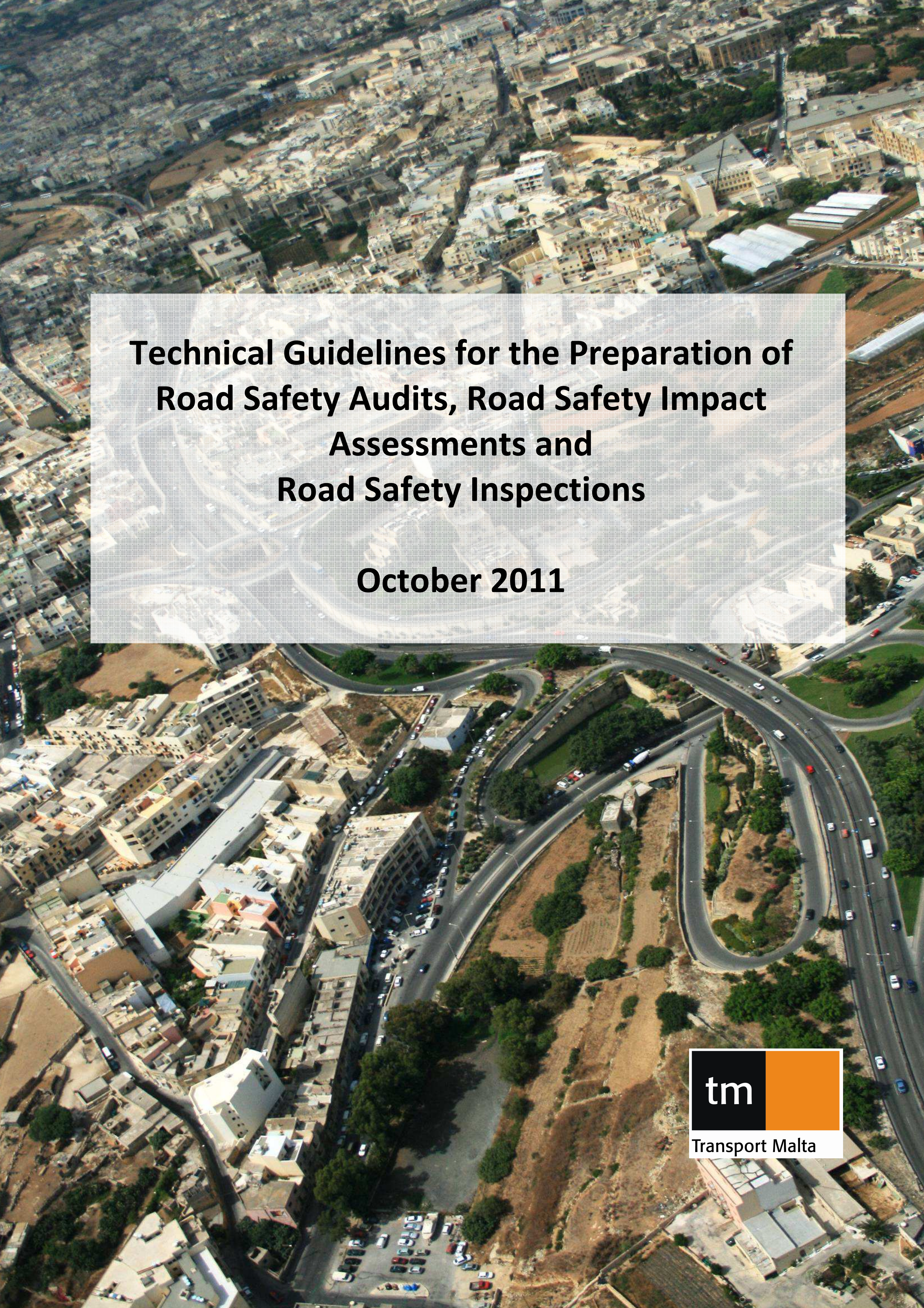

Technical Guidelines for the Preparation of Road Safety Audits, Road Safety Impact Assessments and Road Safety Inspections

October 2011

Transport Malta

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Transport Malta

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Foreword

In the White Paper on European Transport Policy for 2010 and in its Communication on a European Road Safety Action Programme of June 2003, the European Commission announced that it would take the initiative on road infrastructure safety and subsequently the European Parliament invited the Commission to provide guidelines for high-risk spot management and road safety audits.

Directive 2008/96/EC of the European Parliament and of the Council of 19 November 2008 on Road Infrastructure Safety Management has the objective to ensure that safety is integrated in all phases of planning, design and operation of road infrastructure in the Trans-European Road Network (TEN-T).

The Directive requires all Member States to undertake Road Safety Audits, Road Safety Impact Assessments, Road Safety Inspections and high frequency Collision Investigations on the TEN-T roads.

The directive sets out four areas of analysis in relation to existing roads and new roads. Network Safety Ranking and Road Safety Inspections are targeted at the existing TEN-T road network whilst Road Safety Impact Assessments and Road Safety Audits are targeted at new TEN-T roads.

The Directive also requires that Member States to ensure a training curriculum for road safety auditors. Transport Malta has worked with TMS Consultancy to develop this syllabus. Member States are also to ensure that road safety auditors undergo initial training resulting in an award of a Certificate of Competence followed by periodic training courses.

The date identified by the Directive for the transposition of the directive into national law was 19th December 2010. This was transposed and now is part of S.L. 499.57 New Roads and Road Works Regulations since Training Curricula and Auditing Guidelines were required to be in place by 19th December 2011. Safety Audits need to be undertaken by qualified auditors by 19th December 2013.

Transport Malta
October 2011

1. Road Safety Impact Assessment for Infrastructural Projects

Directive 2008/96/EC and S.L. 499.57 define a Road Safety Impact Assessment as a strategic comparative analysis of the impact of a new road or a substantial modification to the existing network on the safety performance of the road network.

Road Safety Impact Assessment is to be carried out at the initial planning stage and the results are to be considered during the planning process. Where changes are required, the impact assessment shall indicate the road safety considerations which contribute to the specific remedial intervention and provide for the analysis of different alternative through a cost-benefit analysis.

It is important to be able to ascertain the impact of road safety which results from the construction of new roads or when carrying out substantial modifications to the existing road network. Such also applies to other schemes or developments which have a considerable impact on the traffic patterns. (Wegman et al., 1994)

The scenario method is used to undertake a Safety Impact Assessment. The first part is to analyse the base line which is the existing road network, the existing traffic patterns and the accident data. (Wegman et al., 1994) The road network is to be perceived as being made up of different types of roads with different characteristics and with junctions and links between junctions. For every section, there are specific traffic volumes and accident data. Alternative scenario s to this existing situation are the changes to be studied in the impact assessment in relation to the physical infrastructure and the resulting traffic volumes in the future. (Wegman et al., 1994)

The second part is to interpret these changes in relation to their impacts on the number of accidents and injuries. (Wegman et al., 1994) Such is carried out through the analysis of quantitative indicators of risk, taken as being injury accident rates per million vehicle km for each type of road. (European Transport Safety Council, 1997)

The third part is to establish the cost-effectiveness of the schemes as part of the road safety impact assessments. Such may sometimes be difficult to quantify accurately. The costs of the projects or works being undertaken on the road network might not be too difficult to quantify however the benefits require an estimate to be made of the difference in accident costs occurring on the proposed schemes compared with the existing scenario and other possible alternative schemes. (European Transport Safety Council, 1997)

If the entity or person overseeing a project considers it unnecessary for a Road Safety Impact Assessment to be applied to a specific Road Upgrading or Re-Design scheme, approval must be obtained from the Road Safety Audit Team of Transport Malta (TM). The request for this exemption must be supported by clear reasons why the impact assessment is not necessary. An exemption will only be approved when in the opinion of the Road Safety Audit Team the effect of the proposed works on the existing road network would be minimal.

The scope of the Road Safety Impact Assessment does not include health and safety legislation in relation to the construction, maintenance and use of such road.

The Road Safety Impact Assessment considers only road safety matters and it is not a check of the design standards and nor does it consider structural safety.

1.1 Impact Assessment Team

The Impact Assessment Team needs to be independent of the Design Team but may be or form part of the Audit Team.

Impact Assessment Team needs to have the necessary training, skills and experience to be accepted for carrying out a Safety Audit.

The Road Safety Impact Assessment Team shall consist of one Impact Assessment Team Leader and at least one Impact Assessment Team member to enable discussion of problems and recommendations and to maximize the potential to identify problems. A maximum of two Impact Assessment Team Observers may join the team to gain experience in carrying out Road Safety Impact Assessments.

1.2 Impact Assessment Team Training, Skills and Experience

The Impact Assessment Team leader requires to have a minimum of four years Accident Investigation or Road Safety Engineering Experience, would have attended at least 10 days of formal Accident Investigation or Road Safety Engineering Training and demonstrate a minimum of two days of Continuous Personal Development in the field of Accident Investigation or Road safety Engineering in the past twenty-four months.

The Impact Assessment Team Member requires to have a minimum of two years Accident Investigation or Road Safety Engineering Experience, would have attended at least 10 days of formal Accident Investigation or Road Safety Engineering Training and demonstrate a minimum of two days of Continuous Personal Development in the field of Accident Investigation or Road safety Engineering in the past twenty-four months.

The Impact Assessment Team Observer requires to have a minimum of one year Accident Investigation or Road Safety Engineering Experience, would have attended at least 10 days of formal Accident Investigation or Road Safety Engineering Training.

The Impact Assessment Team might need to consider the appointment of Special Advisors in the case of complex signal controlled junctions, road design, traffic management or maintenance works. The Advisor would not be a member of the Impact Assessment team but would advise the team on matters related to his/her specialization.

1.3 Impact Assessment Brief

The Design Team is responsible for the preparation of an Impact Assessment Brief.

The Safety Impact Assessment Brief is to include all the information necessary for enable an efficient and effective Road Safety Impact Assessment to be carried out. The Impact Assessment brief should include the:

- All drawings of the proposed scheme showing the full geographical extent of the scheme and any adjacent areas
- Details of any departures and relaxation from design standards
- General scheme details including the purpose of the scheme, speed limits, traffic flows, forecasted flows, queue lengths, non-motorised user flows and desire lines and details of any environmental constraints.
- Any special factors which may affect road safety such as the location of schools, emergency access points.
- The previous 36-month accident data in the form of stick diagrams and interpreted listings. The accident data should be for the extent of the scheme and for adjacent roads.

If the Impact Assessment Team considers that the Impact Assessment brief does not contain all the information required for the purpose then requests for further information are to be submitted to the Design Team. Any information requested but not provided by the Design Team should be identified in the Impact Assessment Report.

1.4 Elements of a Road Safety Impact Assessment

1.4.1 Problem Definition

A full description is to be provided of what is aimed for with the proposed activity, the activity itself and the manner in which it will be carried out as well as a description of the alternatives to this activity which should reasonably betaken into consideration. (Wegman et al. 1994) The alternatives to be described should include those which enable realization of the best options available for the improvement of road safety. (Wegman et al. 1994) This is to describe which problem areas, developments and prognoses have led to the proposed activity, hence the infrastructural changes, and which problems will be solved. (Wegman et al. 1994)

The extent of the assessment depends on the scale of the proposed schemes:
- small-scale schemes where the impact of change can usually be expected to be confined largely within the scheme itself
- for larger schemes, the impact on accident occurrence can be expected to be felt over a larger part of the road network. (European Transport Safety Council, 1997)

and is defined by considering different road types, the corresponding values of relevant safety indicators and the forecast traffic volumes, the impact on accident occurrence can be estimated for different alternatives. (European Transport Safety Council, 1997)

1.4.2 Current Situation and future 'DO SOMETHING' Scenario

STEP 1: Categorising a road network

(Wegman et al. 1994)

The following road characteristics are to be defined:

- Number of carriageways
- Number of lanes per carriageway
- Number of directions per carriageway
- Existence of parallel facilities
- Type of road users
- Vehicle type classification

The road type is to be defined based on the above criteria for road types outside urban areas:

- Arterial/distributor roads with three or more lanes per carriageway
- Arterial/distributor roads with two or more lanes per carriageway
- Arterial/distributor roads with dual carriageway
- Arterial/distributor roads with one carriageway
- All purpose road with dual carriageway
- All purpose road with one carriageway
- All purpose road with one carriageway, two lanes
- All purpose road with one carriageway, one lane

The road type is to be defined based on the above criteria for road types inside urban areas:

- Dual carriageway, two directions, two parallel facilities
- Dual carriageway, two directions, one parallel facility
- Dual carriageway, two directions, no parallel facilities
- One carriageway, two directions, two parallel facilities
- One carriageway, two directions, one parallel facilities
- One carriageway, two directions, no parallel facility
- One carriageway, one direction, two parallel facilities
- One carriageway, one direction, one parallel facility
- One carriageway, one direction, no parallel facilities

STEP 2: Road Safety Indicators per Type of Road

(Wegman et al. 1994)

Per type of road the following variables have to be measured to estimate the road safety indicators:

- Road length
- Number of injury accidents
- Number of casualties
- Number of fatalities

The recommended road safety indicators to be used are:

- Number of injury accidents per kilometer per year per road type
- Number of casualties per injury accident
- Number of fatalities per 100 casualties.

STEP 3: Development of Road Safety Indicators

1.28 The reduction in the number of casualties could be explained partly by the fact that road traffic has become safer over the years and also by the increasing proportion of kilometers traveled on roads with low accident rates. (Wegman et al. 1994) However since such cannot be estimated, it is accepted that road safety indicators per road type are not constant over the years but it is assumed that the reduction in fatality and injury rates will be the same for all road types.

STEP 4: Traffic Volumes

1.29 Traffic count surveys need to be carried out for the road types as established in STEP 1 above and be categorized by type of vehicles. Speed surveys would also be beneficial for the assessment.

STEP 5: Accident Statistics

1.30 Based on the accident statistics database, the accidents information is to be classified and sorted out by location, age group, day of week, time of day, type of road user.

STEP 6: Estimation of Road Safety Indicators

1.32 Based on the traffic volumes estimated in STEP 6 the estimations for the number of injury accidents per km in relation to AADT flows is taken from the following graphs which are based on the relationship between traffic volumes and accidents expressed as follows (Elvik and Vaa, 2004):

$$A = a \times Q^b$$

Where
A : number of accidents
Q: measure of traffic volume
a, b : constants

The above equation means that there is a nearly linear relationship between the frequency of accidents and the traffic volume (PIARC, 2007) at least within the intervals of the usual traffic volumes. Based on this relationship it can be said that increased traffic volumes are basically connected with increasing accident numbers and vice versa. The EuroRap programme uses the accident rate in order to assess the safety level of roads.

$$\text{Accident Rate} = \frac{\text{Number of Accidents for one year} \times 100{,}000{,}000}{365 \times \text{AADT} \times \text{length of road}}$$

STEP 7: Assessment of Road Safety Impact between the Current Situation and 'DO SOMETHING' Scenario

The results of the two scenarios are compared with each other and these results will subsequently be compared with the results for the alternative scenarios.

1.5 Road Safety Objectives

The Road Safety Impact Assessment shall indicate the road safety considerations which contribute to the choice of the proposed alternatives (Moning, 2008)

The Road Safety Impact assessment shall further provide the relevant information necessary for a cost benefit analysis of the different options assessed (Moning, 2008)

1.6 Analysis of impacts on road safety of the proposed alternatives

The impacts are to be assessed for:

- Each intervention of the proposed alternatives as per Table 1
- Assessment of impact of any changes of route choice and traffic distribution patterns.

Table 1 : Possible Accident Reduction in Relation to Specific Interventions

Road Safety Problem	Possible Intervention	Possible Accident Reduction
Road side Obstacles Hit	Apply paint or reflectors	10% fatalities
Loss of Control	Road edge markings	10% fatalities
Drowsiness	Safe Parking Areas	10% fatalities
	Removal of obstacles	10% fatalities
	Delineators	10% fatalities
	Improve lighting levels	15% fatalities and 90% cross-over accidents
	Installation of guard rails	15% fatalities and 90% cross-

Road Safety Problem	Possible Intervention	Possible Accident Reduction
		over accidents
	Installation of crash barriers	15% fatalities and 90% cross-over accidents
	Installation of crash cushions	15% fatalities and 90% cross-over accidents
	Fatigue/Alcohol Education Campaigns	15% fatalities and 90% cross-over accidents
	Guardrails along embankments	40-50% collision reductions
	Clear recovery zones	10-40% collision reductions
Wet Road Skidding	Installation of anti-skid	40-45% of total injuries 80% of wet accidents
Night-time	Improve street lighting levels	15-30% in urban areas 50% in rural areas
Pedestrians at junctions	Pedestrian stage in signals Refuge islands Prohibit parking Improve street lighting	40%
Pedestrians not at a junction	Construct footways	40%
	Install designated crossings	40%
	Pedestrian fencing or barriers	20%
	Traffic calming	60%
	Restrict vehicle access	60%
Speed	Enforcement Traffic Calming	
Turning Traffic at Junctions	Channelisation	30%
	Signals or roundabout	30-50%
	Improved signage	10%
	Clear obstructions	10%
	Improve surface	60%
	Provide turning lane	40%
	Create one-way street	40%
	Restrict turns	40%
	Improve street lighting level	40%
	Install cameras	40%
	Rumble bars/yellow bar markings	35%
Overshoots from minor road	Traffic islands	10%

Road Safety Problem	Possible Intervention	Possible Accident Reduction
Overshoots from roundabouts	Chevrons and warning signs Rumble bars/yellow bar markings	50% 50%
Sight restrictions at junction	Removal of vegetation Relocation of accesses Realignment of oblique angled junctions Improve vertical profile Remove sight obstacles	10-60% 10-60% 10-60% 10-60% 0-5% collision reductions
Overtaking	Double centre lines Restrictive signs Central median Construct dual carriageway	50% 50% 50%
Loss of control on bends	Chevron signs Advisory speed sign Improve super-elevation or alignment Improve skid resistance Guard rails	50-80% 50-80% 60-80% 60-80% 60-80%
Horizontal curves	Uniform vertical signs and horizontal markers with retroreflective materials	50%
Urban areas	Gateway treatment Correcting incorrect signs	75% 5-10% collision reductions
Intersections	Change of the intersection layout and the installation of traffic signals	48%

M. Goodge, 2009
S.V. Gomez, 2005
TMS Consultancy, 2011

1.7 Comparison of Alternatives including Cost-Benefit Analysis

The likely cost-effectiveness of a Safety Impact Assessment is based on the costs for carrying out the assessment in relation to the potential prevention of injuries/fatalities and any changes to the route patterns. (European Transport Safety Council, 1997)

The cost-benefit anaylsis is based on the accident reduction estimates in relation to the costs of accidents and casualties which are estimated as:

Table 2 : Cost per Accident by Road Type and Severity

Road Category	Accident Severity (Euros)		
	Fatal	***Serious***	***Slight***
Non Built-up areas	1,122,000	138,900	10,500
Built-up areas[1]	729,300	90,285	6,825

(Bickel et al, 2006)

Given that this data is not currently available for Malta, it is recommended that the accident costs are based on the above values for Spain because the monthly minimum wage for Spain is very similar to that of Malta being 633.30Euros and 634.75Euros respectively. (FedEE, 2009)

It is recommended that for calculation purposes, an average cost per accident is taken for any junction or link across the Maltese Islands for one year as follows:

Average cost per accident in a non built-up area

= {(a.1122000)+(b.138900)+(c.10500)}/(a+b+c)

Average cost per accident in a built-up area

= {(a.729300)+(b.90285)+(c.6825}/(a+b+c)

Where:
X: previous year
a: number of fatalities in year X
b: number of grevious injuries in year X
c: number of slight injuries in year X

With the forecasted data and the information provided above, the cost benefit analysis is then calculated is 'First Year Rate of Return' (FYRR) method. This is the monetary value of the espected accident savings in the first year of operation of the proposed or alternative scheme, expressed as a percentage of the total cost of the scheme. (Goodge, 2009) Refer to Annex 1 for a worked example.

$$\textbf{FYRR (\%)} = \frac{\textbf{annual collision savings} \times \textbf{100}}{\textbf{Cost of scheme}}$$

1.8 Presentation of the Range of Possible Solutions

The presentation of the range of possible solutions is to be based on the following:

[1] The average cost of an injury collision for built-up areas is taken to be 35% less than that for a non-built-up area. (TMS, 2011)

- Offer a supported overview of all possible alternatives which can be considered in the final decision
- A guidance towards the optimum concrete and operational description of the objectives
- Considers all reasonable alternatives
- Outlines any uncertainties
- Leads to an evaluation plan.

2. Road Safety Audits for Infrastructural Projects

LN 34 of 2011 defines a Road Safety Audit as an independent detailed systematic and technical safety check relating to the design characteristics of a road infrastructure project and covering all stages from planning to early operation. For the TEN-T roads, Road Safety Audits are mandatory for all improvement schemes and are recommended as good practice on other roads.

Road Safety Audits are intended to ensure that operational road safety criteria are implemented during the design and operational phase of a project to ensure that the frequency and severity of accidents are kept to a minimum, to consider the safety of all road users especially vulnerable road users and to improve the awareness of safe design practices.

Road Safety has always been one of the important aspects during the preparation of upgrading schemes however there have been occasions where the details of the design were the cause of accidents on newly operational stretches of roads. Design Teams do not necessary consist of Road safety Engineering professionals and thus they may not fully comprehend the nature of accident causation. (The Highways Agency et al, 2003)

This guidance document sets out the procedures required to implement Road Safety Audits on the road network irrespective of the procurement method. (The Highways Agency et al, 2003) Maintenance works which involve same replacement or refurbishing of existing road features are excluded from the scope of the Safety Audit.

If the entity or person overseeing a project considers it unnecessary for a Road Safety Audit to be applied to a specific Road Upgrading or Re-Design scheme, approval must be obtained from the Road Safety Audit Team of Transport Malta (TM). The request for this exemption must be supported by clear reasons why the audit is not necessary. (The Highways Agency et al, 2003) An exemption will only be approved when in the opinion of the Road Safety Audit Team the effect of the proposed works on the existing road network would be minimal. (The Highways Agency et al, 2003)

The scope of the Road Safety Audit does not include health and safety legislation in relation to the construction, maintenance and use of such road.

The Road Safety Audit considers only road safety matters and it is not a check of the design standards and nor does it consider structural safety. (The Highways Agency et al, 2003)

2.1 Stages of a Safety Audit

The Road Safety Audit consists of four Stages namely:

- STAGE 1: Completion of Draft Design Stage
- STAGE 2: Completion of Detailed Design Stage
- STAGE 3: Pre-Opening Stage
- STAGE 4: Early Operation

STAGE 1: Completion of Draft Design Stage

Stage 1 Road safety Audit will be carried out when the preliminary designs have been completed and prior to planning consent. This is the last opportunity where land requirements may be increased and hence it is important that road safety issues which may effect expropriation, licences or easements are addressed. (The Highways Agency et al, 2003)

At Stage 1 of the Road Safety Audit all the Audit Team Members shall visit together the locations where permanent change to the existing arterial and distributor road layout or characteristics will be effected or where schemes on adjacent road will affect the arterial and distributor road network. (The Highways Agency et al, 2003)

STAGE 2: Completion of Detailed Design Stage

At Stage 2 the Road Safety Audit is focused on the more detailed aspects of the Upgrading Schemes and the assessment will include the layout of junctions, position of signage and line markings, lighting levels. (The Highways Agency et al, 2003)

Stage 2 will also review the issues highlighted in the Stage 1 of the Audit Report and any Exception Report and Feedback Report.

At Stage 2 of the Road Safety Audit all the Audit Team Members shall visit together the locations where permanent change to the existing arterial and distributor road layout or characteristics will be effected or where schemes on adjacent road will affect the arterial and distributor road network. (The Highways Agency et al, 2003)

Stage 3: Pre-Opening Stage

The audit is to be carried out when the road works related to the upgrading or re-design schemes have been completed and before the road is open to the public to minimise the risk potential of road users and to facilitate the assessment process for the Audit Team. (The Highways Agency et al, 2003)

The Audit Team will carry out site visits during the daytime and during the night-time and assess the potential hazards. (The Highways Agency et al, 2003)

The auditors are also to take into consideration the effects of different weather conditions which might not be manifested during the site visit. (The Highways Agency et al, 2003)

The auditors are to review the Stage 2 Audit Report and Exception Report.

Stage 4: Early Operation

The audit is to be carried out approximately a year after the road is opened to traffic.

An analysis of the accident data should be carried out and compared with the data of previous years. The accident monitoring reports should identify road safety problems indicated by the analysis of the data and any further observations during the site visits. The report should make a recommendation for remedial measures where necessary. (The Highways Agency et al, 2003)

2.2 Audit Shelf Life

Stage 1 and Stage 2 Audits will be carried out again should the scheme design change or if the original audit is more than 3 years old.

If during the construction phase, the scheme design is changed, Audit Stage 2 needs to be resubmitted.

2.3 Audit Team

The Audit Team needs to be independent of the Design Team. (The Highways Agency et al, 2003)

The Audit Team needs to have the necessary training, skills and experience to be accepted for carrying out a Safety Audit. (The Highways Agency et al, 2003)

The Road Safety Audit team shall consist of one Audit Team Leader and at least one Audit Team member to enable discussion of problems and recommendations and to maximize the potential to identify problems. A maximum of two Audit team Observers may joint the team to gain experience in carrying out Road safety Audits. (The Highways Agency et al, 2003)

2.4 Audit Team Training, Skills and Experience

The Audit Team leader requires to have a minimum of four years Accident Investigation or Road Safety Engineering Experience, would have completed a minimum of five Road Safety Audits, would have attended at least 10 days of formal Accident Investigation or Road Safety Engineering Training (The Highways Agency et al, 2003) and demonstrate a minimum of two days of Continuous Personal

Development in the field of Road Safety Audit, Accident Investigation or Road safety Engineering in the past twenty-four months.

The Audit Team Member requires to have a minimum of two years Accident Investigation or Road Safety Engineering Experience, would have completed a minimum of five Road Safety Audits, would have attended at least 10 days of formal Accident Investigation or Road Safety Engineering Training (The Highways Agency et al, 2003) and demonstrate a minimum of two days of Continuous Personal Development in the field of Road Safety Audit, Accident Investigation or Road safety Engineering in the past twenty-four months.

The Audit Team Observer requires to have a minimum of one year Accident Investigation or Road Safety Engineering Experience would have completed a minimum of five Road Safety Audits, would have attended at least 10 days of formal Accident Investigation or Road Safety Engineering Training (The Highways Agency et al, 2003).

The Audit Team might need to consider the appointment of Special Advisors in the case of complex signal controlled junctions, road design, traffic management or maintenance works. The Advisor would not be a member of the Audit team but would advise the team on matters related to his/her specialization.

2.5 Audit Brief

The Design Team is responsible for the preparation of an Audit Brief.

The Safety Audit Brief is to include all the information necessary for enable an efficient and effective Road Safety Audit to be carried out. (The Highways Agency et al, 2003)

If the Audit Team considers that the Audit Brief does not contain all the information required for the purpose then requests for further information are to be submitted to the Design Team. Any information requested but not provided by the Design Team should be identified in the Audit Report.

2.6 Structure and Content of the Road Safety Audit Report

Title Page

This should include:

(i) a report title giving the name of the project, together with the stage of construction or rehabilitation at which the RSA is being undertaken (Asian Development Bank, 2003); and

(ii) names of the auditor or audit team and date when the audit was carried out.

Background Information

This should include (Asian Development Bank, 2003):

(i) the introductory statement outlining the content, a description of the scheme, who requested the audit, and when it was done;

(ii) details of names and qualifications of the Road Safety Audit team;

(iii) details of when and where the Road Safety Audit was carried out;

(iv) names of who attended site visits, the date and time of the visit and the site and weather conditions during the site visit;

(v) a list of supportive materials made available such as plans, etc. (this could be referred to and listed as an appendix).

(vi) location plan

Findings and Recommendations

For each location along the route that was identified as having potential hazards, the following needs to be provided (Asian Development Bank, 2003):

(i) **Location:** outline the exact road name or junction reference

(ii) **Summary:** state the type of accident risk

(iii) **Problem description**: briefly outlines what safety problem was found at that point from the site visit and review of plans/ materials; this could be in the form of statements cross-referenced to annotated plans; it could also be supported by photographs or sketches; and

(iv) **Recommendations**, if any, for any corrective action (these should be clearly and uniquely numbered for easy future cross-referencing and referral).

Formal Auditor's Statement

This section consists of a signed and dated statement by the auditor or the team of auditors indicating completion of the audit. (Asian Development Bank, 2003)

It is important to note that recommendations made at each earlier stage of an audit (Stage 1, Stage 2, etc.) are reviewed at the start of each subsequent stage to ensure that the safety issue or problem raised previously has been addressed. It is therefore imperative that each “problem description” and “recommendation” have a unique number for easier referencing between documents. It may also be convenient to use the same headings and items as used in relevant checklists for each stage of the Road Safety Audit. (Asian Development Bank, 2003)

2.7 Safety Audit Draft Design Stage 1

(Asian Development Bank, 2003)

Information Required for the Audit

- Planning and route adoption reports on which the preliminary design has been based
- Traffic reports containing existing and predicted traffic flows, including design flows for all movements at intersections and interchanges
- Preliminary layout plans, cross-sections, grade lines, etc. to be audited
- Departure from standard specifications.

2.7.1 Audit Items to be checked

(Asian Development Bank, 2003)

Design Criteria: criteria are appropriate to the functional class of road, the nature of the topography, and the volume and type of traffic.

Cross-Section:

- Adequacy of lane widths, shoulders, roadside clearances, width of medians and separators, including the provision of adequate right-of-way width for grading, verges, footpaths etc.
- That, if special lanes or carriageways are required for motorcycles, of bicycles, the width are adequate
- For consistency of the cross-section along the route
- The accommodation of drainage, ducting, signing, fencing, lighting, pedestrian and cycle routes.

Horizontal and Vertical Alignment

- The design speed of horizontal curves
- For any substandard curves
- That vertical alignment standard is consistent and coordinated with horizontal alignment
- Adequacy of stopping sight distance, and availability of overtaking sight distance
- For unsatisfactory combinations of vertical and horizontal alignment, this may mislead drivers in respect to overtaking or the direction of the route ahead.

Interchanges and Intersections

- The appropriateness of type of interchanges or intersection
- The adequacy of the layout from a capacity viewpoint
- The design of any necessary acceleration/deceleration lanes

- The achievement of various sight distance criteria, including approach sight distance, entering or crossing sight distance, safe intersection sight distance to queued vehicles, sight distance for pedestrians, sight distance at interchange entry and exit ramp noses
- That the layout caters adequately for large vehicles and for public transport vehicles and for public transport vehicles where applicable; the need / provision of specific safety-related features, e.g., median barriers, street lighting
- That the specific needs of particular road users, such as motorcyclists, bicyclists, and pedestrians, have been considered and any action required at the detailed design stage has been noted

Access Control/Provisions

- The appropriateness of access control, particularly in the vicinity of interchanges and intersections
- Where access is restricted, check the suitability and adequacy of alternative access, particularly to large traffic generators
- Where pedestrian access is restricted, check that the need for appropriate fencing is noted for action at the detailed design stage

Major Land Use Developments

- Consider the road safety implementations of major land use developments adjacent to highways
- The adequacy of access and egress arrangements, e.g., avoidance of entry and exist driveways too close to interchanges and intersection and the avoidance of queues from driveways extending onto the highway
- The layout of driveways and type of traffic control are appropriate to the function of the highway; that the needs for pedestrians and public transport access to the development have been identified and provided for
- The adequacy of “off-street” parking, and the provision of parking controls on the highway

Development of Major Projects

- That the development strategy takes account of traffic safety requirements
- The arrangement and sitting of access points, avoiding locations of poor sight distance, locations complicated by busy intersections and restricted alignment standards
- For unexpected changes in geometric standards, and situations that are likely to result in the unexpected onset of traffic congestion

Road Signs, Carriageway Markings and Lighting

- Check if any sign gantries are required
- Lighting is provided and new lighting has been provided as necessary to support the new scheme
- Location of lighting poles and sign poles
- Design of road markings is to be checked.

2.8 Safety Audit Detailed Design Stage 2

(Asian Development Bank, 2003)

2.8.1 Information Required for the Audit

- Audit report and decisions on earlier stage audits
- Any departure from standards
- Collision details
- Site plan showing road network and general topographic details in the region of the project
- Statement of the design criteria
- Relevant traffic demand information
- Horizontal and vertical alignment plans
- Cross-sections
- Grading and drainage plans showing the location and general details of drainage structures
- Bridge layout plans including cross-sections and details of barrier systems
- Interchange and/or intersection layouts traffic signal layouts and design information
- Traffic signing and road marking plans
- Street lighting layouts and design information
- Landscaping and beautification plans and tree planting details
- Plans showing relevant overhead services/utilities

2.8.2 Audit Items to be checked

(Asian Development Bank, 2003)

General Items

- Design criteria
- Consistency among the items relevant to road safety
- Route planning and location
- Aspects that have adverse safety implications, or previous decisions that have placed constraints to the detailed design that may lead to unsatisfactory safety performance
- Adequacy of reservation width to achieve a safe cross-section, considering the needs of all road users
- Appropriateness of the proposed access control

Details of the Proposed Design Strategy

- Proposed speed limit
- Vehicle type restrictions
- Proposed segregation of vulnerable road users
- On-street parking provisions/restrictions
- Turn restrictions
- Special provisions for pedestrians and/or bicyclists

- Special provisions for motorcyclists
- Special provisions for trucks and/or buses
- Provision of "motorist facilities" such as rest and service areas, laybys, etc.

Climatic and weather implications

- Wet weather and flooding effects
- High winds
- Fog-prone areas

Geometric Design Elements: Horizontal alignment in respect to

- Correct choice and application of design speed
- Consistency of horizontal alignment along the route
- "Substandard"curves
- Provision of transition curves (spirals) where appropriate
- Horizontal alignment at the "interface" between the proposed construction and the existing road network

Geometric Design Elements: Vertical alignment in respect to

- Consistency along the route
- Sight distance.

Combination of horizontal and vertical alignment

- Adequacy of stopping sight distance
- The achievement of overtaking sight distance
- The achievement of approach sight distance at intersections
- Adequacy of sight distance at locations where there is a discontinuity in the cross-section standard

Gradients

- Sections with steep downgrades
- Sharp curves on steep downgrades, check adequacy of super elevation rate to achieve appropriate design speed
- Sections with steep upgrades and the need for "slow vehicle" provisions

Cross-Section

- Number and width of traffic lanes, width of shoulders or emergency stopping lanes
- Median width (where applicable)
- Batter heights and slopes and guardrail requirement
- Use of correct types of kerbs (avoid barrier kerbs)
- The provision of footpaths
- Clearances to barriers and barrier types
- Appropriate transitions at locations where the cross-section changes significantly
- Special provisions needed for vulnerable road users such as pedestrians, bicyclists, motorcyclists
- Differences in level between the roadways of divided roads at intersections or access driveways.

Interchanges and Intersections

- General layout logic
- Visibility and sight distance

Sight distance criteria applicable at intersections

- Approach sight distance
- Entering or crossing sight distance
- Safe intersection sight distance
- Sight distance to queued vehicles
- Sight lines and visibility to traffic signals and signs
- Sight distance to exit nose
- Sight distance to the entry and merge area

Auxiliary lanes and lane continuity

- Protection for turning vehicles at important intersections
- Avoidance of trap lane arrangements

Island size and shape

- Traffic islands should be large enough to be easily visible;
- Traffic Islands should cater adequately for any traffic signs, signals, street lights and provide adequate refuge for pedestrians
- Shape of the islands should guide vehicles into the correct travel path
- Approach noses should be properly offset from the edge of traffic lanes
- At roundabouts, check the shape and positioning of the approach deflection islands to ensure control of entry speed
- Turning roadway widths to provide adequately for large/ heavy vehicles turning at low speed

Kerb type

- Incorrect kerb usage may constitute a hazard to road users, particularly motorcyclists

Provisions for Pedestrians

- Lack of provision of footpaths and kerb ramps at crossing points
- Adequate area/width for medians and roadway separators, including pedestrian refuge islands

Signals, signs, lighting, and other road furniture are not to be placed in vulnerable locations such as at the nose of traffic islands and should not obstruct normal pedestrian movements

Vehicle parking and bus stops

- Identify the need for parking restrictions and check that proposed bus shelters and "waiting" buses will not obstruct
  sight lines important for the safe and efficient operation of the intersection.
- Check that where on-street parking is to be provided, parking maneuvers will not interfere with traffic moving through the intersection.

- Identify sites where stationary buses at bus stops will interfere with the movement of other traffic.

Property access points

- To check for likely unexpected traffic conflicts or otherwise hazardous traffic conflicts.

Traffic Signal Installations

- Traffic signals proposed only where they are warranted
- Proposed signal phasing provides adequately for the required traffic (and pedestrian) movements
- No unexpected conflict situations arise in the signal phasing, and that special phases for right turn movements are provided where justified
- Required intergreen time for each phase change is sufficient to allow safe operation
- The number and location of signal heads and posts ensure that each separately controlled vehicle movement has at least two (and preferably three or four) signal heads controlling it and that minimum visibility requirements are met
- Adequate clearances are provided between the face of kerb and the signal head not located in islands and medians too small or narrow to afford the equipment adequate protection from vehicle impacts
- The correct signal size and brightness are provided and that back plates are provided
- Pedestrian signal displays and associated "call buttons" are provided at sites where it is expected that pedestrians will cross signal-controlled roadways.

Traffic Signs

- Traffic signing provides positive guidance rather than abstract and indefinite information
- Necessary regulatory signs are provided and properly positioned to control, both legally and practically, the movement of traffic along or across the roadway
- Appropriate warning signs are shown on the traffic signing plans
- Any unnecessary warning signs are identified and removed
- Proposed direction and guide signing (consider "unfamiliar drivers")
- Letter/legend size is adequate to enable drivers to read the information displayed in the time available
- Positioning of proposed direction signs will enable drivers to take any necessary action safely
- Appropriate reflectorisation is specified or that internal or external lighting of the signs is required
- Provision of overhead (e.g. gantry-mounted) signs where complex multilane roadway layouts require vehicles to get into specific lanes to reach particular destinations
- Positioning of signs does not obstruct sight lines at intersections and on the inside of curves

- Positioning of signs and selection of the type of signposts prevent these structures themselves from being a significant roadside hazard

Road Marking and Delineation

- The correct type of longitudinal line markings, in terms of line pattern and width, is shown on the relevant plans
- Lines are properly positioned to guide vehicles in respect to the correct use of various traffic lanes and to effectively designate locations of merge and diverge situations, shoulders, and emergency stopping lanes
- For any case of discontinuity in "through" traffic lanes and any unavoidable and inadequately signed "trap" lanes or other illogical lane marking arrangement
- All horizontal and/or vertical curves on two-lane two-way roadways, at which overtaking sight distance is not achieved, are shown to be properly marked with double (barrier) lines and identify lane marking arrangements that may confuse or be unexpected by drivers
- Double (barrier) lines are shown to be marked at any horizontal and/or vertical curves on two-lane two-way roadways at which overtaking sight distance is restricted, in accordance with appropriate guidelines
- Closely spaced short lengths of barrier lining, which may lead drivers into unsafe overtaking maneuvers, are identified
- Approach hazard markings are shown on plans at the approach end of traffic islands, medians, and separating islands and in the exit ramp areas
- The correct positioning of all transverse lines such as "stop" lines, holding (or "give way") lines, and pedestrian crossing lines
- Retroreflective road markings are specified to enhance nighttime visibility
- Retro-reflective pavement markers or road studs are specified to supplement surface markings where there is a need for longer distance visibility at night and more effective pavement delineation

Audit of Street Lighting Design

- The extent of street lighting is appropriate to traffic safety needs of road users and identify situations where unlit short lengths of roadway are mixed with lit sections
- The standard of lighting including uniformity and possible "glare" effects is appropriate to the needs of the traffic situation
- Lighting transitions are provided where street lighting ends
- Lighting poles themselves do not constitute a roadside hazard
- Lighting poles do not significantly obstruct driver sight lines

Audit of Roadside Safety Provisions

- The provision of a "clear zone"
- The use of frangible types of road furniture
- Guardrail provisions and design details
- Minimum length of guardrail required to ensure that it functions properly
- Guardrail positioning relative to kerbs and objects being protected
- Bridge ends and guardrail to bridge rail transitions
- Barriers and railings on bridges and elevated roadways

- Landscaping and beautification
- Other roadside hazards
- Safety treatment of uneven rock cut batters
- Roadways close to permanent deep water such as rivers
- Lakes or seashore slopes close to the traffic lanes
- Horizontal rails in pedestrian fencing close to roadways

Provisions for Pedestrians

- Lack of footpaths or locations where footpaths are obstructed by posts and other road furniture
- Lack of kerb ramps or "dropped kerbs" at crossing points particularly at signalized intersections
- Lack of specific crossing facilities such as signalized crossings, refuge island, zebra crossings, or grade separations where warranted
- Lack of specific pedestrian signal heads and signal phasing at locations where there is significant nighttime pedestrian activity
- Insufficient space for pedestrian refuge on traffic islands, medians, etc.
- Traffic management and devices to enable pedestrians to cross wide roadways with continuous uninterrupted traffic flows

Provision for Motorcycles

- Horizontal and vertical alignment and sight distances, appropriate to the expected operating speed
- Cross-section standards, which provide adequate width of lanes or roadway for motorcyclists
- Appropriate clearances to roadside objects, merge and diverge areas
- Clear designation of priority between conflicting streams of traffic at junctions
- Adequate line and pavement marking to ensure an orderly flow of vehicles and good delineation of the route ahead
- Appropriate regulatory, warning, and direction signing with legibility and sign positioning
- Appropriate types of guardrails or barriers
- Provisions such as fully paved shoulders or special treatments at signalized intersections

Provisions for Cyclists

- Lack of cycle lanes or where cycle lanes are obstructed by posts and other road furniture
- Lack of cycle lane particularly on the approach to and at signalized intersections
- Lack of cycle parking
- Cycle lane design at intersections
- Lighting levels at cycle lanes

2.9 Road Safety Audit during Pre-Opening Stage 3

2.9.1 Audit Items to be checked

General Grading, Alignment, and Cross-Section

- As-built drawings
- Sight distance (e.g., stopping sight distance) over crests, across the inside of horizontal curves, and on the approaches to intersections and at "entry" and "exit" ramps at interchanges
- Combinations of horizontal and vertical alignment resulting in areas of "hidden pavement" that may confuse a driver as to the direction of the route ahead or small depressions that may hide a vehicle momentarily in a potentially hazardous overtaking situation
- The general need for provision of guardrails at embankments and steep side slopes

Road Layout Features

- Departure or relaxation of standard specifications
- The general alignment geometry, particularly in respect to sight distance
- The width of roadways (number of lanes), shoulder parking lane width, widths of median and dividers, and the size of traffic islands
- The layout of channelizing islands and medians at intersections, as seen from a driver's perspective
- The provision of appropriate clearances and offset at the approach noses of traffic islands, medians, and other dividers
- The type of kerb being constructed (e.g., the incorrect use of barrier kerbs)
- The alignment of tapers into and out of auxiliary lanes and the voidance of "trap" lane situations
- The location and treatment of pedestrian walkways and standing areas

Traffic Signs

- The overall traffic signing strategy on the plans and on-site
- Regulatory and warning sign provisions and placement
- Type, size (letter height), amount, and arrangement of legend on traffic signs and the adequacy of their legibility distance
- Types of reflective sheeting, colors, grade, etc. on traffic signs
- The correct positioning of direction and other guide signs
- Obstruction to the visibility of traffic signs by other road furniture items
- The obstruction of essential sight lines by poorly located traffic signs
- The mounting structure of traffic signs (do not create a roadside hazard)
- General structural adequacy of traffic signs mounted over the roadway
- The need for protection of gantry columns with guard-railing
- The adequacy of the mounting height of traffic signs

- The adequacy of clearance under traffic signboards, particularly where mounted over footpaths and the avoidance of sharp edges or corners that could be a danger to pedestrians, pedal cyclists, or motorcyclists
- The need for provision of and arrangement of external lighting for "overhead" signs

Road Marking

- Review the type, location, and arrangement of road markings, both on construction plans and during site inspections.
- Correct use of the different types of lines to designate (to road users) the required traffic management requirements at particular locations
- Appropriate positioning of stop/give way lines at intersections
- The provision of raised retro-reflective pavement markers (or road studs), where considered necessary for safe traffic operation
- The correct provision of "arrow" pavement markings, required to designate traffic lanes that are restricted to particular traffic movements

Roadside Safety Features

- The provision of guardrail or other barrier at hazardous fixed roadside hazards
- The type of guardrail or barrier, and the adequacy of its length in relation to the length of the hazard
- Structural adequacy of the guardrail, e.g., height of the railing, post spacing, rail overlap, etc.
- Location of the guardrail or barrier relative to the hazard, e.g., clearance allowed for deflection during an impact
- Treatment of the approach end of a guardrail or barrier, end anchorage, etc.
- The type of bridge barrier or railing system appropriate to the situation and that allows no horizontal rails to protrude beyond the end posts
- The need for higher-than-normal barrier height on bridges over or close beside a busy roadway below and that the type and height of the railing are adequate to restrain a vehicle from going over the top
- The avoidance of kerbs directly in front of barrier or guardrail systems, or where it is unavoidable, the position of kerb relative to the face of the barrier or guardrail
- The type of median barrier, where applicable, and the treatment of its ends
- The provision and treatment of guardrail or barrier at fixed hazards such as rigid posts, poles, or bridge piers located in a narrow median or road divider
- The correct treatment of lighting poles placed within a median barrier
- The treatment of other narrow isolated hazards such as bridge piers and overhead sign gantry columns
- Measures ensuring that the item cannot be relocated out of the hazardous area
  - Guardrail protection of the item
  - The provision of a suitable "impact attenuator" or "crash cushion" to reduce the severity of likely impacts
  - The treatment of culvert ends and other drainage structures that they do not create hazards

Landscaping

- Trees and other plantations or landscaping features obstructing sightlines
  - – Stopping sight distance or overtaking sight distance (where applicable), particularly across the inside of curves
  - – Sight lines to the "exit" nose and at "entry" at interchanges, particularly where the approach to them is on the inside of curved alignment
  - – Various sight distance criteria at intersections, including signalized intersections and roundabouts
- The sight line across a median, required by the drivers of vehicles making a "right turn" at an intersection or a "U" turn median opening for this purpose
- Sight lines between pedestrians and vehicular traffic, where pedestrians are expected to cross a roadway at a grade, whether signalized or not
- Sight lines of vehicle drivers (including motorcyclists and pedal cyclists) to traffic signals and traffic signs
- Trees and landscaping as potential roadside hazard
- The species of trees and the expected "mature" trunk size of trees planted within the "clear zone"
- Effect of trees on street lighting
- The positioning of trees relative to the lighting poles, their expected canopy height and spread of foliage relative to mounting height of the luminaire and its "outreach"
- Foliage likely to overhang the traffic lanes and infringe the vertical and horizontal clearances for large high vehicles
- Planting of large trees too close behind semi-rigid guardrail such as "W" beam and flexible systems such as "wire rope" types, allowing insufficient clearance for the expected deflection of the barrier during an impact

Condition of Pavements

- If joints appear to have excessive bleeding or low skid resistance
- If surface changes occur at locations where they could adversely effect the stability of a motorcycle

Pedestrians and Cyclists

- Provision of guard-rails, fencing where required
- Provision of cycle lanes and footways
- Provision at crossings:
  - visibility
  - signs
  - surfacing
  - other guard-rails
  - drop kerbs or flush surfaces
  - tactile paving

2.10 Road Safety Audit Early Operation Stage 4 (Optional)

(Asian Development Bank, 2003)

2.10.1 Audit Items to be checked

Vertical and Horizontal Alignment

- General alignment standard
  – Check for consistency throughout the route, note any location where alignment standard changes abruptly and is not as expected by drivers
- Substandard curves
  – Identify any curve with a speed value of more than 10 kilometers (km)/hour(h) below the 85th percentile approach speed; note any evidence of vehicles running off the roadway
- Inadequate sight distance
  – Check and record any location with inadequate stopping sight distance
  – Check and record any location with inadequate overtaking sight distance at which "double lines" have been marked

Cross-Section

- Note any location where the cross-section standard changes abruptly along the route, or is otherwise inconsistent with driver expectations
- Identify any locations where the capacity of the roadway is restricted
- Note locations of regular traffic congestion
- Note any absence of provisions protecting turning vehicles at intersections
- Note any locations with inadequate shoulder width; check that the correct type of kerb has been used and note any location where speeds are greater than 50 km/h and barrier kerb has been used
- Check that the cross-section provides adequately for "vulnerable road users"
  – Pedestrians: have paved footpaths, adequate refuge width on median and islands, and proper ramps up and down kerbs, where there is regular pedestrian traffic
  – Cyclists: segregated areas (e.g., paved shoulders) where numbers are significant
  – Motorcyclists: segregated lanes (paved shoulders), separate roadways, where warranted by demand
- Lack of access control: Identify any location where the cross-section does not allow the development of appropriate access control

Intersections

- Sight distances
  – Check that the sight distances are appropriate for speed limits
  – Approach (stopping) sight distance
  – Entering sight distance
  – Safe intersection sight distance

General Layout Features

- That the general layout of the intersection caters safely for all road users (pedestrian, bicycles, motorcycles)
- That the layout is logical for various traffic movements, that it correctly favors the major traffic movement
- For any lack of auxiliary (turning) lanes
- For any discontinuity of "through" traffic lanes for any instance where "through" vehicles have to change lanes to continue on through an intersection
- For the occurrence of "trap" lanes, i.e., where a "through" lane is suddenly marked, or aligned, as a lane for traffic turning off a roadway
- Any location where the length and width of the "right turn" merge is substandard and instances where pedestrian movements across the continuous traffic flow movement are not properly catered for
- For operational problems at roundabouts, e.g., inadequate deflection (and speed reduction) of traffic at entry point, high vehicle speeds within the roundabout, inadequate width of entry or circulating roadway, etc.
- For situations where channelization islands are too small to be easily seen by drivers, or for pedestrian refuge or for protecting traffic signs, signals, and other road furniture
- That barrier kerbs are not used where traffic speeds are likely to be greater than 50 km/h

Traffic Signal Installations

- That traffic signals are provided only where warranted for safe, efficient, and equitable management of traffic flow along and across arterial roads and for the safe crossing pedestrians
- That the provision, location, and spacing of traffic signals reflect a sensible traffic management strategy along the route
- That signals installed are operating effectively and efficiently
- For any location where there is inadequate signal hardware (signal faces etc.) to safely control various traffic movements, bearing in mind the need for some redundancy to cater for failed light globes, etc.
- That the signal hardware and phasing provides adequately for pedestrians; specific signal faces and phasing should always be provided for pedestrians in urban and other built-up areas
- The positioning and visibility of signal faces and record instances where visibility of signals is obstructed by tree foliage, traffic signs, etc., or where approach roadways are more than three lanes wide, overhead signal faces are not provided

Street Lightning

- That street lightning is provided on arterial roads and highways in cities, towns, and other “built-up” areas, particularly where there are pedestrians and parking along the road
- That where lightning is installed, it is of an appropriate standard, consistent with the needs of the location, pedestrians, and other factors

- Locations where the street lightning poles constitute a hazard to traffic, e.g., on small islands, noses of medians, on the outside of sharp curves, etc.
- For situations where street lightning poles could be eliminated by joint sharing of traffic signal pedestals and electric power poles
- That the arrangement of street lights enhances route guidance rather than confuse the driver's ability to see the direction of the route ahead

Traffic Signing

- For cases of unauthorized traffic signs and use of nonstandard signs (color and shape)
- The location and spacing of signs and note locations where there are too many signs, or the signs are too close together
- That traffic signs are clearly visible and are prominently displayed to the intended road users For instances where the legibility of the information on traffic signs is inadequate, bearing in mind the speed of vehicles and the amount of information displayed
- For instances where signs contain too much information to be capable of being read by drivers traveling at normal operating speed
- The effectiveness of traffic signs by observing them at night and identifying any lack of reflectorization
- The type of signposts used and record situations where sign posts constitute a fixed roadside hazard or where the use of frangible signposts should be considered
- For cases where there is a lack of clearance to traffic signs
- For situations where traffic signs themselves are obstructing essential "lines of sight" for drivers and pedestrians

Regulatory and Warning Signs

- The appropriate regulatory signs are provided where necessary
- Warning signs have been used only where they are required

Guide and Direction Signs

- That guide and direction signing has been done on a systematic route or regional strategy, that it is logical and meets needs of unfamiliar drivers
- That all important intersections are provided with
  – Advance direction signs
  – Intersection direction signs
  – Reassurance (distance) signs
- That these signs are correctly positioned to allow the required action to be taken by the intended drivers
- Inconsistencies in destination names on consecutive signs
- For instances of poor legibility and poor arrangement of information on signs

Pavement Marking

- The general adequacy and visibility of pavement marking, both at night and in wet weather That the correct type of line marking has been used in the various situations, e.g., "continuity lines" at merge and diverge sections, "double (barrier) lines" where overtaking is to be prohibited, etc.

- For any discontinuities in "through traffic lane" marking and the existence of any "trap" lanes
- For any deficiency in the delineation of merge and diverge areas, including situations where through traffic may inadvertently lead into auxiliary and turn lanes
- For locations where there is a lack of hazard marking at approach ends of islands and medians, etc.
- For locations where auxiliary "turn lanes" have been designated with appropriate pavement arrows and locations where the wrong type of arrow has been used
- For locations where pavement arrows and other markings are confusing to drivers, particularly where "old incorrect" markings have not been properly removed
- That the positioning of "stop" lines and "holding" lines are appropriate
- The justification for any yellow bar marking and record locations where it is inappropriately used (such markings should be rarely used)
- The effectiveness of road markings at night and in wet weather, consider the need for retro-reflective pavement markers or road studs to supplement line and hazard makings; identify inadequate provision of these devices and in the use of nonstandard arrangements of them

Roadside Safety and Landscaping

- The "clear zone width" generally available along both sides of the road, and comment on this aspect in the report
- The "fixed roadside objects" that occur within the "clear zone width" and comment on the need to treat them in the interests of road safety
- The provision of guardrail along the road, consider whether it is really justified and identify locations where it is not justified and locations where it has not been provided where it is warranted
- That the correct treatment has been applied to the ends of guardrail sections, including "soft" end treatments, end anchorage, and approach end flaring
- For the adequacy of "bridge railing" systems on all bridges. Take particular note of inadequate railings that will not restrain an impacting vehicle—this is often the case with bridges
- The treatment of "approach guardrail" to bridges; record situations, where there is no "strong" anchorage of the approach guardrail to the bridge railing system and/or no proper transition of the rigidity of flexible or semi-rigid approach guardrail as it approaches and meets the rigid bridge railing
- That ends of median barriers are properly treated to reduce the severity of possible end collisions; identify the need for "crash cushions" or other impact attenuation devices
- The extent to which trees and other vegetation obstruct driver and pedestrian sight lines, which are essential for safe traffic operation
- The existence of poles of various kinds along the road and comment on whether some or many can be removed, relocated to less hazardous positions
- The degree of hazard associated with large trees, boulders, etc. and whether these can be treated to improve roadside safety

General Traffic Management Items

- To see what, if any, special provisions have been made for motorcycles and comment on the need for the provision of such improvements as "paved shoulders," "segregated motorcycle lanes," or "separated motorcycle roadways" in accordance with any adopted warrants, guides, and practices
- The degree of safety afforded to pedestrians, particularly school children, and record instances where there is a need for special provisions to be made
- The adequacy and credibility of existing speed limits and comment if they are not appropriate to the traffic situation and the nature of abutting development or are otherwise unrealistic in the view of most motorists
- The effectiveness of speed limit signing: consider the need for more prominent signing of the start of "restricted" speed zones and for "reminder signs" within the speed zone, particularly near intersections where large numbers of vehicles enter the road in question from side roads
- Substandard curves and low speed curved sections of the road; consider the need for "positive" advice to motorists about the safe travel speed and consider the need for "advisory curve speed" signing
- The need at substandard curves, for other delineation improvements such as the provision of "guide post" delineation, the placement of "chevron alignment" signs, and the use of retro-reflective road studs The degree of safety afforded to all road users in town centers, particularly where highways pass through shopping centers or near schools, record the need for "traffic calming" techniques to improve safety in these sensitive locations
- The availability of overtaking opportunities along the route as a whole and comment on the need of specific "overtaking lanes" at regular intervals along two-lane undivided roads, particularly where traffic flows are high in hilly terrain
- Consider the need for rest areas and other roadside stopping places, e.g., truck stops, scenic viewpoints, wayside picnic areas, etc., and note any current "unofficial" places where vehicles stop and the degree of hazard that this involves
- The existence of roadside stalls and other roadside business activities within the "right of way" of the road; comment on the relative safety of these and the possible need for formal parking arrangements and other regulatory controls The safety of bus stop locations and provisions for buses to stand clear of traffic lanes; also the need for a street light at these locations for the security and safety of bus patrons
- For any special problems and requirements that may be necessary to improve safety during "festive season" and holiday periods, when traffic demands are heavy and most drivers are relatively unfamiliar with the road

2.11 Exception Report

The Exception Report is a report prepared by the Project Manager of the overseeing authority on each recommendation in the Audit Report proposing that the recommended measures are not implemented (Design Manual for Roads and Bridges, 2003).

The overseeing authority has the responsibility to ensure that all problems raised by the Audit Team are considered (Design Manual for Roads and Bridges, 2003). The overseeing authority may wish to consult the Design Team at this stage (Design Manual for Roads and Bridges, 2003). If the overseeing authority considers any problem raised to be insignificant or that the recommendations made are not adequate given the economic and environmental constraints, the overseeing authority prepares an Exception Report giving reasons and proposing alternative solutions (Design Manual for Roads and Bridges, 2003). If there is more than one exception then each exception is to be considered and approved separately (Design Manual for Roads and Bridges, 2003).

The overseeing authority will provide copies of each approved Exception Report to the Design Team and the Audit Team Leader for action and information respectively (Design Manual for Roads and Bridges, 2003).

Through the construction period following the Stage 2 Audit Report , the Design Team is to keep the overseeing authority informed of all the design changes that are required so that any need for a further Stage 2 Audit can be identified (Design Manual for Roads and Bridges, 2005).

The overseeing authority is responsible for initiating immediate action on all recommendations in the Audit Report and on all approved Exception Reports (Design Manual for Roads and Bridges, 2005). Refer to Annex 2 for an example of an Exception Report.

3. Ranking of High Accident Concentration Sections and Network Safety Ranking

Directive 2008/96/EC of the European Parliament and of the Council of 19 November 2008 on Road Infrastructure Safety Management was transposed into national legislation LN 34 of 2011 New Roads and Road Works Regulations 2011 where Network Safety Ranking and Ranking of High Accident Concentration Sections are defined as follows:

- **Network Safety Ranking**: a method of identifying, analysing and classifying parts of the existing road network according to their potential for safety development and accident cost savings;

- **Ranking of High Accident Concentration Sections**: a method to identify, analyse and rank sections of the road network which have been in operation for more than three years and upon which a large number of fatal accidents in proportion to the traffic flow have occurred.

Malta has the following obligations:

- The ranking of high accidents sections and network safety ranking every three years
- To maintain records of all fatal collisions
- To carry out site visits by qualified staff
- To target remedial measures on a cost/benefit basis.

The identification of hazardous road sections, the careful analysis of accident data and the subsequent design of remedial measures have resulted in considerable safety benefits. The effectiveness of this approach can be further maximized by having a strategic programme of remedial measures based on national accident reduction targets. (Asian Development Bank, 1998)

The stages of the process to improve and address hazard locations on the road network are as follows (Asian Development Bank, 1998):

- A correct accident database
- Establishing a hazard location improvement programme
- Accident analysis to identify black spots
- Design of remedial measures
- Implementation of remedial measures
- Monitoring the effectiveness of the implemented remedial measures.

3.1 Identification of Road Sections with a High Accident Concentration

The number of road accidents increases as the number of vehicles on the road increase (Asian Development Bank, 1998). Accidents typically can cost a country 2 % of its gross domestic product and such can be improved by establishing a system to reduce accidents (Asian Development Bank, 1998). The most effective methodology is to establish a system based on research and a realistic approach for long-term accident reduction targets supported by the appropriate institutional arrangements and annual budgets (Asian Development Bank, 1998).

Accidents on the road network have resulted to be clustered at specific locations and are not generally randomly distributed (Asian Development Bank, 1998). The study of accidents at such clustered locations may yield accident patterns and trends or engineering features which, with the adequate upgrading measure, could prevent a repeat of such accident.

The reporting by the police and the accuracy of the police report will ensure the determination of where accidents cluster and will thus enable the preparation of a priority list of hazardous locations which require an intervention. This is carried out by ranking accident locations by actual accident numbers, injury accident numbers or a weighting system to take account of the severity (Asian Development Bank, 1998). Further analysis will be required those accident types which would respond to specific remedial interventions since not all identified accident blackspots would have easily determining patterns which can be improved (Asian Development Bank, 1998).

An **accident blackspot** is defined in road safety management as a place where accidents are concentrated (World Road Association PIARC Technical Committee, 2007). Without the exact location of a road accident, engineers are not able to locate and effectively address the accident blackspots on their road network. Inaccurate localisations results in misguided identifications and result in the loss of financial means and time. The effective evaluation of implemented remedial measures can also be impaired (World Road Association PIARC Technical Committee, 2007).

The actual determination of a 'BLACKSPOT' depends on local conditions. In determining such location is it important to use the same time duration and to be consistent in the section of length of road to establish the cluster within the same road classification (Asian Development Bank, 1998). In the United Kingdom, an accident black spot for treatment are as follows (M. Goodge, 2009):

- Urban junctions with more than 5 injury accidents in previous 3 years;
- Rural junctions with more than 5 injury accidents in previous 5 years;
- Any rural bend with more than 3 wet skid accidents in last year;
- Any residential area with more than 3 pedestrian injury accidents in previous year.

3.2 Analysis of Accident BlackSpots

Accident Reduction strategies at Accident Blackspot locations are classified as follows:

- Black spot: addressing specific types of accidents at a specific location where many accidents occur (Asian Development Bank, 1998)
- Mass action plans: identification of sites with a common accident problem and apply a tried and tested remedial measure or scheme (Asian Development Bank, 1998)
- Route Action Plans: identify a route with a high accident rate and apply a tried and tested remedial measure or scheme (Asian Development Bank, 1998)
- Area-Wide Schemes: apply various measures or schemes across a village (Asian Development Bank, 1998).

At the early stages of the identification and action process to address accident locations, black spot programmes are generally adopted followed by mass action plans, route action plans and area-wide schemes (Asian Development Bank, 1998).

When the accident locations for investigation and analysis have been determined, the investigation is carried out based on the following (Asian Development Bank, 1998):

- A preliminary analysis of the accident data is carried out to establish the accident types, conditions and criteria. Collision Diagrams are a useful tool. Refer ANNEX 3. (Asian Development Bank, 1998).
- A site investigation is carried out by accident investigators to establish the exact conditions at the location (Asian Development Bank, 1998).
- A detailed Accident Analysis is carried out (Asian Development Bank, 1998).

The accident ranking is carried out for single sites and/or for links as follows:

- Single Sites and Junctions
  - collision numbers for the past three years
  - and/or weighting of Killed and Seriously Injured (KSi) Casualties
  - and/or weighting of Vulnerable Road Users (VRU)
- Links
  - collisions/km for the past three years
  - and/or weighting of Killed and Seriously Injured (KSi) Casualties
  - and/or weighting of Vulnerable Road Users (VRU)
  - and/or collision rates (collisions per 10 million vehicle km)

Table 3 : The Weighting used for the Ranking of Accident Locations

Type of Injury	Weighting
Fatal	5
Grievous	5
Slight	1

3.3 Accident Types

The accident type outlines the maneuvers or conflict situations which result in an accident. The conflict situation which resulted in an accident determines the accident type (World Road Association PIARC Technical Committee, 2007).

The classification of accidents according to common features into several groups facilitates and defines the investigation process (World Road Association PIARC Technical Committee, 2007). Hence, in accident analysis, groups of accidents are identified and assessed according to their occurrence and the types of collision (World Road Association PIARC Technical Committee, 2007). The following is a non-exhaustive list of examples of accident types used in Germany. Refer ANNEX 3. (World Road Association PIARC Technical Committee, 2007):

- **Driving Accident** (World Road Association PIARC Technical Committee, 2007)
  An accident in which the driver loses control of the vehicle because he or she was driving at a speed which was inappropriate for the layout, the cross-section, the incline or the conditions of the road, or because he or she did not realise how the road was laid out or that there was a change in the cross-section until it was too late. Driving accidents are not always "one-party accidents" in which the vehicle leaves the road. They can also result in a collision with other road users.

- **Turning-off Accident** (World Road Association PIARC Technical Committee, 2007)
  Turning-off accidents are those triggered by a conflict between a vehicle turning off a road user traveling in the same or the opposite direction. This can happen at junctions and intersections with roads, at field tracks or cycle tracks, or at entrances to properties/car parks.

- **Turning-into/Crossing Accident** (World Road Association PIARC Technical Committee, 2007)
  An accident triggered by conflict between a vehicle which is obliged to give way, turning into a road or crossing the path of other traffic, and a vehicle which has right of way, is referred to as a "turning-into/crossing accident". This can happen at junctions and intersections with roads, field/cycle tracks or at entrances to properties/car parks.

- **Crossing-over Accident** (World Road Association PIARC Technical Committee, 2007)
  An accident is triggered by conflict between a pedestrian crossing the road, and a vehicle, provided the vehicle had not just turned off a road. This rule applies irrespective of whether the accident occurred at a site without any special pedestrian-crossing facilities or at a zebra crossing, a light-controlled crossing or similar installation.

- **Accident caused by Stopping/Parking** (World Road Association PIARC Technical Committee, 2007)
  An "accident caused by stopping/parking" is an accident triggered by conflict between a vehicle in moving traffic and a vehicle which is parked (parking) or has stopped (is stopping) on the road. Such accidents include accidents in which the moving traffic conflicted with a vehicle maneuvering into/out of a parking position. It does not matter whether stopping/parking was permitted.

- **Accident in longitudinal traffic** (World Road Association PIARC Technical Committee, 2007)
  An "accident in longitudinal traffic" is an accident triggered by a conflict between road users moving in the same or opposite directions, provided the conflict is not the result of a maneuvers the corresponds to another accident type.

- **Other Accidents** (World Road Association PIARC Technical Committee, 2007)
  These accidents are all those which cannot be assigned to any other accident type. The basic groups are subsequently divided according to the relevant conflict events into more detailed categories, using the graphical symbols for easier understanding as listed in Annex 4 and Annex 5 which show the Signs and Symbols used in Collision Diagrams and the Vehicle Movement Codes respectively.

3.4 Collision Investigation

The minimum amount of data required to ensure that road engineers have the necessary information for basic accident investigation is as follows (World Road Association PIARC Technical Committee, 2007):

- Police sketch
- Turning movement of road users
- Road surface condition
- Lighting conditions
- Accident identification
  (accident reference number given by Malta Police)
- Time, date and day of week
- Location
- Accident type
- Number and Type of Vehicles involved
- Accident fatalities and/or injuries within 24 hour/30days
- Any damages to property.

This accident information enables a basic evaluation of the level of safety of the road is relation to other road or sections (World Road Association PIARC Technical Committee, 2007). The information provides the road engineer the necessary data to identify locations which have higher accident frequencies, and provides basic data of the possible accident causation factors (World Road Association PIARC Technical Committee, 2007).

The following data provides accident investigators with the road infrastructure information required for the specific accident location. Such data still needs to be supported by a site investigation which may evidence other factors and criteria which might not have been obvious from the accident data desk study analysis (World Road Association PIARC Technical Committee, 2007).

It is also encouraged to use control data to make comparisons between light and dark, wet and dry and before and after scenarios to determine the probability that an accident occurs under such conditions due to random fluctuation. It is to be noted that the size of the control data is to be at least 10 times the number in the sample and be locally representative. Refer to Annex 7.

The set of data can include features as follows (World Road Association PIARC Technical Committee, 2007):

- Road description
  (tangential section, type of intersection, road number, road category, cross section…)
- Specific places/objects
  (Pedestrian crossing, rail crossing, bridge, tunnel, bus/tram stop, parking place, petrol station…)
- Road alignment
  (evident deficiency or not, slope, narrowing…)
- Road surface
  (type, permanent state, actual conditions)
- Road signing and marking
  (availability, condition, location, …)
- Road obstacles
  (tree, column, bridge…)
- Visibility conditions
  (clear, limited by alignment, vegetation, obstacles…)
- Weather condition
  (dry, fog, rain, …)
- Traffic control
  (traffic lights, road signs, policeman)
- Position of accident
  (travel direction of involved participants, locations – traffic lane, shoulder, roadside, …)
- Main causes of accident
  (speeding, overtaking, right of way …)

The acquisition of other vehicle and driver specific data is desirable within the parameters permissible by law according to the Data Protection Act. Such data includes road and traffic data to enable a more detailed and precise investigation as follows (World Road Association PIARC Technical Committee, 2007):

- The driver (category of licence, sex, age, nationality)

- Impairment of the driver (alcohol, drugs, others…)
- Condition of the driver (alert, tired, impulsive, sudden indisposition, suicidal, …)
- Use of restraint devices (helmets, safety belt, child seat…)
- Condition of the pedestrian (alert, impaired by alcohol/drugs, …)
- Behavior of the pedestrian (proper, faulty, poor estimation of vehicle movement, sudden entry to the road…)
- Brand make of vehicle
- Vehicle operator (private, commercial, public transport…)
- Year of production of the vehicle.

3.5 Detailed Accident Analysis

The basis for the accident analysis is the accident type classification made according to the road accident typology (World Road Association PIARC Technical Committee, 2007). It is also necessary to involve other characteristics in the analysis as follows (World Road Association PIARC Technical Committee, 2007):

- Increased road accidents in wet conditions (or other difficult adhesion conditions),
- Increased road accidents at night or dusk,
- Accidents that involve only certain vehicle types (exclusively or predominantly motorcycles, heavy vehicles, busses,…)
- Accidents that occur during a certain time period (e.g. at darkness, dusk, in winter, summer, at sunrise, sunset, on a certain day of the week, etc.).

When the collision diagrams have been prepared, a detailed site inspection at the accident site and the monitoring of traffic are important (World Road Association PIARC Technical Committee, 2007). The amassing of accident types reduces the range of possible road defects which the engineer must focus on during the site inspection (World Road Association PIARC Technical Committee, 2007).

3.6 Parameters for Safety Evaluation

The amount and level of severity of road accidents on sections of the road network depend on average daily traffic volumes and the traffic composition, the design features (cross section, junction type and form, and alignment), the roadside furnishings (roadside design, traffic sign, protective facilities, traffic installations and markings), the road condition (structure and surface condition), and the roadside environment (lateral obstacles) (World Road Association PIARC Technical Committee, 2007). The level of safety of the road section is defined by the accident rate and accident cost (World Road Association PIARC Technical Committee, 2007). The Accident Rates is defined as the average number of accidents along a road section with a 'kilometrage' of 1 million vehicle km (World Road Association PIARC Technical Committee, 2007). The Accident Cost Rate is defined as the corresponding average costs to the economy as a whole, as the result of road accidents which have occurred along this road section with a 'kilometrage' of 1000 vehicle km (World Road Association PIARC Technical Committee, 2007).

3.7 Design and Implementation of Remedial Measures

The main aim to design remedial measures is to address the principle accident cause and avoid a repeat of such. Such remedial measures may include (Asian Development Bank, 1998):

- Addressing the conflict points which are the cause of the accident problem
- Improving the road conditions to improve the awareness of road users
- Reducing speeds to reduce the accident risk and the accident severity.

Annex 4 lists typical accident causation factors with proven remedial measures which have shown to be effective in developing and industrialised countries (Asian Development Bank, 1998).

Further remedial measures which may be applied in urban areas are (Asian Development Bank, 1998 and Directive 2008/96/EC):

- Turning prohibitions, channelisation or protected turning maneuvers
- Traffic signals, roundabouts or revised priority intersections
- Refuges, pedestrian crossings, over- and under-passes, upgrading of existing infrastructure
- Segregated cycle lanes or creating of cycle lanes
- Parking restrictions or controls
- Speed limits and/or enforcement
- Traffic calming
- removing or protecting fixed roadside obstacles
- reducing speed limits and intensifying local speed enforcement
- improving visibility under different weather and light condition
- improving safety condition of roadside equipment such as road restraint systems
- improving coherence, visibility, readability and position of road markings (incl. application of rumble strips), signs and signals
- protecting against rock falling
- improving grip/roughness of pavements
- redesigning road restraint systems
- providing and improving median protection
- changing the overtaking layout
- improving junctions, including road/rail level crossings
- changing alignment
- changing width of road, adding hard shoulders
- installing traffic management and control systems
- reducing potential conflict with vulnerable road users
- upgrading the road to current design standards
- restoring or replacing pavements
- using intelligent road signs

- improving intelligent transport systems and telematics services for interoperability, emeregency and signage purposes.

3.8 Traffic Calming

Traffic calming is an important aspect in accident remedial measures and it results in both environmental and accident reduction improvements (Asian Development Bank, 1998).

Traffic Calming is defined as the improvements of the traffic scenario through a reduction in speeds and possibly a reduction in vehicular traffic volumes, especially in urban areas, with a particular focus on vulnerable road users (Asian Development Bank, 1998).

Research has shown that when pedestrians are traveling at a specific speed (Asian Development Bank, 1998):

- 95% survive at speeds up to 32 km/h
- 55% survive at speeds up to 48 km/h
- 15% survive at speeds up to 65 km/h.

The use of traffic calming measures to manage and reduce speeds can have a marked effect in reducing accident severity. Annex 8 and Annex 9 list the most commonly used speed management and traffic calming measures.

Traffic Calming is effective for area-wide schemes especially in urban areas (Asian Development Bank, 1998). However, traffic calming is also increasingly being used on rural roads especially on the approaches to urban areas (Asian Development Bank, 1998).

The use of Traffic Calming measures is one way of addressing the increased road safety issues that occur when major road are upgraded (Asian Development Bank, 1998). Vehicle speeds tend to increase substantially with the result of increased death and injury accidents (Asian Development Bank, 1998).

4. Road Safety Inspections

Maltese Legislation LN 34 of 2011 defines a Road Safety Inspection as an ordinary periodical verification of the characteristics and defects that require maintenance works for reasons of safety.

The aim of the Road Safety inspection is to highlight the particularities of a specific road and/or junctions, the surrounding area and the environment that can influence road user behaviour or affect his passive safety and thus have adverse impacts on road safety (Demarche ISRI, 2008). The Road Safety Inspection is pro-active, trying to prevent accidents through the identification of safety deficiencies for remedial action rather than responding to recorded crashes.

The Road Safety Inspection applies to existing roads and it differs from a Road Safety Audit which is usually carried out on a new project or the redevelopment of an existing road (Demarche ISRI, 2008) or where there is the potential risk of an accident occurring. Such inspection is separate from the operating visit made by assigned maintenance groups which is usually related to the deterioration of the carriageway, related installations, restraint systems, signs, etc.

The objective of the approach is to provide the entity responsible for road safety with a tool to improve the safety on the roads by developing structured vigilance (Demarche ISRI, 2008). The approach is preventive, simple and practical, recurrent and systematic and at the initiative of and for the benefit of the entity responsible (Demarche ISRI, 2008) and framework of such inspections is based on:

- An inspection being carried out every 3-5 years on the national road network
- Inspections in road works
- Inspection Team is to be headed by trained personnel
- A formal report is to be prepared.

The Irish Road Safety Inspection Draft Procedures define the Road Safety Inspections as a systematic, on site review, conducted by road safety experts, of an existing road or section of road to identify hazardous conditions, faults and deficiencies that may lead to serious accidents. Road Safety Inspections are seen as part of the overall Road Safety Management process (TMS Consultancy, 2011).

The Road Safety Inspection procedure follows the following steps (Demarche ISRI, 2008):

- STEP 1: Scheduling of inspections
- STEP 2: Preparation of the inspection visit
- STEP 3: road safety inspection visit
- STEP 4: communication of observations
- STEP 5: examination of inspection report
- STEP 6: report of the overseeing authority
- STEP 7: monitoring and evaluation

4.1 STEP 1: Scheduling of inspections

The Road Safety Inspection Team determines the inspections required based on a schedule of works or the team may be requested by the overseeing authority to carry out such inspection for a specific section of road.

The itinerary for a Road Safety Inspection is to include (Demarche ISRI, 2008):

- The exact extent of the road section where the inspection is to be carried out
- The period when the inspection is to be carried out taking into account school times, building sites, traffic peak hour, etc.
- Any necessary measures to be taken for inspector safety
- Documents required for the inspection including maps, traffic information, road status, etc.
- Vehicle and equipment required.

4.2 STEP 2: Preparation for the Inspection Visit

An appreciative amount of time is required for the proper preparation for the site visit and reporting.

A layout plan is to be prepared to ensure that local features are well reported. Other specific data is also to be available including:

- Traffic flow and percentages of heavy vehicles
- Status of the road
- Any special events occurring or road works planned.

The inspection visit is prepared by the Road Safety Inspection Team and the inspectors need to (Demarche ISRI, 2008):

- Plan in detail and define the extent of the inspections
- Check the safety equipment: car equipped with flashing light, high visibility safety clothing and a hazard triangle
- Procure the logistics resources: digital camera, report templates, geographical map of area, mobile phone.

4.3 STEP 3: Road Safety Inspection Visit

The inspection visit is intended to identify the most important aspects concerning road safety criteria in relation to the infrastructure, the environment, signage and road markings and consistency of these criteria in relation to road usage (Demarche ISRI, 2008). The visit is not intended to be exhaustive and does not need to make reference to standards or regulations (Demarche ISRI, 2008).

The checklist outlining the criteria which serve as a basis for evaluating the safety of a road is attached in Annex 10.

Profile of the Road Safety Inspector

The Road Safety Inspectors need to be familiar with the roads and with road infrastructure safety to be in a position to identify shortcomings (Demarche ISRI, 2008). Inspectors need to have qualifying training to learn about the methodology to be used and to focus on the challenges of the approach (Demarche ISRI, 2008). The training is not designed to have an inspector being a road safety specialist and nor to have the inspector seeking out non-compliance with regulations (Demarche ISRI, 2008).

Procedure

The inspector is to note any circumstances as guided by the checklist (Refer Annex 10). Inspection visits are carried out by car (Demarche ISRI, 2008). Stops may be required at specific locations for the taking of photographs, making observations, noting, etc… Inspectors may need to re-trace their steps to note further details (Demarche ISRI, 2008). It is important that during the inspection, each type of road users with their specific field of visions and trajectory, be considered and examined by the inspectors (Demarche ISRI, 2008).

During the Road Safety Inspection, the inspector needs to (Demarche ISRI, 2008):

- Move within the traffic flow to record information correctly
- Use the equipment and information at his disposal
- Stop when necessary
- Avoid inspections in bad weather, at peak traffic flow times and during special events.

4.4 STEP 4: Communication of Observations

Following the site inspection, the Road Safety Inspectors prepare a report for the entire inspection. The report comprises three main sections including maps (Demarche ISRI, 2008):

- PART 1: Includes details of the road inspected, the Site Inspection Team, dates, time and conditions during the inspection visit.
- PART 2: Description of the road safety hazards identified including photos and comments on the reason why such conditions pose a hazard to users. Conditions are reported in the direction of travel from the start of the site extents. Conditions noted during the Night Inspection are also included. Certain road safety scenarios might require an analysis of the accidents on the specific section inspected from reports prepared by the police.
- PART 3: Summary of report findings and recommendations.
- Annexes to include photos, diagrams and maps as required.

4.5 STEP 5: Examination of the Inspection Report

The Inspection Report serves as the basis for the preparation of an Action Plan to implement the recommendations of the Inspection Report.

Evaluation of the Site Inspection Report

The evaluation consists of (Demarche ISRI, 2008):

- Examination of the comments and recommendations in the Site Inspection Report
- Verifying any questionable statements and/or recommendations
- Structuring comments with respect to the site.

To verify certain statements or parts of the Inspection Report, a second site visit might be required and the findings be discussed with the Road Safety Inspection Team.

4.6 STEP 6: Report of the Overseeing Authority

On the basis of the conclusions of the Site Inspection Report, the overseeing authority will strive to provide an appropriate response to each section of such report leading to a plan of action.

The plan of action is to be scheduled taking into account interconnecting issues as follows (Demarche ISRI, 2008):

- Deadlines for each stage of implementation
- Scheduling of any additional site visits required
- Classification of measures based on safety impact being addressed
- Classification of measures based on the responsibility for the action especially in the case of local council roads
- Classification of actions into categories namely actions of:
    - normal maintenance
    - actions requiring a brief site study
    - actions requiring specific financing and re-design
    - actions which do not require a follow-up.

4.7 Monitoring and Evaluation

The monitoring of the Site Inspection Report and action taken is to be followed up by (Demarche ISRI, 2008):

- the scheduling of site inspections with the objective of repeating the inspections every three years
- the review of the implementation of the site inspection visits

- scheduling of remedial measures.

The Road Safety Inspections are evaluated in relation to (Demarche ISRI, 2008):
- the improved knowledge of the overseeing authority as a result of the inspections carried out
- development of road safety monitoring by the overseeing authority
- improvement and maintenance of the road safety on the roads inspected.

Annex 1: First Year Rate of Return (FYRR)

Worked Example:

A junction is being analysed. The accidents for a period of 3 years were assessed. There were a total of 14 accidents in 4 years. The junction will cost 30,000Euros to be upgraded. If the average cost per accidents per year is 35,842 Euros and the proposed scheme will reduce accidents by 50%, what is the first year rate of return?

50% accident reduction of a total of 14 accidents = 7

Cost of 7 accidents = 7 x 35842 = 250,894Euros

$$\text{FYRR (\%)} = \frac{\text{annual collision savings} \times 100}{\text{Cost of scheme}}$$

$$= (250894 \times 100) / (30000 \times 4)$$

$$= 209\%$$

Result:

- For each 1 euro spent to upgrade the junction, you get 2.09Euros savings
- For a FYRR of 209%, the scheme will pay for itself within 6 months

Note:

- For a FYRR of 100%, the scheme would pay for itself within 1 year
- For a FYRR of 50%, the scheme would pay for itself within 2 years

Annex 2: Example of an Exception Report

WSP

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DATE 09 June 2006

REF Bath Western Riverside,
Outline Planning Application
Road Safety Audit – Stage 1 Report:
(Mouchel Parkman report ref: 745865/R001A)

Exception Report

Introduction

This Exception Report is prepared in response to the Road Safety Audit – Stage 1 report prepared by Mouchel Parkman, (report ref: 745865/R001/A), commissioned by WSP Development and Transportation, dated May 2006. The Road Safety Audit was undertaken for access arrangements proposed for a primarily residential development at the Western Riverside site in central Bath.

This Exception Report takes each of the identified 'problems' in the Mouchel Parkman report, and sets out WSP's agreement or otherwise with the issues raised. For ease of reference, the same paragraph numbering has been used as applied in the Safety Audit report.

2.0 ITEMS RAISED IN THIS STAGE 1 AUDIT

2.1 TEMPORARY ACCESS – Drawing 0010286/C001/04

2.1.1.1 PROBLEM

Location: *Vehicular exit from the filling station.*

Summary: *The exit from the filling station may be too steep.*

RECOMMENDATION

Check the vertical alignment and ensure that it is acceptable.

Exception:

The potential for an improved link road through from Pines Way was considered during the planning process associated with the introduction of the Petrol Filling Station. At that time it was BaNES policy to protect the corridor from Pines Way through to Windsor Bridge Road via the disused railway embankment for a new road that would have relieved Lower Bristol Road of through traffic. The design of the access arrangements to the Petrol Filling Station took into account the potential introduction of the relief road proposals at a later date. The current Pines Way access proposals are very similar to the previous relief road proposals in the vicinity of the Petrol Filling Station. The owners of the Petrol Filling Station are aware of the development and the need to steepen the accesses in and out of the forecourt.

It is accepted that the exit ramp from the forecourt will be steeper than that normally permitted on a public highway. However, this is believed to be manageable and during the detailed design process every effort will be made to reduce the steepness of the alignment and to provide a smooth transition between the forecourt, the access and the public highway.

2.1.2.1 PROBLEM

Location: *Exit from the Homebase service yard.*

Summary: *The view to the right may be restricted by vegetation.*

RECOMMENDATION

Keep a sight line clear back as far as the junction with Victoria Bridge Road (north).

Exception:
Sight lines from all access and egresses will be approved by and designed to comply with Local Highway Authority standards.

2.1.3.1 PROBLEM

Location: *Pedestrian route through the filling station.*

Summary: *An observed pedestrian route does not seem to be catered for.*

RECOMMENDATION

Provide an informal crossing point near cross section B-B and a link across to the pedestrian / cycle link at Victoria Bridge Road.

Exception:
The pedestrian route identified during the Audit is not a recognised public footway or right of way as it crosses the Petrol Filling Station forecourt which is private property. Therefore the proposed design should not encourage this route due to landownership issues and the potential of endangering pedestrians when crossing the forecourt. It is also considered that the increased vehicle activity at and in the vicinity of the junction of the Homebase service yard will discourage pedestrians from using this route and crossing at this location.

In this scenario, pedestrians are more likely to use Victoria Bridge Road and cross the proposed site access road slightly further to the west. The need for an informal crossing at this location and an additional footway link to Victoria Bridge Road will be considered as part of the detailed design process.

2.1.3.2 PROBLEM

Location: *Junctions with (1) the vehicular exit from the Filling Station and (2) the access to the Homebase service yard.*

Summary: *No provision has been made for drop kerb crossings of the two side roads.*

RECOMMENDATION

Provide drop kerb and tactile paving pedestrian crossing points at both accesses.

Exception:
A dropped kerb crossing complete with tactile paving will be installed on the filling station exit. Subject to landownership and highway boundaries a dropped kerb crossing with tactile paving will also be installed on the Homebase service yard access. See revised drawing No 0010286/C001 rev 07 for details.

2.1.4.1 PROBLEM

Location: *Right turn lane access to Homebase service yard.*

Summary: *Although no signs are shown, it may help to mark "SUPERSTORE" on the carriageway.*

RECOMMENDATION

Mark "SUPERSTORE" on the carriageway in the right turn lane.

Exception:
The legality of members of the public using this access to gain entry to the Homebase car park is being reviewed. Following completion of this review, detail design and consultation with the developer of the Western Riverside site and Homebase, the recommendation to add the suggested road marking will be considered or an alternative sought.

2.2 NORTH ACCESS AT MIDLAND ROAD – Drawing 1158/SK/05F

2.2.1.1 PROBLEM

Location: *Westbound traffic from the City.*

Summary: *Squeezing in two lanes for westbound traffic restricts the space in the middle of the junction.*

RECOMMENDATION

Remove the left turn lane from the City centre to leave a single lane. Consider installing a centre island instead of the left turn lane to assist pedestrians to cross the road. This would be particularly useful as the cycle time is very long.

Exception:
The junction layout has been amended to suit the comments made as indicated on the attached plan number 1158/SK/05G. The left turn lane for westbound Upper Bristol Road traffic has been removed with the westbound through lane moving closer to the southern kerb line. This 'straightens' the through movements and reduces the potential for conflict with right turning traffic into Midland Road.

An island has also been introduced to the east of the junction to assist the pedestrian crossing movement of Upper Bristol Road.

2.2.2.1 PROBLEM

Location: *Midland Road exit from the new development.*

Summary: *Cyclists will need to be detected by the signals as there is a low traffic flow leaving BWR.*

RECOMMENDATION

Ensure that waiting cyclists can be detected by the traffic signal system.

Exception:
It is proposed that Above Ground Detectors be fitted to the signal pole facing the BWR exit thereby allowing cyclists waiting in the Advanced Cycle Reservoir to be detected.

2.2.2.2 PROBLEM

Location: *Midland Road*

Summary: *Cyclists approaching the junction may join the carriageway in front of a vehicle.*

3

RECOMMENDATION

Get the cyclists to join the carriageway further back on the shared use section and keep them on the carriageway.

Exception:
The transfer between footway/cycleway and carriageway previously proposed has been removed as shown on the latest access drawing (1158/SK/05G).

It is proposed that the on site pedestrian, cycle and road network will be designed along the principles of 'shared space' with this extending to within approximately 25m of the junction with Upper Bristol Road. It will therefore be possible for cyclists to join the main carriageway in advance of the transition from shared space thereby avoiding the need for a formal transfer from the footway/cycleway close to the junction.

2.2.3.1 PROBLEM

Location: *North side of Upper Bristol Road.*

Summary: *The existing trees overhanging the footway may obstruct the view of the traffic signals.*

RECOMMENDATION

Remove sufficient vegetation to enable the signal heads and signs to be clearly seen.

Exception:
The need or otherwise to remove overhanging vegetation will be fully considered at the detailed design stage. If required, negotiations will be held with the appropriate BaNES departments to ensure that suitable levels of visibility to the signal heads are achieved.

2.3 SOUTH ACCESS AT LOWER BRISTOL ROAD – Drawing 1158/SK/15C

2.3.1.1 PROBLEM

Location: *City centre side of the junction.*

Summary: *Vehicles servicing the local businesses need access provision.*

RECOMMENDATION

Consider the service arrangements for the local businesses and provide for them wherever possible.

Exception:
The junction layout has been amended to suit the comments raised in the Safety Audit as shown on the attached plan number 1158/SK/15D. The length and width of the right turn lane to Dorset Close have been increased to enable easier access to the Bath Press site whether via the service yard entrance or Dorset Close itself. Access arrangements to the public house and other local businesses not included within the development area will remain the same as existing and are not considered to be adversely affected by the new access junction.

2.3.1.2 PROBLEM

Location: *Right turn lane into Dorset Close.*

Summary: *The right turn lane is only 2.5m wide.*

4

RECOMMENDATION

Provide yellow box markings at the junction in both directions to keep the traffic flowing and to allow safe movements to take place.

Exception:
Although not shown on plan number 1158/SK/15D, it would be possible to provide yellow box markings as recommended. These will be incorporated as part of the detailed design process.

2.3.3.1 PROBLEM

Location: *Footway on the south side of Lower Bristol Road.*

Summary: *The existing footway is narrow.*

RECOMMENDATION

Widen the footway by moving the main road northwards.

Exception:
Plan number 1158/SK/15D identifies that the southern footway has been widened to a minimum 1.8m width through the junction by moving the main road northwards. This width is considered appropriate to allow safe pedestrian passage past the various signal poles.

2.3.3.2 PROBLEM

Location: *Central islands in Lower Bristol Road.*

Summary: *Pedestrians may have to wait on the islands before continuing across the road.*

RECOMMENDATION

Increase the island width in Lower Bristol Road east and the access road to 3.0m and introduce a stagger in the crossings. Delete the crossing over the western arm of Lower Bristol Road as a signalised crossing cannot be provided in the proposed staging.

Exception:
The latest plan identifies that the width of all three islands has been increased to 3m with a stagger introduced as per the recommendation. The crossing of the western Lower Bristol Road arm has not been removed at this stage as it is considered that an early cut off for the westbound Lower Bristol Road traffic within Stage 1 of the signals would allow pedestrians to cross safely as required.

It should be noted that the principal pedestrian desire line across Lower Bristol Road is likely to be at the eastern arm of the junction linking the BWR development to Dorset Close and catering for pedestrian movements between the site and Oldfield Park railway station, to and from the local schools etc. The demand for crossing to the west of the junction is likely to be low and as such the need for a crossing in this location will be reconsidered as part of the detailed design process.

2.4 BUS GATE – Drawing 1158/SK/13C

2.4.1.1 PROBLEM

Location: *Bus crossing of Windsor Bridge Road.*

Summary: *Cyclists may not be detected by the traffic signal system.*

6

RECOMMENDATION

Provide yellow box markings at the junction in both directions to keep the traffic flowing and to allow safe movements to take place.

Exception:
Although not shown on plan number 1158/SK/15D, it would be possible to provide yellow box markings as recommended. These will be incorporated as part of the detailed design process.

2.3.3.1 PROBLEM

Location: *Footway on the south side of Lower Bristol Road.*

Summary: *The existing footway is narrow.*

RECOMMENDATION

Widen the footway by moving the main road northwards.

Exception:
Plan number 1158/SK/15D identifies that the southern footway has been widened to a minimum 1.8m width through the junction by moving the main road northwards. This width is considered appropriate to allow safe pedestrian passage past the various signal poles.

2.3.3.2 PROBLEM

Location: *Central islands in Lower Bristol Road.*

Summary: *Pedestrians may have to wait on the islands before continuing across the road.*

RECOMMENDATION

Increase the island width in Lower Bristol Road east and the access road to 3.0m and introduce a stagger in the crossings. Delete the crossing over the western arm of Lower Bristol Road as a signalised crossing cannot be provided in the proposed staging.

Exception:
The latest plan identifies that the width of all three islands has been increased to 3m with a stagger introduced as per the recommendation. The crossing of the western Lower Bristol Road arm has not been removed at this stage as it is considered that an early cut off for the westbound Lower Bristol Road traffic within Stage 1 of the signals would allow pedestrians to cross safely as required.

It should be noted that the principal pedestrian desire line across Lower Bristol Road is likely to be at the eastern arm of the junction linking the BWR development to Dorset Close and catering for pedestrian movements between the site and Oldfield Park railway station, to and from the local schools etc. The demand for crossing to the west of the junction is likely to be low and as such the need for a crossing in this location will be reconsidered as part of the detailed design process.

2.4 BUS GATE – Drawing 1158/SK/13C

2.4.1.1 PROBLEM

Location: *Bus crossing of Windsor Bridge Road.*

Summary: *Cyclists may not be detected by the traffic signal system.*

6

RECOMMENDATION

Ensure the cycles are also detected to allow them to cross safely, or provide a safe means for them to cross the road. If they are to use the signals to the north of the bus gate, then the route for cyclists should be smoothed (on the west side of the road).

Exception:
The plan provided merely identified a potential arrangement for the bus gate to highlight how BaNES ambitions for the Bus Rapid Transit system could integrate with the BWR development. It is not proposed that the BWR development provide the bus gate. The detailed design of the bus gate will be developed by BaNES following approval of the Bath Major Scheme Bid.

Notwithstanding the above it is considered that cycle crossing movements should be made at the island to the north of the junction. An average waiting time of 2.5 minutes associated with the bus rapid transit services is likely to constitute too long a wait for cyclists yet reducing the cycle time to accommodate cyclists at a controlled crossing is likely to have an adverse impact on the road junctions at either end of Windsor Bridge Road. It is suggested therefore that the cycle crossing be uncontrolled with cyclists taking advantage of gaps in the traffic to cross the road in two halves. This would of course be made easier by the regular passing of the rapid transit buses thereby stopping the traffic on Windsor Bridge Road.

2.4.1.2 PROBLEM

Location: *Footway on the eastern side of Windsor Bridge Road.*

Summary: *The footway diverts to the east at the bus gate. Pedestrians are likely to use a more direct route.*

RECOMMENDATION

Reduce the length of the diversion of the footway. Move the stop line westwards, but ensure the signals can be seen by buses approaching from the east. It is understood that the existing difference in level will be eased.

Exception:
As discussed above, the design of the bus gate will be led by BaNES and will evolve over time. It has yet to be determined whether the bus route itself will be controlled by traffic signals, rising bollards or be gated with the final choice determining where best to encourage pedestrians to cross. The principle of minimising the length of the pedestrian diversion will however be followed through.

7

Annex 3: Road Accidents Typology Catalogue

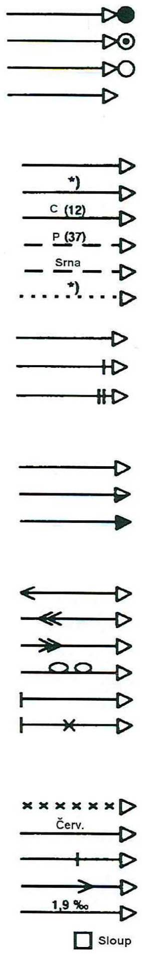
(World Road Association PIARC Technical Committee, 2007)

Figure 1 : Road Accidents Typology Catalogue

Annex 4: Signs and Symbols Used In Collision Diagrams

(Asian Development Bank, 1998)

SIGNS AND SYMBOLS USED IN COLLISION DIAGRAMS



Accident consequences
Death of a person
Seriously injured person
Slightly injured person
Material damage accident

Types of vehicles or road users
Personal vehicle
Other motor vehicle
Cyclist (age)
Pedestrian (age)
Domestic or wild animal
Indirect accident participant *)

Road surface condition
Dry
Wet
Ice, frost, snow

Light conditions
Daylight
Dusk, dim light, dawn
Darkness

Specific movement
Reversing
Slowing
Accelerating
Skidding or aquaplaining
Stopped due to outside conditions
Stopped, parked

Other information
Traffic signals off
Red, red + amber, amber
Driver was aware of right of way
Driver was unaware of right of way
Drinking
Obstacle on road or at roadside

*) Type of vehicle or road user (excl. passenger cars) are shown on the arrow stick. The following abbreviations are used: N (heavy vehicle), NS (Truck-trailers or Semi-trailers), BUS (bus), MOTO (motorcycle), MOP (moped), C (cyclist), P (pedestrian), TRAM (tram), T (tractor). Other road users are shown with spelled words (towed vehicles, handcart, production machinery)

Figure 2 : Signs and Symbols in Collision Diagrams

Annex 5: Vehicle Movement Codes Used In New Zealand

(World Road Association PIARC Technical Committee, 2007)

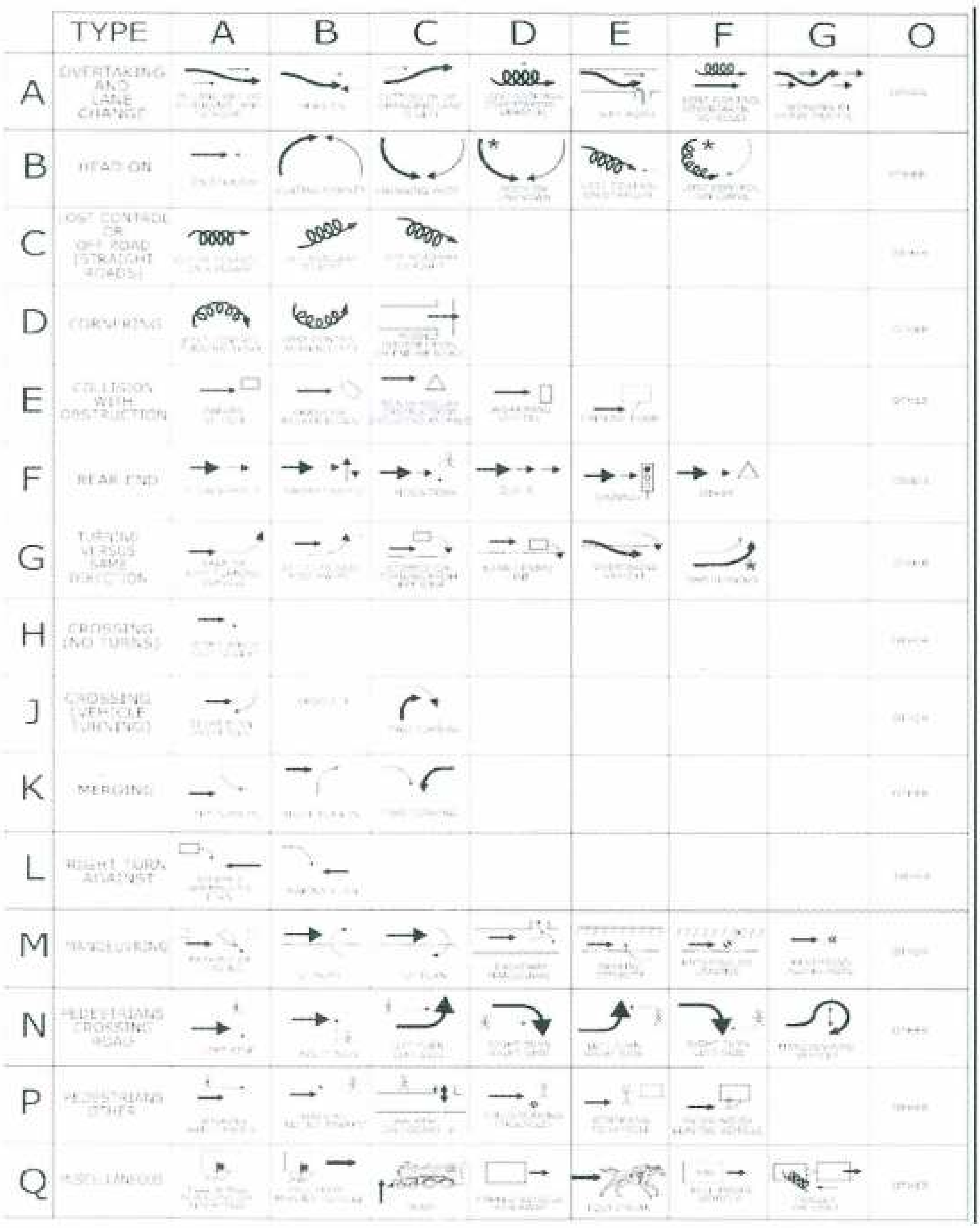


Figure 3 : Vehicle Movement Codes used in New Zealand

Annex 6: Possible Links among Accidents Types, Cause Of Accident and Lead Deficiency

(World Road Association PIARC Technical Committee, 2007)

Type Group 0
Personal road accidents

Major Accidents Causes
Speeding

Road Deficiency
Non-homogeneous roadways, sudden changes in road arrangements, sudden changes in road alignment, poor optical alignment, inappropriate road cross-section, sudden change of road surface, poor quality of road surface.

Potential Improvements Measures
Removal of non-homogeneous road sections, improved optical parameters of horizontal curves, corrected road cross-section, reconstruction of road surfaces, speed reduction measures, appropriate road signing and marking.

Type Group 1
Road accidents of vehicles driving in the same direction outside of junctions

Major Accidents Causes
Speeding

Road Deficiency
Major difference in vehicle speeds, short following distances between vehicles, inappropriate horizontal and vertical road alignment, poor distance estimation, poor road surface.

Potential Improvements Measures
Construction measures to reduce speed, road reconstruction, reconstruction of road surface, appropriate road signing and marking.

Type Group 2
Road accidents of oncoming vehicles outside of intersections

Major Accident Causes
Speeding, illegal or inadvisable overtaking.

Road Deficiency
Non-homogeneous road, optical illusions, poor distance estimation, inappropriate road signing and marking.

Potential Improvements Measures
Construction measures to reduce speeds, road reconstruction (greater visual distance of oncoming vehicles in horizontal curves), reconstruction of road surface, appropriate road signing and marking.

Type Group 3
Road accidents of vehicles entering junction from the same corridor.

Major Accident Causes
High speed of vehicles entering junctions, insufficient lane width distance between vehicles, blind angles.

Road Deficiency
Inappropriate junction layouts, ambiguous channelization – inappropriate guidance in junctions, single-track vehicles (motorcycles, ect.) overtaking in junctions.

Potential Improvement Measures
Easily decipherable junction layouts, consistent road marking and signing with conspicuous design information, or construction measures (e.g. traffic islands) delineating vehicle paths.

Type Group 4
Road accidents of vehicles entering intersections from opposite corridors.

Major Accident Causes
Failure to give way to oncoming vehicles, psychological pressure on drivers, erroneous speed and distance estimations of incoming vehicles.

Road Deficiency
Inappropriate intersections layout, ambiguous channelisation – inappropriate guidance information.

Potential Improvement Measures
More decipherable junction layout, consistent road marking delineating vehicle paths, installation of turning lanes (particularly for left turning), traffic signal installation.

Type Group 5
Road accidents of vehicles entering junction form neighbouring corridors.

Major Accident Causes
The high speed of vehicles entering intersections, insufficient sight distance, effects of psychological rights of way, failure to comply with traffic light signals in traffic-controlled intersections.

Road Deficiency
Inappropriate intersection layout, contradiction between actual and psychological right of way, obstacles in sight triangles, poor intersections lightning, ambiguous

channelization – inappropriate guidance at intersections, obscured road signs, insufficient visibility of road signs.

Potential Improvement Measures
More conspicuous intersection layout, consistent road marking or construction measures (e.g. traffic islands) delineating vehicle paths, installations of clear road signing and marking.

Type Group 6
Accidents between vehicles and pedestrians.

Major Accident Causes
Failure of drivers or pedestrians to comply with traffic light signals, insufficient optical contact, disrespect for pedestrian rights of way, forcing the right of way inappropriately.

Road Deficiency
Insufficient layout of pedestrian pavement and crossings, insufficient separation of pedestrians from motorised traffic, missing pavement width, missing refuge islands.

Potential Improvements Measures
Sensible layout of pedestrian pavements and crossings at heavy pedestrian traffic sites, installation of refuge islands to protect pedestrians, construction measures to improve visibility, traffic calming at the perimeters of pedestrian zones.

Type Group 7
Road accidents with standing parked vehicles.

Major Accident Causes
Driver inattention, inappropriate location of parking sites and their exists.

Roar Deficiency
Inappropriate widths of road shoulders and parking lanes, inappropriate location of parking site exits, poor cycle lane geometry.

Potential Improvement Measures
Better separation of moving and standing vehicles, minimized number of parking site exists and their concentration on single collector roads.

Type Group 8
Road accidents with animals and rail vehicles.

Major Accident Causes
Failure to apply with warning light signals announcing oncoming rail vehicles.

Road Deficiency
Existence of crossing at grade on roads with high traffic volumes, insufficient sight distances, faulty warning light signals, insufficient fencing to prevent animals from the road.

Potential Improvement Measures

Building of grade-separated crossing of roads and railways, upgrading technological equipment at railways crossing, improved sight distance, installation of fences along roads at sites of higher animal traffic, building bio-corridors.

Annex 7: Comparative Testing

As adapted from the TMS Consultancy Course Notes for Road Safety Engineering and Road Safety Audit

Poisson Test

Example:

Table 4 : Comparative Testing - Poisson Test

Year	Number of Accidents
1	1
2	0
3	5

Long Term Average (µ) = (1 + 0 + 5)/3 = 2

What is the likelihood of getting 5 collisions when the long term average is 2 ?

- Go to the Poisson Tables – Single Factor Values
- Go to the column where µ = 2 and take the value for the x = 5
- From tables, the chance of 5 collisions occurring is 0.0361 = 3.6%

What is the likelihood of getting 5 or more collisions ?

- Go to the Poisson Tables – Cumulative Factor Values
- Go to the column where µ = 2 and take the value for the x = 5
- From tables, the chance of getting 5 or more collisions is 0.0526 = 5.26%

Significance Level	Confidence Level %	Interpretation
1	99	Highly acceptable
5	95	Acceptable
10	90	Fair
20	80	Indicative

Result:

- **There is a 3.6% likelihood of having 5 collisions purely by chance**
- **There is a 96.4% confidence that there is a real change in the collision at this location which value is interpreted as being an acceptable level of confidence.**
- **There is a 5.26% likelihood of having 5 or more collisions purely by chance**
- **There is a 94.74% confidence that there is a real change in the collision at this location which value is interpreted as being an acceptable level of confidence.**

POISSON PROBABILITIES - SINGLE FACTOR VALUES

the greek figure "mu" represents the average annual no. of accidents occurring at the site over a number of years

x	μ 0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
0	0.9048	0.8187	0.7408	0.6703	0.6065	0.5488	0.4966	0.4493	0.4066	0.3679
1	0.0905	0.1637	0.2222	0.2681	0.3033	0.3293	0.3476	0.3595	0.3659	0.3679
2	0.0045	0.0164	0.0333	0.0536	0.0758	0.0988	0.1217	0.1438	0.1647	0.1839
3	0.0002	0.0011	0.0033	0.0072	0.0126	0.0198	0.0284	0.0383	0.0494	0.0613
4	0	0.0001	0.0003	0.0007	0.0016	0.003	0.005	0.0077	0.0111	0.0153
5	0	0	0	0.0001	0.0002	0.0004	0.0007	0.0012	0.002	0.0031
6	0	0	0	0	0	0	0.0001	0.0002	0.0003	0.0005
7	0	0	0	0	0	0	0	0	0	0.0001

x denotes the no of accidents observed in the latest year's data

values within the table represent the probabilty of obtaining the latest year's data purely by random fluctuation

x	μ 1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2
0	0.3329	0.3012	0.2725	0.2466	0.2231	0.2019	0.1827	0.1653	0.1496	0.1353
1	0.3662	0.3614	0.3543	0.3452	0.3347	0.323	0.3106	0.2975	0.2842	0.2707
2	0.2014	0.2169	0.2303	0.2417	0.251	0.2584	0.264	0.2678	0.27	0.2707
3	0.0738	0.0867	0.0998	0.1128	0.1255	0.1378	0.1496	0.1607	0.171	0.1804
4	0.0203	0.026	0.0324	0.0395	0.0471	0.0551	0.0636	0.0723	0.0812	0.0902
5	0.0045	0.0062	0.0084	0.0111	0.0141	0.0176	0.0216	0.026	0.0309	0.0361
6	0.0008	0.0012	0.0018	0.0026	0.0035	0.0047	0.0061	0.0078	0.0098	0.012
7	0.0001	0.0002	0.0003	0.0005	0.0008	0.0011	0.0015	0.002	0.0027	0.0034
8	0	0	0.0001	0.0001	0.0001	0.0002	0.0003	0.0005	0.0006	0.0009
9	0	0	0	0	0	0	0.0001	0.0001	0.0001	0.0002

x	μ 2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3
0	0.1225	0.1108	0.1003	0.0907	0.0821	0.0743	0.0672	0.0608	0.055	0.0498
1	0.2572	0.2438	0.2306	0.2177	0.2052	0.1931	0.1815	0.1703	0.1596	0.1494
2	0.27	0.2681	0.2652	0.2613	0.2565	0.251	0.245	0.2384	0.2314	0.224
3	0.189	0.1966	0.2033	0.209	0.2138	0.2176	0.2205	0.2225	0.2237	0.224
4	0.0992	0.1082	0.1169	0.1254	0.1336	0.1414	0.1488	0.1557	0.1622	0.168
5	0.0417	0.0476	0.0538	0.0602	0.0668	0.0735	0.0804	0.0872	0.094	0.1008
6	0.0146	0.0174	0.0206	0.0241	0.0278	0.0319	0.0362	0.0407	0.0455	0.0504
7	0.0044	0.0055	0.0068	0.0083	0.0099	0.0118	0.0139	0.0163	0.0188	0.0216
8	0.0011	0.0015	0.0019	0.0025	0.0031	0.0038	0.0047	0.0057	0.0068	0.0081
9	0.0003	0.0004	0.0005	0.0007	0.0009	0.0011	0.0014	0.0018	0.0022	0.0027
10	0.0001	0.0001	0.0001	0.0002	0.0002	0.0003	0.0004	0.0005	0.0006	0.0008
11	0	0	0	0	0	0.0001	0.0001	0.0001	0.0002	0.0002
12	0	0	0	0	0	0	0	0	0	0.0001

Figure 4 : Poisson Probabilities - Single Factor Values

x	μ 3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4
0	0.045	0.0408	0.0369	0.0334	0.0302	0.0273	0.0247	0.0224	0.0202	0.0183
1	0.1397	0.1304	0.1217	0.1135	0.1057	0.0984	0.0915	0.085	0.0789	0.0733
2	0.2165	0.2087	0.2008	0.1929	0.185	0.1771	0.1692	0.1615	0.1539	0.1465
3	0.2237	0.2226	0.2209	0.2186	0.2158	0.2125	0.2087	0.2046	0.2001	0.1954
4	0.1733	0.1781	0.1823	0.1858	0.1888	0.1912	0.1931	0.1944	0.1951	0.1954
5	0.1075	0.114	0.1203	0.1264	0.1322	0.1377	0.1429	0.1477	0.1522	0.1563
6	0.0555	0.0608	0.0662	0.0716	0.0771	0.0826	0.0881	0.0936	0.0989	0.1042
7	0.0246	0.0278	0.0312	0.0348	0.0385	0.0425	0.0466	0.0508	0.0551	0.0595
8	0.0095	0.0111	0.0129	0.0148	0.0169	0.0191	0.0215	0.0241	0.0269	0.0298
9	0.0033	0.004	0.0047	0.0056	0.0066	0.0076	0.0089	0.0102	0.0116	0.0132
10	0.001	0.0013	0.0016	0.0019	0.0023	0.0028	0.0033	0.0039	0.0045	0.0053
11	0.0003	0.0004	0.0005	0.0006	0.0007	0.0009	0.0011	0.0013	0.0016	0.0019
12	0.0001	0.0001	0.0001	0.0002	0.0002	0.0003	0.0003	0.0004	0.0005	0.0006
13	0	0	0	0	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002
14	0	0	0	0	0	0	0	0	0	0.0001

x	μ 4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5
0	0.0166	0.015	0.0136	0.0123	0.0111	0.0101	0.0091	0.0082	0.0074	0.0067
1	0.0679	0.063	0.0583	0.054	0.05	0.0462	0.0427	0.0395	0.0365	0.0337
2	0.1393	0.1323	0.1254	0.1188	0.1125	0.1063	0.1005	0.0948	0.0894	0.0842
3	0.1904	0.1852	0.1798	0.1743	0.1687	0.1631	0.1574	0.1517	0.146	0.1404
4	0.1951	0.1944	0.1933	0.1917	0.1898	0.1875	0.1849	0.182	0.1789	0.1755
5	0.16	0.1633	0.1662	0.1687	0.1708	0.1725	0.1738	0.1747	0.1753	0.1755
6	0.1093	0.1143	0.1191	0.1237	0.1281	0.1323	0.1362	0.1398	0.1432	0.1462
7	0.064	0.0686	0.0732	0.0778	0.0824	0.0869	0.0914	0.0959	0.1002	0.1044
8	0.0328	0.036	0.0393	0.0428	0.0463	0.05	0.0537	0.0575	0.0614	0.0653
9	0.015	0.0168	0.0188	0.0209	0.0232	0.0255	0.0281	0.0307	0.0334	0.0363
10	0.0061	0.0071	0.0081	0.0092	0.0104	0.0118	0.0132	0.0147	0.0164	0.0181
11	0.0023	0.0027	0.0032	0.0037	0.0043	0.0049	0.0056	0.0064	0.0073	0.0082
12	0.0008	0.0009	0.0011	0.0013	0.0016	0.0019	0.0022	0.0026	0.003	0.0034
13	0.0002	0.0003	0.0004	0.0005	0.0006	0.0007	0.0008	0.0009	0.0011	0.0013
14	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002	0.0003	0.0003	0.0004	0.0005
15	0	0	0	0	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002

x	μ 5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	6
0	0.0061	0.0055	0.005	0.0045	0.0041	0.0037	0.0033	0.003	0.0027	0.0025
1	0.0311	0.0287	0.0265	0.0244	0.0225	0.0207	0.0191	0.0176	0.0162	0.0149
2	0.0793	0.0746	0.0701	0.0659	0.0618	0.058	0.0544	0.0509	0.0477	0.0446
3	0.1348	0.1293	0.1239	0.1185	0.1133	0.1082	0.1033	0.0985	0.0938	0.0892
4	0.1719	0.1681	0.1641	0.16	0.1558	0.1515	0.1472	0.1428	0.1383	0.1339
5	0.1753	0.1748	0.174	0.1728	0.1714	0.1697	0.1678	0.1656	0.1632	0.1606
6	0.149	0.1515	0.1537	0.1555	0.1571	0.1584	0.1594	0.1601	0.1605	0.1606
7	0.1086	0.1125	0.1163	0.12	0.1234	0.1267	0.1298	0.1326	0.1353	0.1377
8	0.0692	0.0731	0.0771	0.081	0.0849	0.0887	0.0925	0.0962	0.0998	0.1033
9	0.0392	0.0423	0.0454	0.0486	0.0519	0.0552	0.0586	0.062	0.0654	0.0688
10	0.02	0.022	0.0241	0.0262	0.0285	0.0309	0.0334	0.0359	0.0386	0.0413
11	0.0093	0.0104	0.0116	0.0129	0.0143	0.0157	0.0173	0.019	0.0207	0.0225
12	0.0039	0.0045	0.0051	0.0058	0.0065	0.0073	0.0082	0.0092	0.0102	0.0113
13	0.0015	0.0018	0.0021	0.0024	0.0028	0.0032	0.0036	0.0041	0.0046	0.0052
14	0.0006	0.0007	0.0008	0.0009	0.0011	0.0013	0.0015	0.0017	0.0019	0.0022
15	0.0002	0.0002	0.0003	0.0003	0.0004	0.0005	0.0006	0.0007	0.0008	0.0009
16	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002	0.0002	0.0003	0.0003
17	0	0	0	0	0	0.0001	0.0001	0.0001	0.0001	0.0001

Figure 4: Poisson Probabilities – Single Factor Values (cont)

x	μ 6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7
0	0.0022	0.002	0.0018	0.0017	0.0015	0.0014	0.0012	0.0011	0.001	0.0009
1	0.0137	0.0126	0.0116	0.0106	0.0098	0.009	0.0082	0.0076	0.007	0.0064
2	0.0417	0.039	0.0364	0.034	0.0318	0.0296	0.0276	0.0258	0.024	0.0223
3	0.0848	0.0806	0.0765	0.0726	0.0688	0.0652	0.0617	0.0584	0.0552	0.0521
4	0.1294	0.1249	0.1205	0.1162	0.1118	0.1076	0.1034	0.0992	0.0952	0.0912
5	0.1579	0.1549	0.1519	0.1487	0.1454	0.142	0.1385	0.1349	0.1314	0.1277
6	0.1605	0.1601	0.1595	0.1586	0.1575	0.1562	0.1546	0.1529	0.1511	0.149
7	0.1399	0.1418	0.1435	0.145	0.1462	0.1472	0.148	0.1486	0.1489	0.149
8	0.1066	0.1099	0.113	0.116	0.1188	0.1215	0.124	0.1263	0.1284	0.1304
9	0.0723	0.0757	0.0791	0.0825	0.0858	0.0891	0.0923	0.0954	0.0985	0.1014
10	0.0441	0.0469	0.0498	0.0528	0.0558	0.0588	0.0618	0.0649	0.0679	0.071
11	0.0244	0.0265	0.0285	0.0307	0.033	0.0353	0.0377	0.0401	0.0426	0.0452
12	0.0124	0.0137	0.015	0.0164	0.0179	0.0194	0.021	0.0227	0.0245	0.0263
13	0.0058	0.0065	0.0073	0.0081	0.0089	0.0099	0.0108	0.0119	0.013	0.0142
14	0.0025	0.0029	0.0033	0.0037	0.0041	0.0046	0.0052	0.0058	0.0064	0.0071
15	0.001	0.0012	0.0014	0.0016	0.0018	0.002	0.0023	0.0026	0.0029	0.0033
16	0.0004	0.0005	0.0005	0.0006	0.0007	0.0008	0.001	0.0011	0.0013	0.0014
17	0.0001	0.0002	0.0002	0.0002	0.0003	0.0003	0.0004	0.0004	0.0005	0.0006
18	0	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002	0.0002
19	0	0	0	0	0	0	0.0001	0.0001	0.0001	0.0001

x	μ 7.1	7.2	7.3	7.4	7.5	7.6	7.7	7.8	7.9	8
0	0.0008	0.0007	0.0007	0.0006	0.0006	0.0005	0.0005	0.0004	0.0004	0.0003
1	0.0059	0.0054	0.0049	0.0045	0.0041	0.0038	0.0035	0.0032	0.0029	0.0027
2	0.0208	0.0194	0.018	0.0167	0.0156	0.0145	0.0134	0.0125	0.0116	0.0107
3	0.0492	0.0464	0.0438	0.0413	0.0389	0.0366	0.0345	0.0324	0.0305	0.0286
4	0.0874	0.0836	0.0799	0.0764	0.0729	0.0696	0.0663	0.0632	0.0602	0.0573
5	0.1241	0.1204	0.1167	0.113	0.1094	0.1057	0.1021	0.0986	0.0951	0.0916
6	0.1468	0.1445	0.142	0.1394	0.1367	0.1339	0.1311	0.1282	0.1252	0.1221
7	0.1489	0.1486	0.1481	0.1474	0.1465	0.1454	0.1442	0.1428	0.1413	0.1396
8	0.1321	0.1337	0.1351	0.1363	0.1373	0.1381	0.1388	0.1392	0.1395	0.1396
9	0.1042	0.107	0.1096	0.1121	0.1144	0.1167	0.1187	0.1207	0.1224	0.1241
10	0.074	0.077	0.08	0.0829	0.0858	0.0887	0.0914	0.0941	0.0967	0.0993
11	0.0478	0.0504	0.0531	0.0558	0.0585	0.0613	0.064	0.0667	0.0695	0.0722
12	0.0283	0.0303	0.0323	0.0344	0.0366	0.0388	0.0411	0.0434	0.0457	0.0481
13	0.0154	0.0168	0.0181	0.0196	0.0211	0.0227	0.0243	0.026	0.0278	0.0296
14	0.0078	0.0086	0.0095	0.0104	0.0113	0.0123	0.0134	0.0145	0.0157	0.0169
15	0.0037	0.0041	0.0046	0.0051	0.0057	0.0062	0.0069	0.0075	0.0083	0.009
16	0.0016	0.0019	0.0021	0.0024	0.0026	0.003	0.0033	0.0037	0.0041	0.0045
17	0.0007	0.0008	0.0009	0.001	0.0012	0.0013	0.0015	0.0017	0.0019	0.0021
18	0.0003	0.0003	0.0004	0.0004	0.0005	0.0006	0.0006	0.0007	0.0008	0.0009
19	0.0001	0.0001	0.0001	0.0002	0.0002	0.0002	0.0003	0.0003	0.0003	0.0004
20	0	0	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002
21	0	0	0	0	0	0	0	0	0.0001	0.0001

Figure 4: Poisson Probabilities – Single Factor Values (cont)

POISSON PROBABILITIES - CUMULATIVE FACTOR VALUES

the greek figure "mu" represents the average annual no. of accidents occurring at the site over a number of years

	μ									
x	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
0	1	1	1	1	1	1	1	1	1	1
1	0.0952	0.1813	0.2591	0.3297	0.3935	0.4513	0.5035	0.5507	0.5934	0.6321
2	0.0047	0.0176	0.0369	0.0616	0.0902	0.122	0.1559	0.1912	0.2275	0.2642
3	0.0002	0.0012	0.0036	0.008	0.0144	0.0232	0.0342	0.0474	0.0628	0.0803
4	0	0.0001	0.0003	0.0008	0.0018	0.0034	0.0058	0.0091	0.0134	0.019
5	0	0	0	0.0001	0.0002	0.0004	0.0008	0.0014	0.0023	0.0037
6	0	0	0	0	0	0	0.0001	0.0002	0.0003	0.0006
7	0	0	0	0	0	0	0	0	0	0.0001

x denotes the no. of accidents (or more) observed in the latest year's data

values within the table represent the probability of obtaining the latest year's data purely by random fluctuation

	μ									
x	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2
0	1	1	1	1	1	1	1	1	1	1
1	0.6671	0.6986	0.7274	0.7535	0.7768	0.7979	0.8174	0.8347	0.8505	0.8646
2	0.3009	0.3372	0.3731	0.4083	0.4421	0.4749	0.5068	0.5372	0.5663	0.5939
3	0.0995	0.1203	0.1428	0.1666	0.1911	0.2165	0.2428	0.2694	0.2963	0.3232
4	0.0257	0.0336	0.043	0.0538	0.0656	0.0787	0.0932	0.1087	0.1253	0.1428
5	0.0054	0.0076	0.0106	0.0143	0.0185	0.0236	0.0296	0.0364	0.0441	0.0526
6	0.0009	0.0014	0.0022	0.0032	0.0044	0.006	0.008	0.0104	0.0132	0.0165
7	0.0001	0.0002	0.0004	0.0006	0.0009	0.0013	0.0019	0.0026	0.0034	0.0045
8	0	0	0.0001	0.0001	0.0001	0.0002	0.0004	0.0006	0.0007	0.0011
9	0	0	0	0	0	0	0.0001	0.0001	0.0001	0.0002

	μ									
x	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3
0	1	1	1	1	1	1	1	1	1	1
1	0.8776	0.8892	0.8997	0.9094	0.9178	0.9256	0.9329	0.9392	0.945	0.9501
2	0.6204	0.6454	0.6691	0.6917	0.7126	0.7325	0.7514	0.7689	0.7854	0.8007
3	0.3504	0.3773	0.4039	0.4304	0.4561	0.4815	0.5064	0.5305	0.554	0.5767
4	0.1614	0.1807	0.2006	0.2214	0.2423	0.2639	0.2859	0.308	0.3303	0.3527
5	0.0622	0.0725	0.0837	0.096	0.1087	0.1225	0.1371	0.1523	0.1681	0.1847
6	0.0205	0.0249	0.0299	0.0358	0.0419	0.049	0.0567	0.0651	0.0741	0.0839
7	0.0059	0.0075	0.0093	0.0117	0.0141	0.0171	0.0205	0.0244	0.0286	0.0335
8	0.0015	0.002	0.0025	0.0034	0.0042	0.0053	0.0066	0.0081	0.0098	0.0119
9	0.0004	0.0005	0.0006	0.0009	0.0011	0.0015	0.0019	0.0024	0.003	0.0038
10	0.0001	0.0001	0.0001	0.0002	0.0002	0.0004	0.0005	0.0006	0.0008	0.0011
11	0	0	0	0	0	0.0001	0.0001	0.0001	0.0002	0.0003
12	0	0	0	0	0	0	0	0	0	0.0001

Figure 5 : Poisson Probabilities - Cumulative Factor Values

x	μ 3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4
0	1	1	1	1	1	1	1	1	1	1
1	0.955	0.9593	0.9632	0.9667	0.9699	0.9728	0.9753	0.9776	0.9795	0.9817
2	0.8153	0.8289	0.8415	0.8532	0.8642	0.8744	0.8838	0.8926	0.9006	0.9084
3	0.5988	0.6202	0.6407	0.6603	0.6792	0.6973	0.7146	0.7311	0.7467	0.7619
4	0.3751	0.3976	0.4198	0.4417	0.4634	0.4848	0.5059	0.5265	0.5466	0.5665
5	0.2018	0.2195	0.2375	0.2559	0.2746	0.2936	0.3128	0.3321	0.3515	0.3711
6	0.0943	0.1055	0.1172	0.1295	0.1424	0.1559	0.1699	0.1844	0.1993	0.2148
7	0.0388	0.0447	0.051	0.0579	0.0653	0.0733	0.0818	0.0908	0.1004	0.1106
8	0.0142	0.0169	0.0198	0.0231	0.0268	0.0308	0.0352	0.04	0.0453	0.0511
9	0.0047	0.0058	0.0069	0.0083	0.0099	0.0117	0.0137	0.0159	0.0184	0.0213
10	0.0014	0.0018	0.0022	0.0027	0.0033	0.0041	0.0048	0.0057	0.0068	0.0081
11	0.0004	0.0005	0.0006	0.0008	0.001	0.0013	0.0015	0.0018	0.0023	0.0028
12	0.0001	0.0001	0.0001	0.0002	0.0003	0.0004	0.0004	0.0005	0.0007	0.0009
13	0	0	0	0	0.0001	0.0001	0.0001	0.0001	0.0002	0.0003
14	0	0	0	0	0	0	0	0	0	0.0001

x	μ 4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5
0	1	1	1	1	1	1	1	1	1	1
1	0.9833	0.985	0.9863	0.9875	0.989	0.9899	0.9909	0.9916	0.9926	0.9932
2	0.9154	0.922	0.928	0.9335	0.939	0.9437	0.9482	0.9521	0.9561	0.9595
3	0.7761	0.7897	0.8026	0.8147	0.8265	0.8374	0.8477	0.8573	0.8667	0.8753
4	0.5857	0.6045	0.6228	0.6404	0.6578	0.6743	0.6903	0.7056	0.7207	0.7349
5	0.3906	0.4101	0.4295	0.4487	0.468	0.4868	0.5054	0.5236	0.5418	0.5594
6	0.2306	0.2468	0.2633	0.28	0.2972	0.3143	0.3316	0.3489	0.3665	0.3839
7	0.1213	0.1325	0.1442	0.1563	0.1691	0.182	0.1954	0.2091	0.2233	0.2377
8	0.0573	0.0639	0.071	0.0785	0.0867	0.0951	0.104	0.1132	0.1231	0.1333
9	0.0245	0.0279	0.0317	0.0357	0.0404	0.0451	0.0503	0.0557	0.0617	0.068
10	0.0095	0.0111	0.0129	0.0148	0.0172	0.0196	0.0222	0.025	0.0283	0.0317
11	0.0034	0.004	0.0048	0.0056	0.0068	0.0078	0.009	0.0103	0.0119	0.0136
12	0.0011	0.0013	0.0016	0.0019	0.0025	0.0029	0.0034	0.0039	0.0046	0.0054
13	0.0003	0.0004	0.0005	0.0006	0.0009	0.001	0.0012	0.0013	0.0016	0.002
14	0.0001	0.0001	0.0001	0.0001	0.0003	0.0003	0.0004	0.0004	0.0005	0.0007
15	0	0	0	0	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002

x	μ 5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	6
0	1	1	1	1	1	1	1	1	1	1
1	0.994	0.9946	0.9952	0.9953	0.9958	0.9963	0.997	0.9972	0.9974	0.9974
2	0.9629	0.9659	0.9687	0.9709	0.9733	0.9756	0.9779	0.9796	0.9812	0.9825
3	0.8836	0.8913	0.8986	0.905	0.9115	0.9176	0.9235	0.9287	0.9335	0.9379
4	0.7488	0.762	0.7747	0.7865	0.7982	0.8094	0.8202	0.8302	0.8397	0.8487
5	0.5769	0.5939	0.6106	0.6265	0.6424	0.6579	0.673	0.6874	0.7014	0.7148
6	0.4016	0.4191	0.4366	0.4537	0.471	0.4882	0.5052	0.5218	0.5382	0.5542
7	0.2526	0.2676	0.2829	0.2982	0.3139	0.3298	0.3458	0.3617	0.3777	0.3936
8	0.144	0.1551	0.1666	0.1782	0.1905	0.2031	0.216	0.2291	0.2424	0.2559
9	0.0748	0.082	0.0895	0.0972	0.1056	0.1144	0.1235	0.1329	0.1426	0.1526
10	0.0356	0.0397	0.0441	0.0486	0.0537	0.0592	0.0649	0.0709	0.0772	0.0838
11	0.0156	0.0177	0.02	0.0224	0.0252	0.0283	0.0315	0.035	0.0386	0.0425
12	0.0063	0.0073	0.0084	0.0095	0.0109	0.0126	0.0142	0.016	0.0179	0.02
13	0.0024	0.0028	0.0033	0.0037	0.0044	0.0053	0.006	0.0068	0.0077	0.0087
14	0.0009	0.001	0.0012	0.0013	0.0016	0.0021	0.0024	0.0027	0.0031	0.0035
15	0.0003	0.0003	0.0004	0.0004	0.0005	0.0008	0.0009	0.001	0.0012	0.0013
16	0.0001	0.0001	0.0001	0.0001	0.0001	0.0003	0.0003	0.0003	0.0004	0.0004
17	0	0	0	0	0	0.0001	0.0001	0.0001	0.0001	0.0001

Figure 5: Poisson Probabilities – Cumulative Factor Values (cont)

x	μ 6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7
0	1	1	1	1	1	1	1	1	1	1
1	0.9975	0.998	0.9981	0.9984	0.9985	0.9986	0.9987	0.9989	0.9991	0.9989
2	0.9838	0.9854	0.9865	0.9878	0.9887	0.9896	0.9905	0.9913	0.9921	0.9925
3	0.9421	0.9464	0.9501	0.9538	0.9569	0.96	0.9629	0.9655	0.9681	0.9702
4	0.8573	0.8658	0.8736	0.8812	0.8881	0.8948	0.9012	0.9071	0.9129	0.9181
5	0.7279	0.7409	0.7531	0.765	0.7763	0.7872	0.7978	0.8079	0.8177	0.8269
6	0.57	0.586	0.6012	0.6163	0.6309	0.6452	0.6593	0.673	0.6863	0.6992
7	0.4095	0.4259	0.4417	0.4577	0.4734	0.489	0.5047	0.5201	0.5352	0.5502
8	0.2696	0.2841	0.2982	0.3127	0.3272	0.3418	0.3567	0.3715	0.3863	0.4012
9	0.163	0.1742	0.1852	0.1967	0.2084	0.2203	0.2327	0.2452	0.2579	0.2708
10	0.0907	0.0985	0.1061	0.1142	0.1226	0.1312	0.1404	0.1498	0.1594	0.1694
11	0.0466	0.0516	0.0563	0.0614	0.0668	0.0724	0.0786	0.0849	0.0915	0.0984
12	0.0222	0.0251	0.0278	0.0307	0.0338	0.0371	0.0409	0.0448	0.0489	0.0532
13	0.0098	0.0114	0.0128	0.0143	0.0159	0.0177	0.0199	0.0221	0.0244	0.0269
14	0.004	0.0049	0.0055	0.0062	0.007	0.0078	0.0091	0.0102	0.0114	0.0127
15	0.0015	0.002	0.0022	0.0025	0.0029	0.0032	0.0039	0.0044	0.005	0.0056
16	0.0005	0.0008	0.0008	0.0009	0.0011	0.0012	0.0016	0.0018	0.0021	0.0023
17	0.0001	0.0003	0.0003	0.0003	0.0004	0.0004	0.0006	0.0007	0.0008	0.0009
18	0	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0003	0.0003	0.0003
19	0	0	0	0	0	0	0.0001	0.0001	0.0001	0.0001

x	μ 7.1	7.2	7.3	7.4	7.5	7.6	7.7	7.8	7.9	8
0	1	1	1	1	1	1	1	1	1	1
1	0.9991	0.9993	0.9993	0.9994	0.9994	0.9995	0.9995	0.9995	0.9997	0.9996
2	0.9932	0.9939	0.9944	0.9949	0.9953	0.9957	0.996	0.9963	0.9968	0.9969
3	0.9724	0.9745	0.9764	0.9782	0.9797	0.9812	0.9826	0.9838	0.9852	0.9862
4	0.9232	0.9281	0.9326	0.9369	0.9408	0.9446	0.9481	0.9514	0.9547	0.9576
5	0.8358	0.8445	0.8527	0.8605	0.8679	0.875	0.8818	0.8882	0.8945	0.9003
6	0.7117	0.7241	0.736	0.7475	0.7585	0.7693	0.7797	0.7896	0.7994	0.8087
7	0.5649	0.5796	0.594	0.6081	0.6218	0.6354	0.6486	0.6614	0.6742	0.6866
8	0.416	0.431	0.4459	0.4607	0.4753	0.49	0.5044	0.5186	0.5329	0.547
9	0.2839	0.2973	0.3108	0.3244	0.338	0.3519	0.3656	0.3794	0.3934	0.4074
10	0.1797	0.1903	0.2012	0.2123	0.2236	0.2352	0.2469	0.2587	0.271	0.2833
11	0.1057	0.1133	0.1212	0.1294	0.1378	0.1465	0.1555	0.1646	0.1743	0.184
12	0.0579	0.0629	0.0681	0.0736	0.0793	0.0852	0.0915	0.0979	0.1048	0.1118
13	0.0296	0.0326	0.0358	0.0392	0.0427	0.0464	0.0504	0.0545	0.0591	0.0637
14	0.0142	0.0158	0.0177	0.0196	0.0216	0.0237	0.0261	0.0285	0.0313	0.0341
15	0.0064	0.0072	0.0082	0.0092	0.0103	0.0114	0.0127	0.014	0.0156	0.0172
16	0.0027	0.0031	0.0036	0.0041	0.0046	0.0052	0.0058	0.0065	0.0073	0.0082
17	0.0011	0.0012	0.0015	0.0017	0.002	0.0022	0.0025	0.0028	0.0032	0.0037
18	0.0004	0.0004	0.0006	0.0007	0.0008	0.0009	0.001	0.0011	0.0013	0.0016
19	0.0001	0.0001	0.0002	0.0003	0.0003	0.0003	0.0004	0.0004	0.0005	0.0007
20	0	0	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0003
21	0	0	0	0	0	0	0	0	0.0001	0.0001

Figure 5: Poisson Probabilities – Cumulative Factor Values (cont)

Chi-Square (x^2) Test

Example:

Table 5 : CHi-Square (x^2) Test Example

	Site	**Control**	**Total**
Dark	10 a	70 c	80 g
Light	5 b	165 d	170 h
Total	15 e	235 f	250 N

$$x^2 = [\,(|ad - bc| - N/2)^2 N\,] / efgh = 7.2$$

What is the probability that an accident occurs in the dark due to random fluctuation ?

- Go to the Chi 2 Distribution Tables
- For a value of v = 1, find the closest value of x^2 = 7.2
- Read off the probability value α = between 0.01 and 0.005, hence between 1% and 0.5%

Result:

- **The probability that there is an accident occurring during the dark due to random fluctuation is less than 1%**
- **There is a 99% of a real difference is risk between site and control and this value is interpreted as being a highly acceptable level of confidence.**

THE CHi2 DISTRIBUTION

"alpha" is the probability of obtaining that value through random fluctuation

α =	0.995	0.99	0.98	0.975	0.95	0.9	0.8
ν = 1	0.0000393	0.000157	0.000628	0.000982	0.00393	0.0158	0.0642

v=1 is the calculated Chi squared value

α =	0.75	0.7	0.5	0.3	0.25	0.2	0.1
ν = 1	0.102	0.148	0.455	1.074	1.323	1.642	2.706

↑ x^2

α =	0.05	0.025	0.02	0.01	0.005	0.001
ν = 1	3.841	5.024	5.412	6.635	7.879	10.827

Figure 6 : The CHi2 Distribution

Annex 8: Toolbox for Road Safety Interventions

- Pedestrian Crossing and Raised Pedestrian Crossing
- School Ahead Warning Signs and Road Markings
- Pedestrian Railings and U-Bars
- Pedestrian Footways
- Cycle Lanes
- Provision for Alighting/Boarding
- One-Ways and Access Restrictions
- Traffic Mirrors
- Rumble Strips

Pedestrian Crossing and Raised Pedestrian Crossing

Aims of Measure:
To improve road safety by provide a safe crossing area

Implementation of Measure:

- identification of the road crossing based on a pedestrian behavioral setting survey
- implementation of the pedestrian crossing including all signage and carriageway markings as per standard specifications
- the measure may include pedestrian railings as required
- anti-skid material may be applied on the immediate approach to the pedestrian crossing
- The types of pedestrian crossings used are as follows, thus:

Table 6 : Pedestrian Crossing Characteristics

Type of Crossing	Characteristics
Zebra	• Path across a road where pedestrians may cross; • Marked with black and white stripes; • White zig-zag lines for 15metres before the crossing; • Give-way line at 1000mm from the crossing; • Black and white poles with flashing orange beacons (Belisha); • Minimum of 200metres between successive crossings; • For 50km/h road speed the minimum visibility is 65m; • For 65km/h road speed the minimum visibility is 100m; • For 80km/h road speed the minimum visibility is 150m; • For road widths greater than 11m, a refuge island should be constructed and must include a lighted bollard at each end; • A staggered refuge layout is optional where the carriageway is between 11m – 15m wide, but is essential for carriageways greater than 15m; • On roads with a speed greater than 55km/h, additional primary signals should be provided.
Pelican	• Signal-controlled crossing; • Operated by pedestrians; • White zig-zag lines for 15metres before the crossing; • Minimum of 200metres between successive crossings; • For 50km/h road speed the minimum visibility is 65m; • For 65km/h road speed the minimum visibility is 100m; • For 80km/h road speed the minimum visibility is 150m; • For road widths greater than 11m, a refuge island should be constructed and must include a lighted bollard at each end; • A staggered refuge layout is optional where the carriageway is between 11m – 15m wide, but is essential for carriageways greater than 15m; • On roads with a speed greater than 55km/h, additional primary signals should be provided.

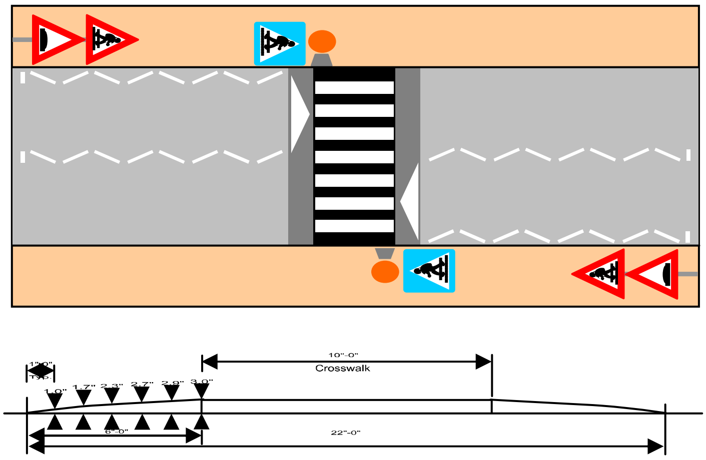


Figure 7 : Raised Zebra Crossing

Warning Signs and Road Markings

Aims of Measure:
To improve road safety by providing advance warning signs and road markings to vehicular drivers on the approach to hazardous locations

Implementation of Measure:
- identification of the hazardous location
- determination of the location of the appropriate signage road markings

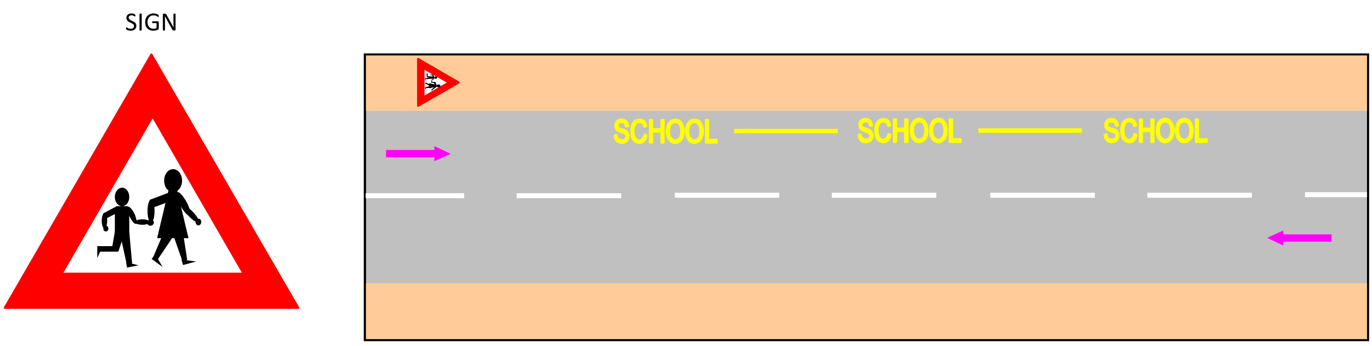


Figure 8 : Road Markings / Approach to School

Pedestrian Railings and U-Bars

Aims of Measure:
To improve road safety by implementing measures which guide pedestrians to specific safe locations.

Implementation of Measure:
- identification of potential hazardous locations based on a pedestrian behavioral settings survey
- identification of location/s for the implementation of the pedestrian railings/U-Bars and their extent
- implementation of measure

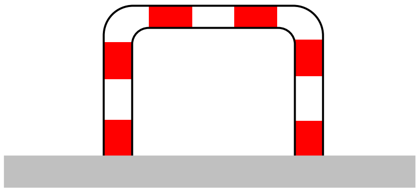


Figure 9 : Pedestrian U-Bar

Figure 10 : Pedestrian Railing

Pedestrian Footways

Aims of Measure:
To improve road safety by ensuring the provision of safe pedestrian walkways

Implementation of Measure:

- survey of existing pedestrian walkways on the approach to the hazardous location
- identification of sections of the existing pedestrian footways which require repairs
- identification of missing sections of footways
- removal of any obstructions on existing footways
- in very narrow roads where the construction of a pedestrian footway is not permitted, a 600-800mm wide pedestrian priority strip, defined by a continuous white edge line with WALKING MAN emblem at 10meter centre-to-centre maximum spacing, is recommended

Figure 11 : Pedestrian Footways Emblem

Cycle Lanes

Aims of Measure:
To improve road safety by ensuring the provision of cycle lanes

Implementation of Measure:
- implementation of modal choice survey
- analysis of modal choice survey
- identify the roads used for cycling
- identification of sections of the existing approach roads where it is safe to include a cycle lane
- identification of any necessary repair works to the road surface
- implementation of cycle lane

General Criteria for Route Selection and Planning

The selection of the cycle route depends on various factors and based on the following analysis, thus:
- Identification of bicycle trip generation within a 5 –10km circuit;
- The linking of scenic, recreational and functional potential of the route to promote its use in the broadest sense;
- Identification of routes that are free from heavy traffic and are well surfaced;
- Identification of parking areas, both for passenger vehicles and for bicycles, along the route;
- Identification of areas with climate extremes, such as wing traps;
- Mapping and investigating the route conditions, including:
  - Uphill gradients/distance ratios;
  - Potential for uninterrupted cycle routes;
  - Available width to accommodate the cycle route and all necessary signage, lighting and resting areas;
  - Identification of nodes of vehicular conflict and physical barriers.

Recommended Widths for Cycle Routes

The following table outlines the recommended width for various classification and usage of cycle routes, hence:

Table 7 : Recommended Widths for Cycle Routes

ROUTE	WIDTH (metres)
Cycle Lanes	
One Way	1.00-2.00
Two Way	1.50-3.60

Design Elements

The main points of design are as follows, thus:
- Surface materials are to be durable and easy to maintain;
- The pavement and bikeway is to have positive drainage with a minimum of 2% cross-slope. All drainage structures are to be located off the cyclepath;

- Traffic control/ information systems facilitate the use of the cyclepath. These include signage and pavement markings and are to be as follows, thus:
  - Sign posts are to be set-back a minimum of 900mm from the edge of the path and any bottom sign edge should be set at 1.5 – 2.1metres above the finished level of the path to allow for adequate visibility;
  - Signage is to be kept at a minimum;
  - Signs are to be used to mark out and delineate routes, to regulate the path usage, and provide all necessary safety/approach warnings.
- Adequate lighting and street furniture is to be installed along the paths and at intersections. The criteria are as follows:
  - Lighting is to be from 6 – 10 lux;
  - The location of lighting and street furniture is to be according to a fixed design to act as embellishment;
  - All street furniture is to be set-back from the cycle path so as to prevent points of conflict.

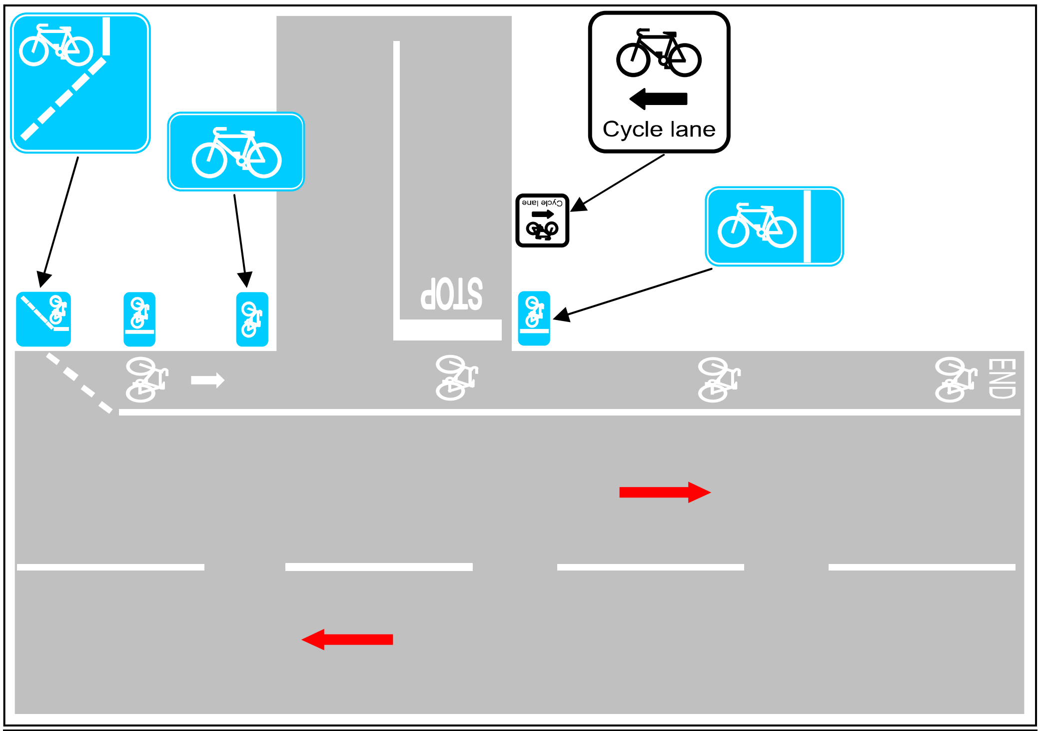


Figure 12 : Typical Signage Layout for Cycle Routes

One-Ways and Access Restrictions

Aims of Measure:
To improve road safety by managing the traffic volumes and direction on the road network

Implementation of Measure:

- survey of existing traffic patterns and traffic volumes in the area

- identification of streets which can be made one-way
- identification of streets which may be closed off for vehicular traffic
- identification of adequate alternative routes to support one-way systems and/or road closures
- identification of any necessary upgrading measures at junctions to support one-way systems and/or road closures
- re-design and implementation of road signage to support one-way systems and/or road closures
- a road closure is not recommended if such would result in traffic circulation problems in the locality since such would create other road safety hazards in itself

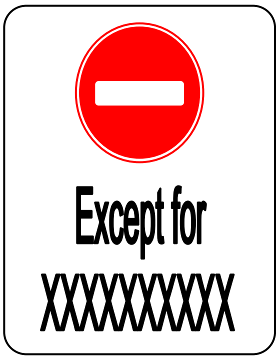


Figure 13 : One – Way or Restricted Access Sign

Traffic Mirrors

Aims of Measure:
To improve road safety by improving visibility lines

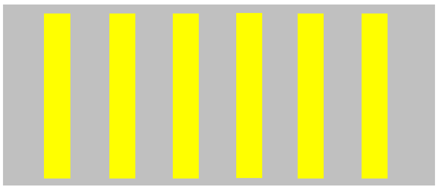
Implementation of Measure:
- analysis of existing traffic patterns in the area
- analysis of visibility lines at sensitive locations
- identification of locations where traffic mirrors are required
- the placing of the traffic mirror is not to create prejudice is created to third party rights
- The mirror is to be located at the standard height in relation to the finished footway level
- The mirror is to be angled such that appropriate and maximum visibility is obtained

Rumble Strips

Aims of Measure:
To alert the driver that he is approaching a traffic sensitive area

Implementation of Measure:

- survey of existing traffic patterns and traffic volumes in the area
- identification of locations where rumble strips can be effective
- Rumble strips are to be located at 200m on the approach to the traffic sensitive area;
- the length of the rumble strips depends on the width of the road;
- for the safety of cyclists, a clear gap of 75mm-1000mm is to be left between the rumble strips and the footway;
- for rumble strips sited 200m away from a residential area, they are not to exceed 10mm in height and no vertical face is to exceed 6mm in height;
- for rumble strips sited within a residential area, they are not to exceed 5mm in height and no vertical face is to exceed 4mm in height;



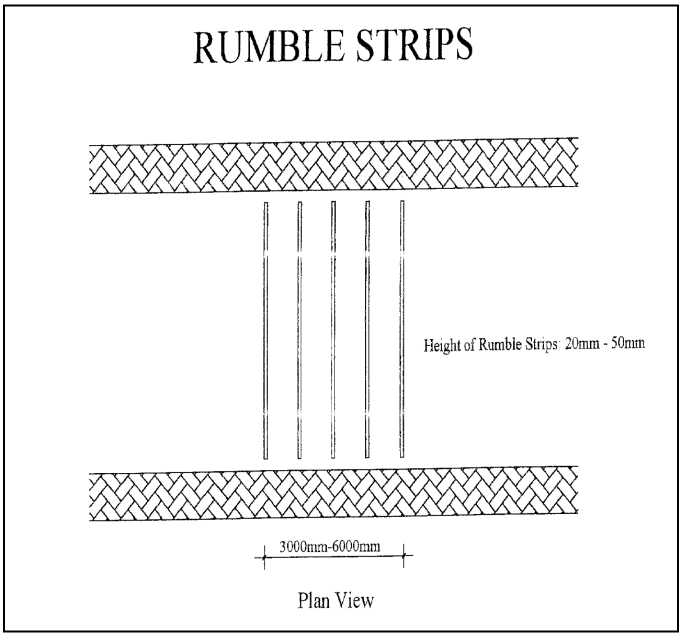


Figure 14 : Rumble Strips

Annex 9: Toolbox for Speed Control Measures

- Speed Limit
- Dragons' Teeth
- Yellow Bar Markings
- Round Topped Road Humps
- Road Thumps
- Build-outs/Pinch Points
- Chicanes
- Mini Roundabout and Traffic Islands
- Speed Cushions
- Lane Narrowing
- Gateways

Traffic Calming: Speed Limit

Aims of Measure:
To improve road safety by reducing the vehicle speeds

Implementation of Measure:

- identification of the main school routes and the extent of the area of influence
- determination of the revised speed limit
- implementation of SPEED LIMIT sign, repeater signs and the corresponding END OF SPEED LIMIT sign
- implementation of speed roundels
- implementation of REDUCE SPEED NOW signs
- SLOW road markings

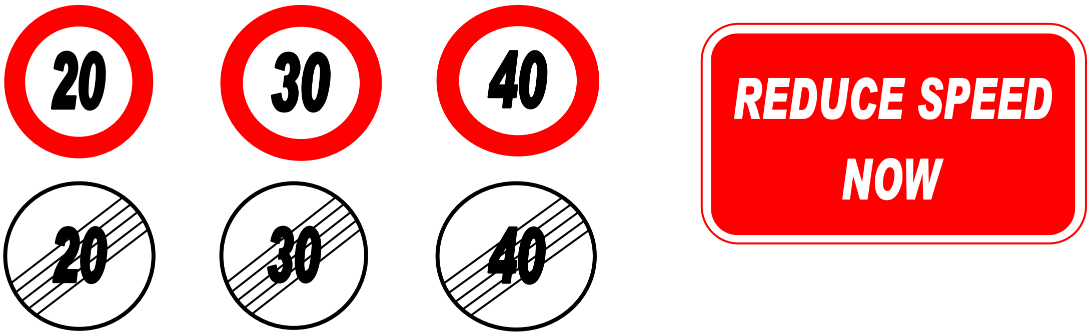


Figure 15 : Speed Limit Signage

Figure 16 : Speed Limit Road Markings

DRAGONS' TEETH

Aims of Measure:
To reduce the speed of vehicles proceeding towards speed sensitive areas

Implementation of Measure:
- identification of the speed sensitive locations
- implementation of Dragons' Teeth road markings
- complement speed reduction measures
- may be used a part of a gateway design
- the dimensions of the Dragons' Teeth have a width of 750mm and they increase in height in the direction of traffic from 600mm to 1000mm but retain the centre-to-centre spacing of 1500mm

Figure 17 : Dragon's Teeth Road Markings

MINI ROUNDABOUTS AND TRAFFIC ISLANDS

Aims of Measure:
To reduce vehicular speeds and to regularise and manage vehicle movements.

Implementation of Measures according to standard specifications:
- measure can be implemented on straight roads to break up the road into sections
- measure can be implemented at T-junctions, Y-junctions and at crossroads
- the mini roundabout, with a diameter not exceeding a maximum of 4.0meters, may be either painted or constructed as a mountable round area with a crest height not exceeding a maximum of 100mm
- the mini roundabout is recommended for locations where the external diameter does not exceed 28meters

YELLOW BAR MARKINGS

Aims of Measure:
To reduce the speed of vehicles proceeding towards speed sensitive areas

Implementation of Measure:

- identification of the speed sensitive locations
- implementation of Yellow Bar Markings
- complement speed reduction measures
- may be used a part of a gateway design
- the Bar Markings have a width of 200mm and their centre-to-centre spacing decreases in the direction of traffic

Table 8 : Spacing of Yellow Bar Markings on the road

Bar No	Distance from D1 (m)	Bar No	Distance from D1 (m)	Bar No	Distance from D1 (m)	Bar No	Distance from D1 (m)	Bar No	Distance from D1 (m)
D1	0.00	D21	60.10	D41	133.75	D61	224.70	D81	338.15
D2	2.75	D22	63.45	D42	137.85	D62	229.80	D82	344.65
D3	5.50	D23	66.80	D43	142.00	D63	234.90	D83	351.35
D4	8.25	D24	70.15	D44	146.15	D64	240.10	D84	358.30
D5	11.05	D25	73.60	D45	150.40	D65	245.40	D85	365.50
D6	13.90	D26	77.05	D46	154.65	D66	250.70	D86	373.20
D7	16.80	D27	80.55	D47	158.95	D67	256.10	D87	380.90
D8	19.70	D28	84.10	D48	163.35	D68	261.50	D88	388.60
D9	22.60	D29	87.65	D49	167.75	D69	267.00	D89	396.25
D10	25.55	D30	91.30	D50	172.25	D70	272.60	D90	403.95
D11	28.55	D31	94.95	D51	176.75	D71	278.20		
D12	31.60	D32	98.65	D52	181.30	D72	283.90		
D13	34.65	D33	102.40	D53	185.95	D73	289.60		
D14	37.70	D34	106.15	D54	190.60	D74	295.45		
D15	40.80	D35	110.00	D55	195.35	D75	301.30		
D16	43.95	D36	113.85	D56	200.10	D76	307.25		
D17	47.15	D37	117.75	D57	204.90	D77	313.30		
D18	50.35	D38	121.70	D58	209.80	D78	319.35		
D19	53.55	D39	125.65	D59	214.70	D79	325.55		
D20	56.80	D40	129.70	D60	219.70	D80	331.75		

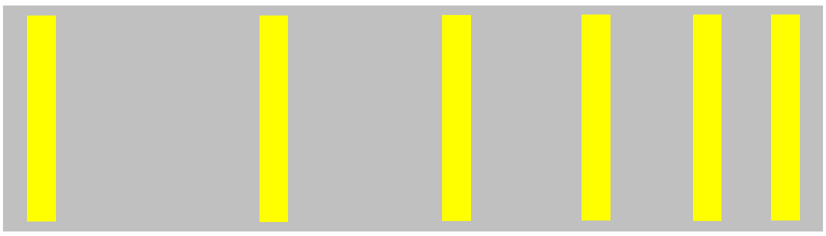


Figure 18 : Yellow Bar Markings

ROUND TOPPED ROAD HUMPS

Aims of Measure:
To reduce the speed of vehicles proceeding towards speed sensitive areas

Implementation of Measure:

- identification of the speed sensitive locations
- implementation of Round Topped Road Hump
- complement speed reduction measures
- for two-way roads, the road hump should not be implemented within the 15m distance from the corner
- for one-way roads, the road hump should not be implemented within the 5m distance from the corner
- if the street is a bus route, the crest of the hump is not to exceed 50mm
- if the street is not a bus route, the crest of the hump is not to exceed 100mm
- the hump width is to be 3.7m
- the hump is not to impede or obstruct access to garages
- adequate width is to be allowed between the edge of the carriageway and the edge of the hump to permit unimpeded flow of rainwater drainage

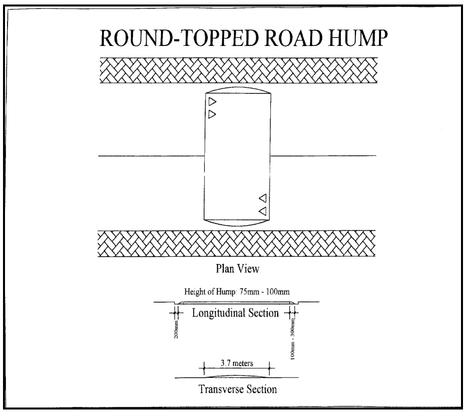


Figure 19 : Specifications for Round-Topped Road Hump

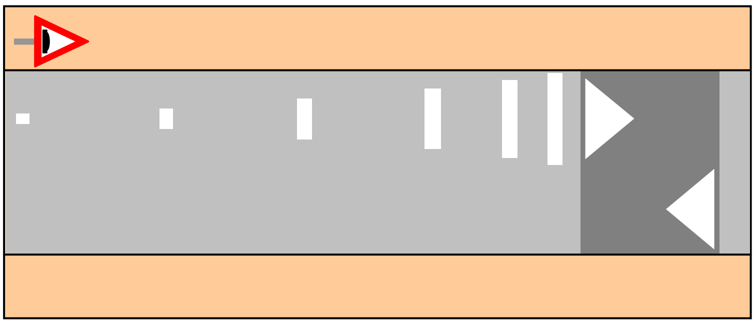


Figure 20 : Line Markings and Signage for Round-Topped Road Hump

BUILD-OUTS/PINCH POINTS

Aims of Measure:
To reduce vehicular speeds

Implementation of Measure:

- narrowing of the road
- re-organisation of on-street parking
- may include a pedestrian crossing
- identification of the speed sensitive locations
- implementation of the pinch point/build-outs
- complement speed reduction measures
- effective road width to be determined depending on the road classification
- the pinch point/build-out is not to impede or obstruct access to garages
- the pinch point/build-out is to permit unimpeded flow of rainwater drainage
- may include soft landscaping not exceeding 50mm in height
- may include a raised pedestrian crossing depending on the location of the measure and the vehicle flow direction of the road

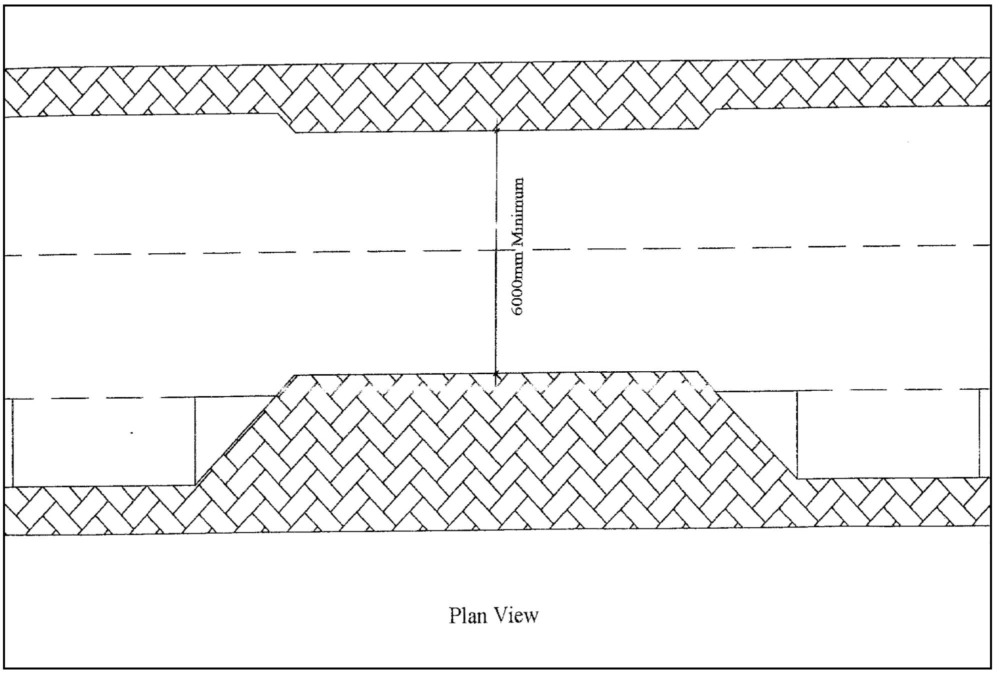


Figure 21 : Build Outs

CHICANES

Aims of Measure:
To reduce vehicular speeds

Implementation of Measure:

- identification of the speed sensitive locations
- implementation of the pinch point/build-outs
- complement speed reduction measures
- effective road width to be determined depending on the road classification
- the pinch point/build-out is not to impede or obstruct access to garages
- the pinch point/build-out is to permit unimpeded flow of rainwater drainage
- may include soft landscaping not exceeding 50mm in height
- may include a deflection in the road alignment
- narrowing of the road
- on-street parking arrangements with the chicane will depend on the dimensions of the chicane, the 85th percentile vehicle speed and the traffic volumes

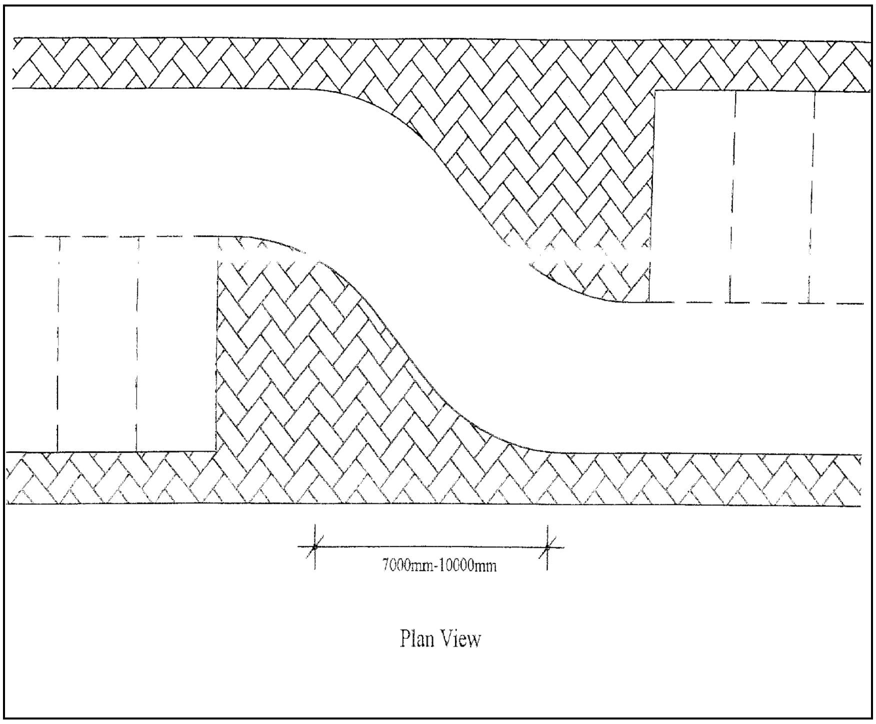


Figure 22 : Chicanes

SPEED CUSHIONS

Aims of Measure:
To reduce vehicular speeds of passenger cars

Implementation of Measure:

- the speed cushions are to be constructed as per dimensions outlined in the illustration
- the distance between the speed cushions is such that the axle of the passenger vehicle is effected by the cushions however, the wider axle of heavy vehicles and public transport vehicles is not effected

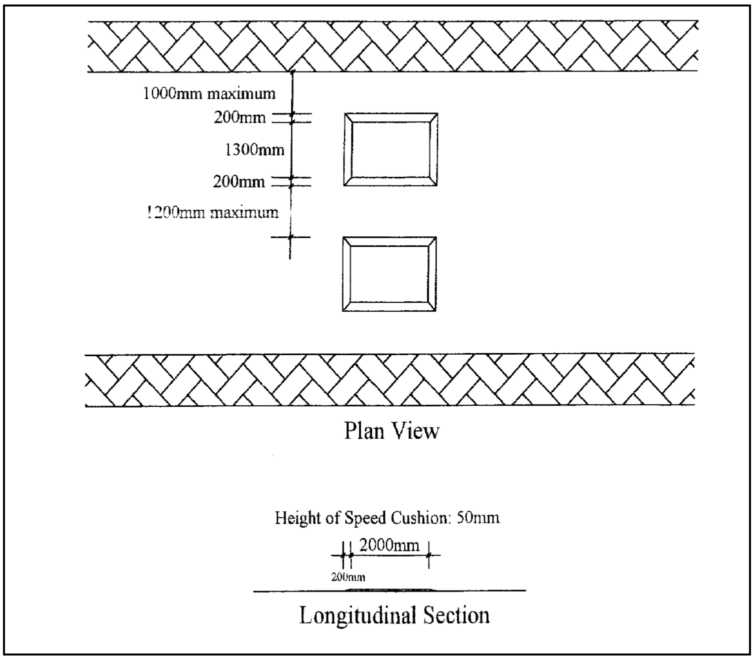


Figure 23 : Speed Cushions

LANE NARROWING

Aims of Measure:

To reduce the speed of vehicles proceeding towards speed sensitive areas or prior to a change in speed limit.

Implementation of Measure:

- identification of the speed sensitive locations
- implementation of edge and centre hatching lines
- implementation of road narrowing lines
- complement speed reduction measures
- may be used a part of a gateway design

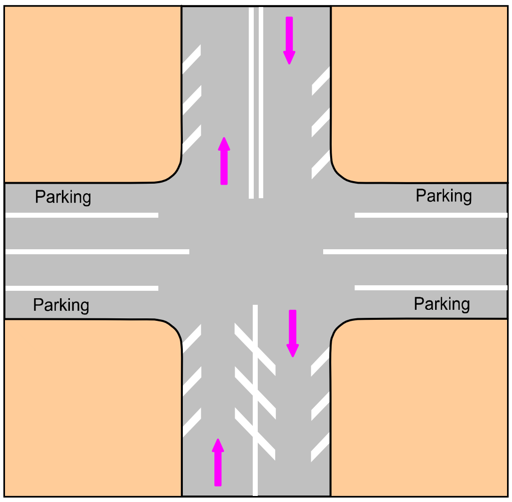


Figure 24 : Lane Narrowing - Hatching

PINCH POINT

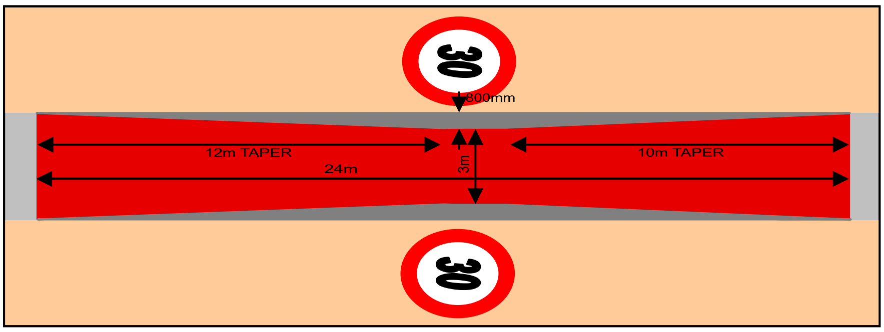


Figure 25 : Lane Narrowing - Pinch Point

GATEWAYS

Aims of Measure:
To reduce the speed of vehicles proceeding towards speed sensitive areas or prior to a change in speed limit.

Implementation of Measure:

- identification of the 85th percentile speed of the road
- identification of location for gateway
- recommended for implementation on arterial and distributor roads, roads with linking functions and roads within the village which have high traffic volumes
- gateways are a combination of road safety measures complementing each other for maximum effectiveness

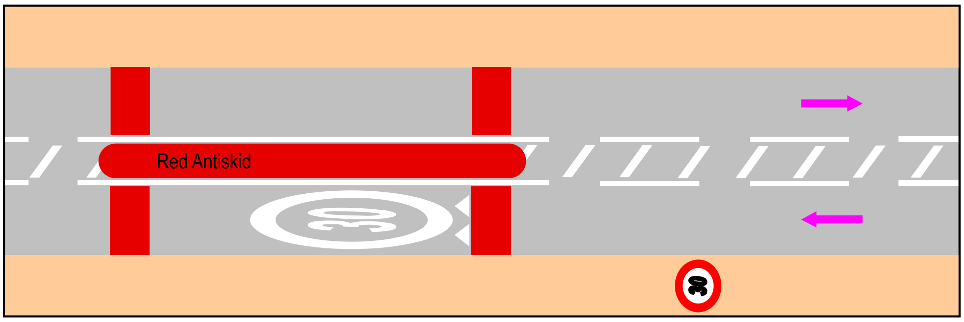


Figure 26 : Gateway including Hatching, Anti-Skid Material, Speed Limit and Central Island

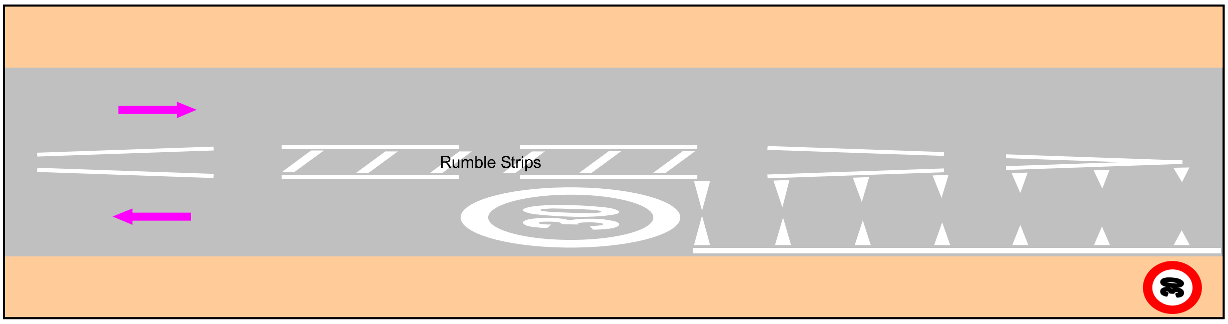


Figure 27 : Gateway including Hatching, Dragons' Teeth, Speed Limit, Rumble Strips and Central Island

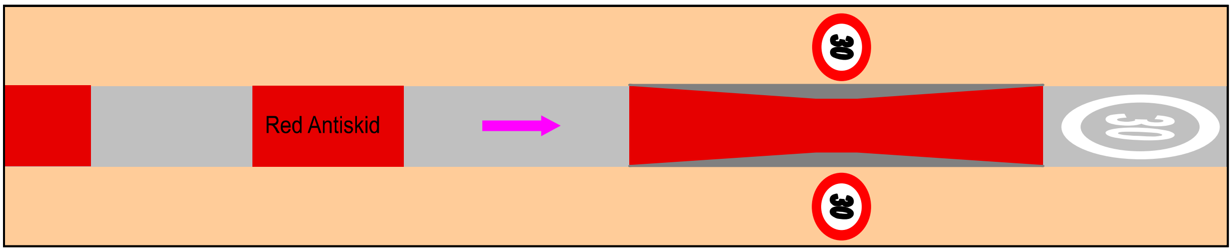


Figure 28 : Gateway including Road Narrowing, Anti-Skid Material and Speed Limit

Annex 10: Checklist for Road Safety Inspections

(TMS Consultancy, 2011)

Table 9 : Checklist for Road Safety Inspection

Characterisation	No.	Question	Yes ✓ No ✗	Comments
1. Function, operating elements and surroundings	**0**	Have eventual final audit result from previous audit phase been taken into consideration?		
	1	Are there any issues from accident date if available?		
	2	Are there specific traffic composition characteristics to be taken into consideration?		
	3	Are special measures required for particular groups e.g. for young people, older people, sick people, physically handicapped, hearing-impaired or blind people?		
	4	Is the design of the road according to its function and hierarchy in the network?		
	5	Are there build up areas with mixed traffic?		
	6	Is access to abutting properties and agriculture appropriate for road safety?		
	7	Are there any parallel ways to be used by cats and farm equipment?		
	8	Do we realize the change of functions and characteristics early enough? 100km/h > 300 m ahead 80km/h > 200 m ahead 50 km/h > 150 m ahead		
	9	Are there anywhere accumulations of events such as curves + hilltops + Intersection etc?		
	10	Are transitions installed between different functions and road characteristics?		
	11	Are there traffic islands and lane shifts at the entrance of villages and towns		
	12	Are speed limits and traffic calming measures in villages		

Characterisation	No.	Question	Yes ✓ No ✘	Comments
		and towns required and applied in the same way?		
	13	Can road maintenance service vehicles be parked safely?		
	14	Is stopping sight distance guaranteed along the entire section? 100 km/h > 185 m for trucks 80 km/h > 130m for trucks 60 km/h > 85m for trucks		
	15	Is the landscaping work finished?		
	16	Are all fixed or painted obstacles that can be dangerous placed outside the safety zone? 100 km/h >9m 80km/h > 6 m 60km/h > 3 m (away from skidding cars?)		
	17	Is the transition from a built-up to a rural road or from an Illuminated to a not Illuminated road appropriately designed (village/town outskirts)?		
	18	Is the end of the construction area away from critical points, e.g. summits, downgrades, curves, areas with restricted sight distance or distractions?		
2. Cross Section	**1**	Is the cross section appropriate to the function?		
	2	Does the road surface provide the required grip over the long term where small radii occur (e.g. also on ramps)?		
	3	Are there any doubts regarding the surface grip because of excess bleeding or polished components?		
	4	Is the surface even and free from grooves?		
	5	Is the surface free from short or long waves?		
	6	Is there sufficient drainage for the road and its surroundings?		
	7	Is there sufficient cross/diagonal fall ?		

Characterisation	No.	Question	Yes ✓ No ✗	Comments
	8	Is the cross fall in straight sections constant?		
	9	What is the medium width of the road shoulders?		
	10	Are the shoulders and the carriageways at the same level?		
	11	Are the road verges strong and stable enough?		
	12	Have sufficient measures been taken on cutting slopes to prevent falling material (e.g. falling rocks)?		
	13	Is stopping straight obstructed, for example by safety barriers, plants?		
	14	Is narrowing of the carriageway required and, if so, designed in such a way to ensure traffic safety?		
	15	Have suitable measures been taken to ensure that speed limits are obeyed?		
	16	Have the needs of public transport and its users been taken into consideration?		
	17	Is slow and non motorized traffic separated from fast and heavy traffic? Or have pedestrian and cyclist requirements been considered (e.g. separate cycle facilities)?		
	18	Is there a median? Does it have a safe design, e.g. safety barrier or sufficient width to prevent turn accidents?		
	19	Is a separating strip required between cycle path and parking strip?		
	20	Are there any bottlenecks? If so, are they properly signed?		
	21	Do curves with small radii have an enlarged width of the pavement?		
	22	Does the embankment require passive safety installations?		
	23	Do the elements of the cross section realize the situation for the road users?		

Characterisation	No.	Question	Yes ✓ No ✗	Comments
Alignment	**1**	Is the existing speed limit adequate for the horizontal and vertical elements of the alignment?		
	2	Is sight obstructed, for example by safety barriers, fences, road equipment, parking areas, traffic signs, landscaping/ greenery, bridge abutments, buildings?		
	4	Is visibility in curves ensured?		
	5	Is the super elevation in curves sufficient		
	6	Are there sufficient overtaking possibilities		
	7	Has the uphill sector a passing lane for overtaking slow traffic?		
	8	Has the passing lane a sufficient length in order to ensure that the vehicle can overtake and return safety?		
	9	Are there hidden dips in the vertical alignment?		
	10	Is the alignment consistent and easily recognized by the road users? Or full of surprises for the drivers?		
	11	Are changes (surprises) indicated by the transitions like signing, points of fixation?		
	12	Are the outside of the curves framed parallel and consistent?		
	13	Are the insides of the curves free from side obstructions?		
	14	Are there optical illusions ?		
4. Intersections **4.1 Geometry** **And lay out**	**1**	Are the intersections perpendicular?		
	2	Is the main direction clearly recognizable? And if so, is the right of way clearly recognizable?		
	3	Are the movements guided clearly and easily to understand? Are traffic flows guided by marking?		

Characterisation	No.	Question	Yes ✓ No ✗	Comments
	4	Are the auxiliary lanes or tapers for turning movements large enough?		
	5	Is the intersection fully visible and recognizable in time from all approaches for different driver eye heights of: Cars, trucks, motorcycles, bicycles, etc; and are the required sight triangles clear?		
	6	Does the ambient lighting present any special requirements?		
	7	Is sight obstructed, for example by safety barriers, fences, road equipment, parking areas, traffic signs, landscaping/greenery, bridge abutments, buildings?		
	8	Are type and designs of the intersections suitable for the function and traffic volume of the intersecting roads? (Separate answers for each intersection?)		
	9	A pedestrian/cyclist routing at the intersections adapted to the actual conditions and clearly marked and signposted?		
	10	Are all approaches equipped with pedestrian and cycle crossing?		
	11	Has right of way been specified and clarified at cycle crossings, in particular for cycle paths that are set back?		
	12	Is the transition safely designed if footpaths end on an intersection or road or are directed across the road?		
	13	Are stop lines for motorists further back for the benefit of cyclists?		
	14	Have suitable measures been taken to ensure that speed limits are obeyed?		
	15	Are there no-stopping zones?		
	16	Is a reduction in speed required in the direction of the intersection? And are there		

Characterisation	No.	Question	Yes ✓ No ✗	Comments
		transitions for speed reductions on the minor road?		
	17	Does the obligation to yield right of way need to reinforced (e.g. using repetition?)		
	18	Are pedestrian crossings clearly marked? Is each section equipped with signals (including railway structures)?		
	19	Are the crossings for pedestrian and cyclists provided with low kerbs?		
	20	Should turns be prohibited (block diversions)?		
	21	Are the type of spacing of different crossing installations coordinated (e.g. traffic signals, zebra crossings)?		
	22	Is right of way clearly defined at points where cyclists come into contact with each other or with motorized traffic?		
	23	Are refuges large and wide enough for crossing pedestrians and cyclists to stand and wait?		
	24	Are the islands above the level of the carriageway?		
	25	Are the islands made only by markings?		
Roundabouts	**26**	Are the islands clearly visible and of a suitable design?		
	27	Is there a danger of underestimating speed and overestimating distance of crossing vehicles?		
	28	Are all approaches to roundabouts perpendicular and radial to the center?		
	29	Is the central island of the round about shaped as a hill?		
	30	Is the through – visibility effectively stopped by the roundabout and the hill?		
	31	Is the central island of the roundabout free from fixed obstacles which could be reached by vehicles?		

Characterisation	No.	Question	Yes ✓ No ✗	Comments
4.2 Traffic signals	**1**	Is the stopping line correlated with the traffic signal so that the signal can be seen?		
	2	Have any turning movements been excluded from signal control? If so, is the traffic management safe?		
	3	Are traffic signals easily recognizable?		
	4	Have cyclists requirements been considered (e.g. route through the intersection)?		
	5	Are stop lines for the motorists further back for the benefit of cyclists?		
	6	Are all the approaches equipped with pedestrian and cycle crossings?		
	7	Are pedestrian crossings clearly constructed? Is each section equipped with signals (including railway structures)?		
	8	Are exclusive green phases provided for pedestrians and cyclists where necessary?		
	9	Can pedestrians cross the road in one go? Is the green time sufficient?		
	10	If there is no exclusive pedestrian interval provided?		
	11	Are phase offsets required for pedestrians and cyclists within the cycle?		
	12	Are separate signals provided for cyclists? (Are the signal aspects correctly located for cyclists? Avoid protected turn phases/risk of cyclists crossing on red)		
	13	Is the maximum delay reasonable for cyclists? Are cyclists partly or totally removed from signal control?		
	14	Are the type and spacing of different crossing installations coordinated (e.g. traffic signals, zebra crossing)?		
	15	Are the signals are effected at dawn/dusk by direct sunlight?		

Characterisation	No.	Question	Yes ✓ No ✗	Comments
	16	Are advanced warnings provided for traffic signals that cannot be seen in time?		
	17	Have the location for the signals been selected correctly (additional signals, etc.)?		
	18	Are secondary signals provided as necessary?		
	19	Does the existing road lighting lead to conflicts in recognizing the yellow indication (sodium discharge lamps)?		
	20	Is access from abutting properties affected and, if necessary, included in signal control?		
	21	Are perspectives that appear to be continuous (passage effect) interrupted by highlighting the nearest signals ?		
	23	Are the traffic signals properly situated so that they can distinguished by each particular traffic flow?		
	24	Are there any additional signs correlated with the traffic signals to show the direction to which that traffic signal is referring to?		
	25	Is the visibility of the traffic signal ensured on a sunny day?		
	26	Is the stopping line correlated with the traffic signal so that the signal can be seen?		
	27	Are the signals covered /obstructed (e.g. by traffic signs, lightning masts, plants, traffic jams)?		
5. Services **5.1 Services and rest areas**	**1**	Are service and rest areas and parking facilities on both sides of the road? In case not, are there left turn lanes?		
	2	Are there deceleration and acceleration lanes at the entrance and exit?		
	3	Are the dimensions of the parking areas sufficient for parking for passenger vehicles, trucks and buses?		

Characterisation	No.	Question	Yes ✓ No ✗	Comments
	4	Is the layout of the service or rest area appropriate for the different traffic movements? And if so, is layout suitable in access areas to and from property?		
	5	Is the layout in such a way that vehicles are running at the appropriate speed?		
	6	Are non-stopping zones provided as necessary?		
	7	Are the dimensions of the parking areas sufficient for parking for passenger vehicles, trucks and buses?		
	8	Are parking areas easily accessible and do they provide sufficient maneuvering space?		
	9	Are there any pedestrian facilities? And if so, are they of a safe design?		
	10	Do users feel safe and secure?		
	11	Have measures been taken to ensure safe access for rescue vehicles/maintenance vehicles fire service?		
	12	Are sufficient parking areas provided to minimize illegal parking on footpaths, cycle facilities, and on the carriageway with corresponding preventative measures been taken?		
	13	Are loading areas provided next to the road where it is unavoidable?		
	14	Is it possible to enter and leave parking areas safely?		
	15	Is sight obstructed by parking areas or by illegally parked vehicles?		
5.2 Public Transport	**1**	Are bus lanes separated from the vehicle traffic?		
6. Needs of vulnerable Road Users **6.1 At Public transport stops**	**1**	Are stops easily and safely accessible to pedestrians and are the pedestrians crossings the rear of the bus stops?		

Characterisation	No.	Question	Yes ✓ No ✗	Comments
	2	Are the bus stops signposted and detectable by the drivers? Is reconcilability guaranteed?		
	3	Are the bus stops situated outside of the carriageways where appropriate?		
	4	Are areas for waiting pedestrians and large enough?		
	5	Are the queuing areas for waiting passengers sufficient?		
	6	Is sight obstructed , for example by safety barriers, fences, road equipment, parking areas, traffic signs, landscaping/greenery, bridge abutments, buildings?		
	7	Is cyclist routing safely designed in the area near public transport stops?		
	8	Is lighting required? And if so, is it appropriately designed?		
6.2 Other needs of pedestrian and cyclists	**1**	Are the pedestrian crossings located where most required by pedestrian traffic?		
	3	Have pedestrian crossings been appointed in such a way that collective use is guaranteed and the road will be not crossed at other points?		
	4	Is there a risk of pedestrian underpasses and bridges being bypassed? Are suitable measures in place?		
	5	Are further crossing aids required?		
	6	Are areas for waiting pedestrians and cyclists sufficient?		
	7	Are refuges large and wide enough for crossing pedestrians and cyclists to stand and wait?		
	10	Is a two-way visual contact ensured between pedestrians and motorist?		
	11	Have cyclists requirements been considered (e.g. route across central refuges, bottlenecks)?		

Characterisation	No.	Question	Yes ✓ No ✗	Comments
	12	Has priority been giving to cyclists over other traffic where necessary?		
	13	Is the visibility for motorized traffic adequate to see cyclists along the road?		
	14	Are parked vehicles obstructing the visibility of the road users regarding cyclists?		
	15	Are points where cyclists cross intersecting roads provided with low curbstones?		
	16	Are the pedestrian ways physically separated by kerb stones, barriers or greenery?		
	17	Is there a speed limit? And if so, is it respected by the drivers?		
	18	Are there traffic islands at the entrances of these areas?		
	19	Are the pedestrian crossings signposted and detectable by the drivers?		
	20	Have pedestrian crossings been placed in a way that collective use is guaranteed and the road will not be crossed at other points?		
	21	Are the islands clearly visible and properly placed?		
	22	Is lightning provided where necessary?		
6.3 Needs of Motorcyclists	**1**	Are motorbikes a remarkable percentage of the traffic?		
	2	Have devices or objects that might destabilize a motorcycle been avoided on the road surface?		
	3	Is the road side clear of obstructions where motorcyclists may lean into curves?		
	4	Will warning or delineation be adequate for motorbikes?		
	5	Have barrier kerbs been avoided in high speed areas?		
	6	In areas more likely to have motorcyclists run off the road is the roadside forgiving or		

Characterisation	No.	Question	Yes ✓ No ✗	Comments
		safety shielded?		
7. Traffic signing, marking, lightning **7.1 Signing**	**1**	Have appropriate speed limits been signed appropriately (start, end, height, location)?		
	2	Are there speed limitations of 70/60/50 km/h ahead of intersections and build up areas?		
	3	Is the visibility of the road course assisted by edge delineation?		
	4	Is sight obstructed by the traffic or by the signs?		
	5	Is prohibition of overtaking for trucks, buses, etc. appropriately designed and located? Are there warning signs ahead of the intersection prohibiting overtaking?		
	6	Can the signs be clearly recognized and read (size of signs)? And do the signs conform to the conventions of Vienna and Geneva?		
	7	Are there more than 2 different traffic signs at one place and are all traffic signs necessary?		
	8	Is a reduction in speed, when approaching the intersection ,assigned to the correct place and property designed?		
	9	Is signing logical and consistent? Does it show the right of way clearly?		
	10	Is signing for service and rest areas clear?		
	11	Have variable direction signing or traffic control systems been installed and are fully functional?		

Characterisation	No.	Question	Yes ✓ No ✗	Comments
	12	Is pedestrian/cyclists routing at intersections adapted to the actual conditions and clearly signposted?		
	13	Are the installations shared by pedestrians and cyclists, including underpasses and bridges, properly signposted?		
	14	Is right of way clearly defined at points where cyclists come into contact with each other or with motorized traffic?		
	15	Is it clear to the motorist whether he is crossing a one-way or two-way cycle path?		
	16	Are advanced warning in place for features that cannot be seen in time?		
	17	Could greenery lead to safety problems if the vegetation grows (e.g. as a result of covered road signs)?		
	18	Are signs located in such a way as to avoid restricting visibility from approaches or intersecting roads?		
	19	Is the roundabout fully visible and recognizable from all approaches and are the markings and signs clear and unambiguous?		
	20	Are signs retro reflecting or are they illuminated at night? In daylight and darkness, are signs satisfactory regarding visibility?		
	21	Are the additional information panels uniform?		
	22	Are there misunderstanding or misguiding traffic signs or additional information panels?		
	23	Is readability ensured at the required distance? Are there background problems?		

Characterisation	No.	Question	Yes ✓ No ✗	Comments
	24	Have signs been located above the carriageways where needed?		
	25	Do the signs have a dimension according to the type of road?		
	26	Are the signs provided with protective edges?		
	27	Are the signs at a uniform position, compared to the pavement?		
	28	Is the vertical signing properly placed and complete?		
	29	Are the sign masts and foundations sufficiently protected against collisions?		
	30	Do the traffic signs, including their supports, have a sufficient passive safety by: low mass or/ and Break away structure or/and Are they beyond the safety zone? Passive safety Installations?		
	31	Do delineators have a break away structure?		
	32	Do all signs and markings correspond without any contradictions?		
7.2 Markings	**1**	Are the road markings clear and recognizable?		
	2	Have old markings signs been completely removed (phantom markings)?		
	3	Have any turning movements been excluded from signal control? If so, are markings clear for turning motorists?		

Characterisation	No.	Question	Yes ✓ No ✗	Comments
	4	Are the markings in a parallel line to the edge of the road surface?		
	5	Is right of way clearly defined at points where cyclists come into contact with each other or with motorized traffic?		
	7	Is it clear to the motorist whether he is crossing a one-way or two-way cycle path?		
	8	Are stop lines for motorists further back for the benefit of cyclists?		
	9	Is pedestrian/cyclist routing at intersections adapted to the actual conditions and clearly marked and signposted?		
	10	Are the markings appropriate for the function and category of the road?		
	11	Are the markings likely to be effective under all expected conditions (day, night, wet, dry, fog, rising and setting sun)?		
	12	Are the markings according to the pedestrian/cyclist traffic flow?		
	13	Is the obligation to yield right of way enforced by markings according to the one enforced by signing?		
73. Lighting	**1**	Is the road sufficiently illuminated?		
	2	Is the stationary lightning appropriate?		
	3	Is the lightning of special situations (transitions zones, changes in cross section) suitably designed?		

Characterisation	No.	Question	Yes ✓ No ✗	Comments
	4	Do remaining unlit areas present potential problems?		
	5	Does the existing road lighting lead to conflicts in recognizing the yellow indication (sodium discharge lamps)?		
	7	Does lightning need to changed so that crossing pedestrians are clearly visible?		
	8	Is contrast lightning required at the intersection?		
	9	Does the ambient lightning present any special requirements?		
	11	Can the stationary lighting cause problems in recognizing the traffic signs or the alignment of the road?		
	12	Are the lightning masts situated outside of the safety zone or properly protected?		
	13	Is stationary lighting at intersections/service and rest areas property situated?		
	14	In the areas where is no stationary lightning, are there any potential dangers?		
8. Road side features and passive safety Installations **8.1 Other road equipment**	**1**	Are there any features within the safety zone 100 km/h > 9m 80 km/h > 6 m 60 km/h > 3m		
	2	Are antidazzle screens provided as required?		
	3	Has suitable road equipment (fog warning signs, etc.) been installed and is it fully functional?		
	4	Are the emergency telephones in appropriate and safe positions with regard to		

Characterisation	No.	Question	Yes ✓ No ✗	Comments
		traffic?		
	5	Is the beginning and end of game fencing correctly determined?		
	6	Is sight obstructed, for example by safety barriers, fences, road equipment, advertising billboards, and traffic signs?		
	7	Have sufficient measures been taken on cutting slopes to prevent falling material (e.g. falling rocks)?		
8.2 Plantings	**1**	Is there any vegetation along the road?		
	2	Are there trees?		
	3	Are tree trunks free of scars from accidents?		
	4	Does any greenery or will the growth of greenery lead to future safety problems?		
	5	Does the greenery and type of planting preclude irritations to the road users (e.g. alignment)?		
	6	Is sight obstructed by the planting? Is good visibility ensured at the intersection?		
	7	Is visual contact motorist-pedestrian-cyclist restricted by greenery?		
	8	Does vegetation protected the road from natural disasters like land slides etc?		
	9	Is the vegetation along the road old and could lead to safety problems?		
	10	Does road side vegetation guide the drivers in curves continuously?		
	11	Does it obstruct the visibility on the road course?		
	12	Is the vegetation monotonous? Or does it help to avoid a monotonous character of the road?		
8.3 Civil Engineering structures	**1**	Is reconcilability guaranteed?		
	2	Are passive safety installations set up at the required locations?		

Characterisation	No.	Question	Yes ✓ No ✗	Comments
	3	Are parapets and overpasses at a safe distance from the road?		
	4	Have mast, abutments, supporting walls, bridge railing etc. been safeguarded?		
	5	Is lighting appropriately designed?		
	6	Have cyclists' requirements been considered (e.g. separate cycle facilities)?		
Drainage	**7**	Is the drainage system in a linear obstacle with deep ditches in the safety zone?		
	8	Are the constructions of culverts obstacle like?		
8.4 other obstacles	**1**	What is the distance of the road directional signage to the pavement?		
	2	Are the light poles to be considered as an obstacle (steel, concrete construction)?		
	3	Are there unprotected supports for other cables than lighting in the obstacle-free zone?		
	4	Are traffic signs (other than road directional signs) to be considered as dangerous obstacles?		
	5	Are there unprotected advertisement boards or other fixed obstacles outside the safety zones are they available, or safeguarded?		
8.6 Passive safety installations	**1**	Are fixed obstacles avoidable, set up at sufficient distances or safeguarded (masts, abutments, supporting walls, bridge railing, trees etc)?		
	2	Have passive safety installations been set up at the required locations?		
	3	Are all road safety barriers in place and safety located so that they are not obstacles themselves?		
	4	Is the length of any guardrail adequate?		
	5	Is the guardrail correctly installed, regarding: - End		

Characterisation	No.	Question	Yes ✓ No ✗	Comments
		treatments – Anchorages, - Post spacing, - Post depth, - Rail overlap?		
	6	Are dangerous windows of guardrails avoided?		
	7	Are all necessary medium barriers in place and properly signed or delineated?		
	8	Are barriers placed so that they do not restrict visibility?		

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