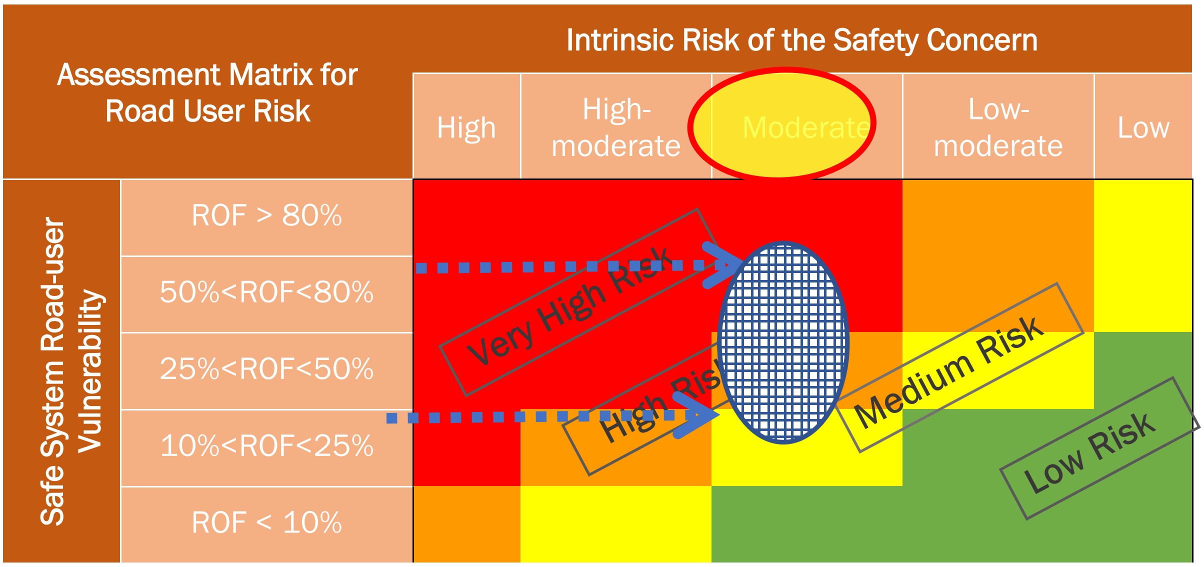



**Step 4: Determine road-user vulnerability**




Road-user risk ranges between 25% (driving at speed limit) and 80% (Driving at upper range of speed law enforcement buffer)

Step 5: Determine Road-User Risk




Road-user risk ranges between High risk and Very high risk. The onus lies with the road safety audit team to determine if other elements exist to adjust the Road User Risk determination upwards or downwards, taking into account the broader perception of the safety of the road as determined during the site inspection.

In this particular case, the major use of the road would be by drivers familiar with the conditions on the road. This road safety concern is located on a section of roadway which is not conducive to over-speeding. The safety concern is located in an area without any attraction for pedestrians.

After due consideration the adjusted Road User Risk was set at:

HIGH RISK

# APPENDIX V3-B5 MODEL RSA REPORT LAYOUT.

Cover Page

Executive Summary *[To be prepared in case of large or complex RSA]*

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1 Introduction

1.1 Road Safety Audit

1.2 Commissioning Authority

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2.2 Items resulting from previous road safety audits

3 Road Safety Concerns from this road safety audit

4 Road safety audit team statement

APPENDICES

A Marked-up drawing with indicative location of safety concerns

B List of reviewed drawings

C Copy of Road Safety Audit Brief

D Risk Assessment matrices

E RSA Decision Tracking Form *[To be included upon finalization]*

# APPENDIX V3-B6: MODEL PROMPT LIST

## INTRODUCTION

This appendix contains two model prompt lists[15] to be used as an *Aide Memoire* for the road safety audit team during the audit site visit as well as the review of design drawings to confirm that the project has been reviewed extensively.

Experience has shown that checklists:

- Are poorly used in practice
- Are not comprehensive for all conditions given the variability of projects
- Are used as a substitute for challenging design conditions and applying experience.
- Lead to the degeneration of road safety audits into question-and-answer tick-lists.

## HIGH LEVEL PROMPTS - ROAD SAFETY ISSUES

**Road function and context:**

- Type of project and suitability for function of the road (residential/local road, collector, distributor etc.)
- Type of project and suitability for traffic flow and mix
- Character and scale of project 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 project (Could safety be improved through re-location/re-alignment?)
- Controls for adjacent roadside 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 expected vehicle types and variation in these:
  - Buses, mini-buses and other public transport
  - Trucks and service vehicles
  - Road maintenance vehicles
  - Agricultural equipment/vehicles
  - Emergency services
  - Cars and motorbikes
  - Pedestrians and cyclists

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15 *African Development Bank, Road Safety Manuals for Africa: New Roads and Schemes*

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

**Forgiving environment and passive safe infrastructure:**

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

**Management of vehicle speeds:**

- Speed limits appropriate for road function
- Speed limits credible and likely to be obeyed (Impression of the road/ general levels of compliance)
- Speed limits safe/ segregation of road-users subject to differential speed
- Temporary speed limits during construction

**Consistency, road readability and driver expectancy**

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

## HIGH LEVEL PROMPTS - PHYSICAL ROAD ELEMENTS TO CONSIDER DURING THE SITE INSPECTION

The following list includes physical road elements that should be examined whilst reviewing project drawings and during the site inspection. Not all items will be relevant at all stages. The list is deliberately high level so that it does not limit consideration by the RSA Team.

**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

**Roadside:**

- Clear zone/ obstacles (trees, signs, lighting columns, culverts etc.)
- Vegetation/trees likely to obscure signage or become an obstacle when they grow
- Vehicle restraint systems/ Guard rail (adequacy, necessity, safe installation/gating or non-gating 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/ refuge areas
- 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

**Roadway:**

- 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 curves, warning signs/treatments, anti-skid high friction surfacing, camber, clear zones/guard rail
- Vertical alignment: Hidden 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 and intervisibility
  - Provision for VRUs
- Roundabouts:
  - Alignment and deflection on approaches
  - - Visibility of roundabout and traffic islands
  - - Obstacle free zone in central island or see-through across the 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 V3-B7: EXAMPLES OF DESIGN SAFETY CONCERNS

## Design for Safety

Proper road design is essential to prevent human errors in traffic. Reducing human error will result in less accidents. The human factors concept in relation to road safety considers road and infrastructure that influences correct behaviour by all road users, including the possible operational errors that a driver may make. To prevent human errors, three basic safety principles should be applied systematically in the design of roads and traffic projects:

- Prevent unintended use of roads and streets,
- Prevent large discrepancies in speed, direction and mass at moderate and high speeds,
- Prevent uncertainty amongst road users.

Current best practice is based on the Safe System approach. The Safe System approach works on the principle that it is not acceptable for road users to be killed or seriously injured if they make a mistake.

The Safe System approach aims to create a forgiving road system taking cognisance of four principles:

### PEOPLE MAKE MISTAKES

We need to recognise that people make mistakes, and some accidents are inevitable.

### PEOPLE ARE VULNERABLE

Our bodies have a limited ability to withstand forces during an accident without being seriously injured or killed.

### WE NEED TO SHARE RESPONSIBILITY

System designers and people who use the roads must all share responsibility for creating a road system where accident forces do not result in death or serious injury.

### WE NEED TO STRENGTHEN ALL PARTS OF THE SYSTEM

We need to improve the safety of all parts of the system – roads and roadsides, speeds, vehicles, and road use so that if one part fails, other parts will still protect the people involved.

**A safe road environment should:**

- **Warn** road users of any unexpected features or those requiring special attention,
- **Inform** road users of changes in the approaching road environment and what is likely to be expected,
- **Guide** the road user through unusual sections,
- **Control** road users' passage through conflict points and road links,
- **Forgive** the driver for inappropriate behaviour.

An error in perception or judgement or a faulty action on the part of the driver can easily lead to an accident. Roads should be designed in such a manner that only one decision at a time is required from a driver, ensuring that he/she is never surprised by an unexpected situation, and that adequate time is provided to make the decision.

Standardization in road design features and traffic control devices plays an important role in reducing the number of required decisions, as the driver becomes aware of what to expect on a certain type of road.

## Principles of safe design

Fundamental to the Safe System approach is designing a road network that reduces the amount of kinetic energy to levels which the body can tolerate during an impact to eliminate fatal and serious injury accidents (FSI accidents) based on the following concepts:

- *Functionality*: roads should be physically and visually different to demonstrate their differing functions.
- *Homogeneity:* there should be limited interaction between road users travelling at different speeds, in different directions and between vehicles and road users of different mass or type.
- *Predictability:* roads should be "self-explaining", and the function and road rules should be clear to road users without causing surprises.
- *Forgivingness:* roads and roadsides should be forgiving in the event of an accident and accommodate driver error.
- *Status awareness*: road users should be able to measure their own capability of performing the driving task.

Drivers and other road users must perceive and process information, make decisions and react, all within specific time frames. Comfortable and safe driving and riding occurs when road users are operating well below a stressful processing and decision-making rate, and above the minimum level of arousal. The driver should not be over-stimulated or lulled into boredom. These aspects are critical components in the development and maintenance of a safe road environment.

Similar situations should be treated in similar fashion.

Situations to be avoided are:

- *Inadequate treatment (not treating a situation to an appropriate level)*
- *Inappropriate treatment (using the wrong treatment for the situation)*
- *Excessive treatment (using "more treatment for more safety", thereby masking other similar situations that have already been treated to the appropriate level).*

The illustrative examples that are shown hereafter are intended to sensitise the road safety practitioner on issues that are commonly found during road safety audits. It is essential that the designer as well as the Resident Engineer and the Maintenance Supervisor pay particular attention to detail to identify similar issues and prevent the duplication of unsafe practices. Reducing these conditions will contribute to the improvement of the safety performance of the road environment.

# Illustrative Examples of Design Safety Concerns:

## Illustrative examples related to the Function of the road

### *Linear and Informal Settlements*

The diverse socio-economic conditions in South Africa have led to extensive development of linear settlements along inter-urban roads and in rural villages. The sprawl of development along main roads that become the spine of such a development creates issues related to the movement and frontage functions. Development intensifies and the traffic on the roads and speeds increase, and the vehicle mix becomes more complex with the growth of through traffic.

Linear settlements create a mixture of through traffic with local slow traffic and non-motorized road-users. Daily operation of such roads and especially when road upgrading is done, increases conflict between pedestrians and vehicles as a result of an increase in differential speed and the increased risk of injuries or fatalities, especially if no provision is made to distinguish the pedestrian realm from the vehicle realm.

This results in problems such as:

- Risk of fatal or serious injury accidents increases significantly,
- It becomes harder for pedestrians to cross the road safely,
- Pedestrian safety is affected,
- It becomes more hazardous for cyclists,
- Driver vision is confined,
- Stopping distance is increased with higher speeds,
- Pedestrian attraction to frontage activity increases risk of conflict with moving vehicles,
- Pedestrian activity is dispersed along the length of the development,
- Pedestrians who want to cross the road are delayed,
- Parking and searching for parking affect traffic flow and safe movement,
- Delivery and pick-up from kerbs create conflict with pedestrian and vehicle movements.

## *Road function and Road categories*

Growth in traffic volumes is often an indication of the economic growth of any community. This leads to the widening of main roads to accommodate the increased volumes. Such widening and the corresponding increase in complexity of the traffic has led to preferential treatment for vehicles over pedestrians. Facilities for pedestrians would often be considered as less important compared to the mobility needs of vehicles.

This trend affects the vulnerable road-users and business more extensively and increases the risk of accidents involving non-motorized traffic.

The continuation of inter-city rural roads directly into smaller towns often leads to a situation where the urban road has an arterial function, but the frontage development in town does not support a homogeneous traffic use, leading to vehicles or road users with widely differing needs being forced together.

A common low-cost solution to address the concern of ever-increasing traffic volumes with restrictions in roadway traffic capacity, leads to the establishment of one-way roadway pairs to accommodate the increased levels of traffic, whilst reducing the risk of head-on or opposing flow traffic safety concerns. Although this may offer a capacity solution, it may increase the risk of other types of accidents, for example – midblock pedestrian crossings where pedestrians need to cross a much wider roadway under conditions where vehicles are driving faster

## *Traffic calming*

On many roads being road safety reviewed (both new road designs and existing roads) the speed and volume of traffic increased significantly compared with the conditions which existed at the time when the road was initially conceived or constructed The time interval between the initial decision to investigate the possible upgrading of a road and the commissioning thereof normally depends on the priority of that road measured against the needs of the community in general and other road projects in particular. It is therefore possible that the implementation period would be quite long, resulting in the safety of road-users being threatened.

Under these conditions road authorities are pressurized to “DO” something, which may result in the consideration of traffic calming measures to protect vulnerable road users.

Care should be taken that the introduction of traffic calming measures is combined with appropriate advance warning and do not introduce other side-effects with the possible increase in the exposure to risk, such as violation of driver expectancy, implementing inappropriate measures or introducing hazardous fixed objects within the clear zone.

## *Access Management*

Access management is the systematic control of access to mobility roads. It includes, but is not restricted to, the location, spacing, design and operation of driveways, intersections, interchanges and medians[16].

Access requirements are specified in different policy guidelines to enable safe access to different types of development and could include guidance aimed at segregating different types of traffic. Approval for a specific access normally includes conditions stating that the right to require specific improvement of the access (should conditions change in future) rests with the property owner.

16 *COTO, TRH26 South African Road Classification and Access Management Manual, CD, 2019*

### *Emergency facilities: Truck Escape Ramps*

In certain areas emergency facilities are being installed along roads which would be prone to high severity accidents should an incident occur. Emergency truck escape ramps are an example of such facilities.

Road safety inspections on these facilities often indicate the lack of proper maintenance thereof, or (as shown in this photo) also the misuse of the entry into the facility as a temporary storage for collected roadside trash.

## Illustrative Examples related to Alignment

### *Principal design policies for roadway alignment*

As a general point of departure, it would be possible to include road safety features in a road design at a much lower cost when done initially than to retrofit road safety measures once problems have been identified. Principal design policies for safer roads design include various aspects:

- Guiding the driver along the safest route without surprises,
- Proper guidance requires adequate forward visibility to observe the alignment, provide orientation and improve its predictability,
- Forward visibility determines stopping sight distance, decision sight distance and overtaking sight distance; all aspects related to design and operational speeds and influencing the safe system and the speed related forces to be mitigated in case of any accident.
- The faster we drive, the farther we look ahead and the less attention we give to potential safety concerns in lateral view. This principle also holds true in the opposite, namely the farther we can see ahead, the faster we tend to drive. It is therefore important that we provide visual clues or points of fixation in accordance with the relevant design speed to counter the perceived increase in speeds.

**Prolonged straights affect driver expectation and attention**

- Horizontal curves should be designed so that they can be negotiated safely by approaching vehicles. It is important that a consistency of design be achieved. It is particularly important that a flowing design be achieved to reduce potential surprises to the driver.
- Good design should not encourage excessive speeds but should provide frequent overtaking opportunities.
- Care should be taken to balance the design in meeting stopping sight distances as well as passing sight distances, to avoid road-users taking undue risk to overtake vehicles, based on a false perception because stopping sight distances are easily met.

It is important to review the horizontal and vertical alignments in combination. The problem of a hidden horizontal curve following a vertical curve is well known yet is often observed resulting in a surprise to the approaching driver

**Hidden horizontal curves**

A lesser known, yet equally problematic situation occurs when a sag vertical curve is combined with a horizontal curve. The apparent radius that the driver perceives of the resultant curve would be larger than the actual curve, leading to the entry into the curve at a larger speed than recommended for the actual radius.

Various other possible inconsistencies may be identified on road sections that have a negative influence on the safety of the alignment.

**Conflicting Movement**


**Extended curvilinear alignment**


## Illustrative Examples related to Cross sections

### *Principal design policies for cross sections*

The type of cross section depends on numerous aspects, including:

- Urban or rural location,
- Functions of the road
- New road or upgrading of the road
- Traffic volumes and the mixture of vehicles
- Provision for public transport and other service vehicles
- The need to segregate children, older people and in general, allow for non-motorized traffic based on the differential speed between different road-users.

Certain types of cross section have been identified as having greater risk for accidents, especially in areas where aggressive driving is prevalent. These cross sections include four-lane wide road sections without a median or two-lane roads with wide lanes and shoulders being used as 4-lane wide facilities ignoring lane designation (especially under poor maintenance conditions).

### *Lanes converging*

Changing cross sections requires that one lane is dropped or converged into an adjacent lane. In the case of rolling terrain where climbing lanes exists, this lane drop normally occurs on the downgrade beyond the crest curve allowing the overtaken heavy or slower vehicle the opportunity to accelerate and reduce the differential speed with adjacent traffic before merging. The typical merge under these conditions provides for the slow lane to be merged into the adjacent faster lane; following the principle that an auxiliary lane was added, and that the auxiliary lane is terminated. Termination of the slow lane allows the merging vehicle to escape on to the downstream shoulder, should it not be possible to accept a gap to merge safely.

Slow lane dropping, however, is not always the case and conditions exist where the fast lane traffic is expected to merge into the slow lane. This is often the case when the cross section is continually reversing to establish a 2+1 cross section in opposing directions. Under these conditions it is critical to provide a buffer zone as a possible run-out section should the merge be hampered.

A third option occurs mainly in urban areas where three lanes converge into two lanes on a simultaneous basis, as indicated below. (Internationally designated as a zipper merge.) This style of merge is not recommended in higher speed environments due to the violation of driver expectancy and the prevalence of aggressive driving in South Africa.

### *Uncontrolled median crossing or U-turn*

Medians reduce accidents by eliminating conflict between opposing traffic. However, unless median crossings are provided to allow vehicles to turn across oncoming traffic, they require drivers to travel further to a major junction where they can make an unsafe U-turn or they encourage drivers to travel short distances against the oncoming traffic. Median gaps are therefore useful, but if poorly designed, they can expose turning vehicles to danger from high-speed vehicles. Poor design includes lack of deceleration lane, lack of protection when waiting to turn and unprotected entry into high-speed traffic.

On dual carriageway roads it became practice to provide for median gaps at regular intervals to allow for emergency vehicles to be able to U-turn and render speedier support. Care should also be taken that the location of such median gaps is in areas where level differences between carriageways support the movement between the carriageways. Unfortunately, the introduction of median vegetation to reduce oncoming glare at night created conditions where vehicles legitimately using the median gap are exposed to high-speed traffic upon entering the receiving carriageway.

In urban environments where commercial facilities are located close to intersections it

has been observed that median openings are provided to allow potential customers to cross the medians and enter the commercial facilities on the opposite side of median. These median openings also provide for customers to return from the commercial facilities and cross the road in the preferred direction. These median gaps also allow road-users to make U-turns at speeds significantly lower than the ruling speed on the main road. This leads to large speed differentials and increased risk of serious injury, suggesting that median gaps should be closed, or protected slots be created for traffic waiting to turn.

## Illustrative Examples related to Intersections

### *Principal design policies for intersections*

Intersections are a key component of the road network, often regulating the volume of traffic that can be handled on the network. The need to improve an existing intersection is usually prompted by problems such as inadequate capacity, a pattern of road traffic accidents, too many vehicle conflict points, or poor visibility on certain approaches,

To avoid these problems in the design of the intersection, it is necessary to consider numerous factors during the planning stage:

- Volume, type and pattern of traffic using the intersection and its anticipated traffic distribution and rate of growth,
- Topographical and environmental aspects such as the alignment, grades and future development of the approach roads, positions of adjacent property improvement, accesses, public utilities, bus stops, etc
- The need for, and type of traffic control devices, their location and installation.
- The need and requirements for street lighting
- The approach roads and or traffic movements as well as requirements for pedestrians, cyclists and vulnerable road users.

The solution to intersection problems requires the combination of these factors, against the background that safety would be the most important factor, and not to be distracted from by other considerations.

Because of the complex traffic manoeuvres at an intersection, the principles of the Safe System approach also find its clearest application here.

Both in crossing and merging manoeuvres it is necessary for a vehicle in one stream to find appropriate gaps in the other. Accidents occur if the length or location of the gap is misjudged. Congestion occurs if not enough gaps of sufficient size are available in the receiving or crossing stream of traffic.

**Visibility towards oncoming traffic at T-junctions: Horizontal and vertical alignment**

### Skew junctions

- Common reason for misjudging gaps is the acuteness of the crossing angle, possible multiple maneuvers, lack of spatial guidance and high approach speeds.
- Situation may be improved in making conflicting streams of traffic at more obtuse angles, replacing complex maneuvers with successive simple ones (e.g. replacing skew crossing with successive right-angled T-junctions – Right/Left preferable), or inserting channelizing island to redirect movements.

### Continuation through the junction

- In multi-lane intersections where opposing approaches are not co-aligned, traffic needs to execute a curved movement through the intersection. This movement often leads to sideswipe accidents unless guidelines are painted to assist in the selection of the line to follow through the intersection.
- Observations at large intersections with a channelized central island or kerbed nose to a median identify that the line of the kerbed island coincides with the line of the kerbs on the approaches to the intersection, instead of being set back or tapered from the continuation between the kerbs. This results in glancing impact on to the central kerbed island and the driver taking uncontrolled evasive movement leading to sideswipe incidents.

### Insufficient deflection through a roundabout

- Modern roundabout design requires that entering traffic be deflected into the circulatory movement required by the roundabout, reducing approach speed and complying with the Yield condition upon entry. Traditional layout of a traffic circle does not include the deflection and often results in approaching traffic impacting the raised portion of the roundabout, increasing the risk of loss-of control.
- Observations of accidents at such traffic circles/ roundabouts lead to incorrect traffic signs and poor road marking practice, both aspects that would improve the safety performance of traffic at the roundabout.

### Hidden access on crest

### Hidden access on inside curve

## Illustrative Examples related to Roadside design safety concerns

The design of safe roadsides is a key element in providing safer roads. An errant vehicle leaving the road is likely to come to a stop within a certain distance – the clear zone distance. Hazardous objects within the clear zone increase the risk of severe injury or fatalities.

The objective of safe roadside design is to reduce the risk of run-off-road crashes and removing or treating hazardous objects within the clear zone. The primary function of a median on a divided road is to separate opposing traffic flow reducing the risk of head-on accidents. Medians also serve as an area to install services applicable on both carriageways.

If the median width is too narrow to contain the clear zone, or if it contains hazardous elements such as trees and lighting posts without adequate protection (vehicle restraint systems) then the benefit of the divider between opposing traffic flows is lost and the risk of crossing the median or impacting a fixed object remains. This becomes an even greater concern when it is recognised that the median divides the higher speed opposing flow directions.

### Narrow median and unprotected median hazards

Unprotected roadside hazards

Non-recoverable side drains in close proximity

Rigid objects within roadside clear zone


*1 Violating Zone of Intrusion*
*2, 3 & 4 No energy absorbing crash cushion or transition*

Inadequate vehicle restraints


*1 & 3 Inadequate anchoring*
*2 Improper overlap*
*4 Improper shielding of rigid objects in both directions*

## Illustrative Examples related to Traffic Control Devices

Traffic signs, markings and signals are the primary means which the designer has available to directly communicate with road-users. If all geometric standards are met, then warning signs would still be required to advise road users of potential locations where for example, pedestrians would be crossing a road. Furthermore, signs are also required to advise road-users of specific regulatory conditions on a section of the road.

A precondition for good signing is the need for consistency and uniformity, allowing road-users to understand the signs without additional explanation, allowing speedy response to the signs. Signs also provide road-users with directional and other information that requires the road-user to read, interpret and respond to the information in an unhurried and safe manner.

Unfortunately, signs and markings are often missing, worn or illegible, rendering the required messages ineffective or non-existent. Safety inspections often report signs to be obscured by vegetation, other vehiclesor other street furniture. A tendency also exists to over-sign situations, merely to ensure that any possibility of road-user impropriety can be easily countered. The distracting factor of too many signs may easily lead to overloading of information causing confusion or leading to road-users only responding selectively to signs and markings.

### Traffic Signals

Traffic signals are widely used in urban areas to allocate intersection space to different streams of traffic on a time-allocation basis. In the South African context, driver discipline at traffic signals is often poor and may result in accidents of increasingly high level of severity. Increased levels of an all-red phase may cause even greater degree of ill-discipline than to improve the accident profile at an intersection.

Traffic signals need regular maintenance and continuous power supply. Both signals and detection equipment are prone to malfunction and requires regular maintenance to ensure proper functioning by day and by night.

### Visibility and perception of signs and lines: daytime and nighttime



### Driver expectation

- Particular attention should be given to ensure that signs and markings do not contribute to potential confusion when viewed in an environment where conditions seem to be contra-indicative of the message on the signs.

## Illustrative Examples: Public and Private Services

### Public transport

## Illustrative Examples related to Vulnerable road-users

### *Principal design policies for pedestrians and cyclists*

Different types of traffic need different facilities. The survivable speed concept of the Safe System Approach emphasizes the benefits of segregating vulnerable road-users from motorised traffic. Aspects to be considered include:

- A safer situation can be developed for all road-users if a simplified traffic situation can be developed with slower moving traffic be segregated from main-stream traffic.
- Cyclists and pedestrians can share facilities, provided facilities are designed to accommodate these technically,
- Opportunities for segregation are limited in rural areas but should be considered nevertheless.

Close proximity to vulnerable road users

Provision for pedestrians and cyclists at work zones

### Continuity of walkway and sloped ramps

### Extraordinary pedestrian situations

Various situations occur in the South African context that introduce extraordinary pedestrian conflict situations on roads. These include recyclers with pushcarts *en-route* recycling plants as well as pension pay-out days in rural locations. Under both conditions pedestrians are found on the road in close proximity of vehicular traffic

## Livestock / Lack of Fences

Road Safety observations in rural or peri-urban areas often identify the lack of fences as a safety concern.

This is a particularly disconcerting condition in areas where cattle are held and where cattle-herding may not be properly done. Lack of fences is of particular concern where the potential exists that cattle may end up on the road during nighttime situations.

# APPENDIX V3-B9: ABBREVIATED INJURY SCALE (AIS)

The Abbreviated Injury Scale (AIS©) is an anatomically based, consensus derived, global severity scoring system that classifies each injury by body region according to its relative importance on a 6-point ordinal scale (1=minor and 6=maximal).

The AIS provides standardized terminology to describe injuries and ranks injuries by severity. Current AIS users include health organizations for clinical trauma management, outcome evaluation and for case mix adjustment purposes; motor vehicle crash investigators to identify mechanism of injury and improve vehicle design; and researchers for epidemiological studies and systems development, all of which may influence public policy (laws and regulations).

**Abbreviated Injury Score (AIS)**

| AIS-Code | Injury | Example | AIS % prob. of death |
|---|---|---|---|
| 1 | Minor | superficial laceration | 0 |
| 2 | Moderate | fractured sternum | 1 – 2 |
| 3 | Serious | open fracture of humerus | 8 – 10 |
| 4 | Severe | perforated trachea | 5 – 50 |
| 5 | Critical | ruptured liver with tissue loss | 5 – 50 |
| 6 | Maximum | total severance of aorta | 100 |
| 9 | Not further specified (NFS) | | |

AIS© is the basis for the Injury Severity Score (ISS) calculation of the multiple injured patient. The ISS is calculated by assigning an Abbreviated Injury Scale (AIS) value of 1-6 to 9 different body areas.

## Injury Severity Score (ISS)

| Body Region |
|---|
| Head |
| Face |
| Neck |
| Thorax |
| Abdomen |
| Spine |
| Upper Extremity |
| Lower Extremity |
| External and other |

| Score | Abbreviated Injury Scale (AIS) |
|---|---|
| 1 | Minor |
| 2 | Moderate |
| 3 | Serious |
| 4 | Severe |
| 5 | Critical |
| 6 | Unsurviveable |

Multiple injuries are scored by adding together the squares of the three highest AIS scores. The ISS can range from 1 to 75, with 75 being the maximum score. By convention, a patient with an AIS of 6 in one body region is given an ISS of 75.

Internationally, within the road safety environment, injury severity is assessed by means of the maximum abbreviated injury scale (MAIS). The Maximum Abbreviated Injury Scale (MAIS) is **a globally accepted and widely used trauma scale used by medical professionals**. It provides an objective and reliable basis for data collection and international comparisons. The injury score is determined at the hospital with the help of a detailed classification key.

The international MAIS trauma scale (maximum abbreviated injury score) has been used as the European Union definition of serious road traffic injuries since 2014. The ‘scale 3 and more’ (MAIS3+) is the one that applies to serious injuries today.

*(Source: Berg, H.V. 2015. The use of the Abbreviated Injury Scale in the Swedish Road Safety effort; The definition of a severe injury, Swedish Road Transport Agency).*