RISMET

Data requirements for road network inventory studies and road safety evaluations - Guidelines and specifications

Deliverable 3

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Deliverable Nr 3 – Guidelines and Specifications

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Executive summary

Improving road safety is and has been a priority in most first world countries with the result that road crashes and resultant traffic injuries have thankfully been declining. However, improvements in road safety have also brought about new challenges for managing the remaining problems. One of these challenges is that the declining number of serious injury crashes mean a sparser distribution on the network whereby traditional reactive approaches such as blackspot analysis and remedial treatments are less effective. Consequently there is a need to to understand the applicability and suitablity of other more pro-active tools and methods for managing road safety.

All road safety management tools require some level of data. These data typically include road accident, traffic, road geometry, vehicle, road user and other related data. The level of details also varies depending on the tool that is being applied. The frequency and manner in which such data are collected depend on both the nature of the required analysis and the purpose for which it is intended. In many cases such data are collected incidentally (i.e. for a specific purpose or study) and not applied or used generally whereas others may be collected structurally serving more than one application and purpose. T**his deliverable reviews data that are currently being collected within EU countries and recommends a minimum set of data that can provide a basis for basic road safety assessments. The guideline is intended to stimulate road authorities to collect a minimum set of data needed for conducting road safety evaluations and serves to provide a set of standard definitions for these data.**

To this end it is useful to collate knowledge on the available state of the art tools that can be used to assess safety and the effectiveness of countermeasures. Through surveys of road authorities within the European Union, a number of tools were identified as being used within the EU to assess the safety levels of road sections, including

1. Road safety audits
2. Road safety inspections
3. Network screening
4. Accident modelling
5. Road Protection Scoring
6. Safety Performance Indicators
7. Monitoring of road user behaviour
8. Conflict studies/Naturalistic Driving
9. In-depth analyses of accidents

The utilisation of tools appears to be related to the ease in which these tools may be used and in particular the level of data requirements for each tool. To better facilitate the use of such tools this **guideline**

1. **Identifies tools that might be useful in terms of proactive network management**
2. **Provides an outline of the data requirements for each tool**
3. **Compares what authorities already collect to that which the tools require**
4. **Make recommendations on what sort of data set authorities should aim to collect so that they can use a variety of these tools.**

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1 Introduction

“ERA-NET ROAD – Coordination and Implementation of Road Research in Europe” was a Coordination Action funded by the 6th Framework Programme of the EC. The partners in ERA-NET ROAD (ENR) were United Kingdom, Finland, Netherlands, Sweden, Germany, Norway, Switzerland, Austria, Poland, Slovenia and Denmark (www.road-era.net). Within the framework of ENR this joint research project was initiated.

The project aims at developing suitable road safety engineering evaluation tools as anticipated by the ERANET Programme "Safety at the Heart of Road Design" (2009) and furthermore those of the Directive for Road Infrastructure Safety Management (2008). These evaluation tools allow the easy identification of both unsafe (from accidents or related indicators) and potentially unsafe (from design and other criteria) locations in a road network. With such evaluation tools estimates of potential benefits at the local and the network level can be calculated and potential effects on aspects such as driver behaviour can be estimated. Such tools empower road authorities to improve their decision-making and to implement (ameliorative) measures to improve the road safety situation on the roads.

Since evaluation tools rely on good quality data, RISMET aims at reviewing available data sources for effective road infrastructure safety management in EU-countries, linked to a quick scan and assessment of current practices. This assessment will expand upon what was learned in the RIPCORD-ISEREST project. It will pay specific attention to new developments such as Safe speeds and credible speed limits (NL); Sustainable safety network categorisation and evaluation approaches (NL); Inventory based traffic and safety management schemes (Elvik; Sørensen). Furthermore, RISMET aims at exploiting results related to the development and use of Accident Prediction Models (APMs) in road safety management.

RISMET culminates in a set of easy to use guidelines and codes of practice for the development and use of comprehensive road safety engineering evaluation tools, with a specific focus on APMs. These systems based tools will consider the relationship between road design, road user behaviour, traffic and road safety. A guideline and data specification providing the minimum requirements for data collecting and recording will be included.

1.1 Background

Road crashes are a persistent concern worldwide, and it is unlikely that road user movement within the road network will ever be completely risk free. However, the quest continues to design a “safe” road that can transport users from origin to destination with minimal risk of injury. This can entail improving road safety through an “…increased awareness and acceptance of implementing joint road safety solutions throughout Europe, recognising human limitations and tolerances.” (ERAnet Road, 2009)

Road safety varies from country to country. While there are some assessment and evaluation tools that can be utilised for this purpose, the details of these are not always available or well documented, making it a challenge to access these as a ready resource. Moreover, some of these tools do not specifically contain predictive capabilities to assess the effect of local measures on overall safety performance within the network.

Simple crash reduction effects no longer appear adequate as a gauge of road safety - countries more advanced in road safety initiatives (such as the United Kingdom,The Netherlands and Sweden) have made considerable progress in mitigating the risk of crashes and injury on road networks. Standard measures historically used to identify problem areas such as Blackspot Programs are considered somewhat unsuitable as a measure in these countries due to the lower incidence of crash clusters. Traditional approaches rely on the occurrence of accidents and consequently are considered reactive approaches. The trend is now leaning toward a pro-active approach aimed at mitigating potential problems before they result in serious injury crashes. Such an approach requires different indicators with which to determine and define safety levels and where historical crash data only supports the identification of potential problems (lessons from the past).

This then necessitates a systematic review of the availability and suitability of tools to improve the safety performance in a a network. An EU Directive (2008) on Road Infrastructure Safety Management details expectations of actions to be taken by road stakeholders. In essence it seeks "…the establishment and implementation of procedures relating to road safety impact assessments, road safety audits, the management of road network safety and safety inspections by the Member States" [1]. Some key aspects of the Directive are quoted below:

- Member States shall ensure that a road safety impact assessment is carried out for all infrastructure projects.
- Member States shall ensure that road safety audits are carried out for all infrastructure projects.
- Member States shall ensure that the ranking of high accident concentration sections and the network safety ranking are based on reviews, at least every three years, of the operation of the road network.
- Member States shall ensure that safety inspections are undertaken in respect of the roads in operation in order to identify the road safety related features and prevent accidents.
- Member States shall ensure that guidelines, if they do not already exist, are adopted by 19 December 2011, in order to support the competent entities in the application of this Directive
- Appendix I-III – Road safety impact assessment for infrastructure projects, road safety audits for infrastructure projects and ranking of high accident concentration section and network safety ranking

In order to identify suitable tools that are widely applicable within the various contexts, the challenge is to develop the ideal safety assessment tool given the economic and practical limitations for data collection and management. Many road authorities are limited in their capacity for extensive data collection and creating a tool with high data requirements may simply render the tool redundant.

There are a number of databases currently in existence that serve as a data resource. Work Package 2 of RISMET (Stefan et. al, 2011) specifically identifies data and system requirements necessary for safety assessment. Work Package 3 (Elvik, 2011) provides insights into the use of various state of the art safety evaluation tools in Europe. This guideline summarises and collates data requirements for such tools in an easily accessible manner; and by linking clearly the data requirements with the tools, attempts to provide road authorities with reasons for collecting these data.

2 Purpose and Users of the Guidelines

Based on the above influences and objectives, RISMET has as general objectives the development of appropriate evaluation tools that allow the easy identification of both unsafe (from accidents or related indicators) and potentially unsafe (from design and other criteria) locations on a road network. This guideline has as its general purpose to provide an outline for the data that road authorities should collect in order to be able to make use of the state of the art tools needed for effective road safety management. These tools are described in more detail in a recent report by Elvik (2011).

Chapter 3 of the guideline provides an overview of data that is currently being collected by European road authorities. It also provides an overview of road design factors that from research have been found to be associated with certain crash types. Chapter 4 gives an overview of the use of state of the art assessment tools by European road authorities. Chapter 5 proposes a framework for a database necessary to support these tools. Chapter 6 describes data collection techniques and Chapter 7 provides a detailed description of the proposed set of data variables, the data specifications. Chapter 8 concludes the guideline with a brief discussion.

2.1 Purpose

This deliverable has a two-fold objective:

- It seeks to present the basic road safety data that are being currently collected by road authorities in the European Union, and recommends any additional data that is considered essential in assessing road safety levels using state of the art evaluation tools.

- Secondly, it aims to provide details of the data required to use current state of the art road safety management tools.

The guideline also briefly describes methodologies to collect data and furthers the aims of the EU Directive of 2008.

This deliverable focuses on higher order rural-roads and including high volume single carriageway roads.

The state of the art tools are not the focus of the guideline, the data requirements and specifications are the primary subject. Each tool applied in different countries can require different factors to be considered. The detail required to provide such specifications was considered to be beyond the time frame and budget, and hence outside the scope of this deliverable. Many resources are available detailing the use and specific methods of application for each tool and the reader is encouraged to seek appropriate literature on tool background and application.

2.2 Users

This set of guidelines is likely to be of assistance to the following users:

- Traffic engineers
- Road safety officers
- Managerial staff in the position of coordinating and implementing program evaluations
- Data collection institutes

3 Data Currently being Collected

Road authorities regularly collect road data to facilitate both maintenance and safety activities. However, the specific data, the methods of collection, and the end results seem to vary from country to country, even within the EU. As a result, comparison of even the basic parameters prove difficult.

This chapter attempts to summarise the data currently being regularly collected by the EU countries.

3.1 Countries Surveyed

WP2 of RISMET examined the availability of data in Europe that are considered relevant for road safety management (Stefan et.al, 2011). A questionnaire was developed to show what information is being collected and how this information is made available in each country.

Completed questionnaires were received from Germany (GE), Hungary (HU), Lithuania (LT), the Netherlands (NL), Norway (NO), Poland (PL), Portugal (PT), Slovenia (SI), Sweden (SE), United Kingdom (UK) and Austria (AT). For each respondent (i.e. data source) the following multiple-choice items had to be specified:

<u>Availability</u>
Public: Data is already being published by the data provider and/or interested people/parties are entitled by law to ask for this information.
Non-public: Data provider has the right to prohibit dissemination of data.

<u>Spatiality</u>
National level: Data available for the whole of a country (e.g. population of inhabitants) or the entire road network (e.g. motorways, all A-level roads etc.).
Regional level: Data available for federal states, counties, parts of the primary or secondary road network (road sections).
Local level: Data available for municipalities, short road sections (several hundred meters) or road sites (e.g. pedestrian crossings, roundabouts, junctions etc.).

<u>Data scale</u>
Aggregated: Merged data in order to ease analysis efforts or investigate relationships for higher-level entities.
Disaggregated: Data set is on the lowest possible level.

<u>Operational level</u>
Operational: The data set can be worked with/used
Raw data: Data have not yet been prepared (diagnosis of outliers, missing values etc.)

<u>Purchase of data possible</u>
Yes: Data are available for sale.
No: It is not possible to acquire data.

<u>Quality</u>
Good: collected reasonably consistently in all areas, are generally considered accurate (although there may be under-reporting), and are a key source of road safety evidence.
Sufficient: e.g. not available for all areas, not providing enough information, but still have some useful features and help provide a fuller picture of road safety.
Poor: possibly incomplete, inaccurate or not up-to-date, and so are not currently used.

3.2 Results

- Table 1 provides an overview of the basic data availability (yes/no), whether data is public or non-public; and operational level of data (raw/operational) is given by sub-categories and country.

Table 1: Availability and operational level of data in eleven European countries by road safety categories (Source Stefan et. al. 2011)

Main category	Sub-category	GE	HU	LT	NL	NO	PL	PT	SI	SE	UK	AT
Exposure	Population (S)	P	P	P	P	P	P	P	P	P	P	P
	Traffic volume (S)	P/NP	P/NP	NP	P	P	P	P	P/NP	P	P	P/NP
	Traffic performance (S)	P/NP	P	P	P	P	P				P	P
	Intersection counts				P							
	Road links				P/NP							
	Traveller kilometers				P							
	Vehicle Fleet (S)	P/NP	P	P	P/NP	P	P	P		P	P	P
	Vehicle use				P/NP							
	Vehicle kilometers				P							
Road accidents	Injury accidents (S)	P/NP	P/NP	P/NP	P/NP	P/NP	P	P	P/NP	P	P	P/NP
	Property damage (S	P/NP	P	NP	P/NP		P	NP	P		NP	NP
Infra-structure	Cross-section (S)	SP	NP	P	P	NP		NP	NP	SP	NP	NP
	Intersection (S)	SP			P			NP	NP	SP	NP	
	Alignment (S)	SP/NP						NP	NP		NP	
	Speed limits (S)	SP/NP	NP	P	P	P		NP	NP		NP	P
	Road surface (S)	SP/NP	NP	P	P	NP		NP	NP		NP	NP
	Reference populations		NP	P								P
	Road network	SP			P							
Vehicle	Defects (S)			NP		NP		NP			P	NP
Road user behavior	Daytime running lights (S)		P	NP		P						NP
	Speed (S)	NP	NP	NP	NP	P	P	P	NP		P	NP
	Seatbelt (S)	P/NP	P	NP	P	P	P	P	NP		P	NP
	Police enforcement (S)	NP	NP	NP	NP	P	NP	P		SP	NP	P
	Police fines				P/NP							
Environ-ment	Weather (S)	P	P	P	P	P	P	P	P		NP	P
Hospital	Inpatients (S)	NP	NP	NP	NP	NP	NP	P		P	NP	NP
	Work accidents (S)		NP	P		P	P	NP		P		P
In-Depth Data	Fatal accidents (S)	NP	P	NP	NP	NP				SP	NP	NP
	Serious accidents				NP							

Note: Basic availability: grey = no data or no answer given. Type of availability: public = P, non public = NP, semi public = SP. Operational level: orange = contains raw data. Pre-defined sub-categories are indicated by "(S)" (Standard) as opposed to non-standard sub-categories that have been added by single respondents.

For the standard sub-categories (S) - only a few countries added extra categories of their own - the following summary of results can be given for the questionnaires received:

- Data availability (yes/no) by categories is best for basic exposure, injury and weather data (about 90% non-grey cells in table 1), medium for in-depth data (70%), data on road user behaviour (78%), hospital data (80%), and least for infrastructure (66%) and vehicle data (50%).

Data availability among countries (yes/no) ranges between about 50% (SE) and 90% (LT, UK, AT).

3.3 Road design factors associated with crashes

With many European countries improving their road safety levels to the extent that clusters of crashes are gradually becoming less common, there is a current need to identify alternate means of highlighting locations of high crash risk. However, this does not preclude the identification of factors common to certain crash types as one means of assessing safety levels. A cluster of such factors could indicate a higher probability of this crash type. It follows then that minimising these factors can help increase the level of safety overall at the location.

Work package 2 (Stefan et. al, 2010) identified research based factors that have been associated with certain crash types. These include:

Head-on Collisions:

- Curves (density, radius and change rate);
- Vertical alignement (steep grades);
- Cross-sectional elements (narrow road widths incl. shoulder, run off area);
- Design consistency (speed changes >15km/h);
- Sight distances;
- Road surface;
- inappropriate speed choice; and
- roadside area and equipment

Single vehicle Collisions:

- cross-sectional elements,
- clear zones,
- shoulder treatments, and
- curve radius and curve density

Rear-end Collisions:

- presence of traffic signals,
- high congestion roads, and
- poor road surface

Lateral Collisions:

- poor visibility,
- involvement of older drivers,
- intersection control type; and
- inattention

Table 2 presents some of the above factors along with a descriptor of the factor (indicator) and a rating of the relative importance of each in terms of data needed for use in safety assessment (Stefan, C. et. al. 2011). The ratings are based on literature findings as well as expert judgement.

Table 2 - Predominant accident factors

Accident factor	**Indicators**	**Rating** 1 = essential 2 = nice to have 3 = minor relevance
Curves	Curvature change rate	1
	Curve density	1
	Ratio of consecutive curves	1
	Curve radius	1
Vertical Alignment	Gradient	1
Visibility	Sight distance	2
	Time of day	2
	Mist/Rain	2
Design consistency	Driven speed (v85)	1
	Speed limit	1
	Average radius of curvature	1
	Curve radius ratio (singular curve to average in a section)	2
Traffic control devices	Markings (control)	2 (all markings)
	Curve warning signs	1
	Delineation	2
	Guidance devices	2
Junction	Signalisation	1
	Adequacy of junction delineation	2
	Junction warning signs	2
	Type of junction	1
	Junction arms	1
	Turning pockets	2
	Angle of deflection or quality of (roundabouts)	2
	Consistency of intersections	3
	Access control/ junction frequency	1
Cross section	Lane width	1
	Road width	1
	Median/Overtaking restrictions	1
	Emergency/hardened shoulders	1
	Shoulder drop-off	2
	Number of lanes	1
	Road complexity	3

Accident factor	**Indicators**	**Rating** 1 = essential 2 = nice to have 3 = minor relevance
Roadside area and equipment	Obstacles	1
	Distance to obstacles	1
	Protective devices (guardrails, crash cushions)	2
	Depth and slope of ditches, gutters, etc.	2
	Road verge slope	2
Road surface	Friction coefficient IFI (International Friction Index) – combination of friction coefficient measured at 60 km/h and macro texture Skid resistance (relevant to rear end and intersection crashes)	2 2 2
Behavioural factors	Close following (Tailgating)	3
	Excess speed	1
	Speed differential	2
	Attention	3
	Driver age	3
Vehicle fleet	Age of vehicle fleet (should indicate vehicles with safe systems such as ABS, stability control programme etc)	2
	Fleet composition (impact upon rear end collision likelihood – LGVs, company car drivers)	2

4 Current Assessment Tools

A number of analytical tools were identified by WP3 of RISMET for quantitative assessments of safety levels of road sections (Elvik, 2011). Listed below are the most commonly used state of the art tools within the EU, with slightly altered tool names to those presented in WP3 report:

1. Road safety audits
2. Road safety inspections
3. Network screening (also referred to as network safety management)
4. Accident modelling
5. Road protection scoring
6. Safety Performance Indicators
7. Impact assessment of investments and road safety measures
8. Monitoring of road user behaviour
9. Conflict studies/Naturalistic Driving
10. In-depth analyses of accidents
11. Other tools for road safety management

These analytical tools are used either during pre-construction to eliminate immediately identifiable design errors or post-construction to proactively monitor and address safety, assess road operations with regard to safety, and directly target road stretches with poor safety indicators. Key elements of **state-of-the-art** versions of each tool is briefly described and references given to more extensive descriptions. The concept of state-of-the-art implies the highest level of development of a given tool at the time of publication and as recognised by international literature. Certain countries may have country specific tools which for that country are considered state of the art but in the context of this guideline not as the internationally recognised state of the art tool. The (state of the art) tools discussed here are based on the results of WP3 (Elvik, 2011).

4.1 Tools for Establishing Safety Level of a Road Section

4.1.1 Crash-Based

A traditional means of establishing the relative safety of a road section is to identify the crash history at the site. Crashes are often the result of a combination of factors, including human limitations and erroneous driving behaviour, design and infrastructure deficiencies, vehicle design features, and can be exacerbated by additional influences such as the weather.

However, it is possible to identify some key design features that are often heavily associated with certain crash types and crash outcomes.

The following section presents the design, vehicle and human factors identified through WP 2 of RISMET to be associated with the four main crash types, head-on crashes, single-vehicle crashes, lateral crashes and rear-end crashes. In addition to this, other general factors affecting crash frequency and outcome are presented, based on the results from WP 2 and WP 3 (see these reports for detailed findings).

1. Network Screening

Network screening is a process where variation in the number of accidents between sections of a road network is analysed statistically. The objective of network screening is to identify road sections that have safety problems – either in the form of an abnormally high number of accidents, a high share of severe accidents or a high share of a particular type of accident. Screening may comprise the entire road system within a jurisdiction or be limited to a particular type of road or traffic environment.

There are several versions of network screening, ranging from rankings of road sections according to the recorded number of accidents to statistically advanced techniques based on accident prediction models. Different approaches to network screening have been adopted wordwide (eg. the ESN approach in Germany and the SafetyAnlyst approach in the USA). The method of network screening implemented in SafetyAnalyst, which is recommended in the Highway Safety Manual, represents the state-of-the-art (Harwood et al. 2002A, 2002B, 2002C, 2002D).

Table 3 presents factors and data parameters that can be considered when conducting Network Screening or a Route -based Analysis. Aspects such as road cross section, distance to hazards, delineation and road surface condition are highlighted as factors to consider. However, it is noted that the specific data needs are often site-specific. Table 3 therefore serves as an indicator of the typical data parameters that are required for network screening and may in one case not be exhaustive whilst in the other too detailed.

Table 3- Network Screening/Route Based Analysis

Infrastructure Design	
General	**Specifics**
Cross-section	Road width
	Width of lanes
	Presence of (sealed) shoulders
	Width of shoulders
Vertical Alignment	Gradient
	Sight distance
Horizontal alignment	Curve radius
	Curve density
	Passing sight distance
	Lateral distance to nearest hazard
Road Surface	Texture, skid resistance
Delineation	Linemarking visibility (retroreflectivity)
	Visibility of signage (potential foliage obstructions)
	Signage comprehensibility
	Presence of guidance devices
	Signage location and distance to traffic lane
Roadside	Presence of hazards
	Protective devices
	Average distance to nearest roadside hazard
Design Speed	Design speed, posted speed limit
Intersection	Average number of intersections per length (intersection density)
	Intersection control
	Consistency of intersection type per length
Design Traffic Data	
General	**Specifics**
Design Vehicle Volumes	AADT
Operational Traffic Volumes	Annual average,volumes in the vicinity of the crash, road user specific volumes if relevant
Potential Presence of Vulnerable Road Users (VRUs)	% of pedestrians, motorcyclists, cyclists and heavy vehicles
Operational Speed	Average speed, spot speeds
Potential Conflict with VRUs	Availability of pedestrian facilities, design speed at locations of facilities
Crash Details	
General	**Specifics**
Crash Frequency	Crash numbers
	Crash types
	Crash date, annual frequency
	Roadusers involved (passenger vehicles, pedestrians, motorcyclists, cyclists and heavy vehicles)
Crash Locations (per km)	GPS or chainage detail, intersection or midblock
Crash Outcome	Crash severity (F, SI, OI)
Site Specific Crash Risks	Crossing animals, unexpected intersection geometry, location prone to severe weather

2. In-depth Analyses of Crashes

In-depth analysis investigates details within a crash that could affect the crash occurrence and the outcome, providing a better understanding of these factors but also providing a means of better identifying crash preventative measures. In-depth analysis relies on an on-site investigation of the accident and its location. These investigations are usually confined to crashes with fatal or serious injuries and are conducted as soon as possible after such a crash (preferably within 24h) to ensure that evidence is not destroyed or lost (such as skid/scuff marks on the road surface, police markings of vehicle positions etc). Collecting photographic evidence is often an integral part of such investigations.

Important elements of in-depth studies are generally not part of official accident statistics. These include the reconstruction of pre-crash speed, the estimation of impact speed, the identification of technical defects in vehicles and a comprehensive assessment of the role of human factors, such as blood alcohol content, traces of illicit drugs, seat belt wearing (which is often incompletely or inaccurately reported in official statistics), the sudden onset of illness immediately before the accident, indications that the driver had fallen asleep before the accident or indications of driver distraction.

Table 4 presents the data often necessary to conduct In-depth Crash Analyses. The more detail on the crash, the more easily the crash cause and crash dynamics can be understood and the more easily preventative measures can be developed. Details include crash type, road users, traffic volume at time of crash, road cross section, driver behaviour and environmental factors.

Table 4 - In-depth Analysis of Crashes

Infrastructure Design	
General	**Specifics**
Cross-section (depending on crash type)	Road width
	Number of lanes
	Width of lanes
	Turning Provisions
	Presence of (sealed) shoulders
	Width of shoulders
	Cross fall
Vertical Alignment (depending on crash type)	Gradient
	Sight distance
	Longitudinal distance to nearest intersection/hazard
Horizontal alignment (depending on crash type)	Curve radius
	Curve density
	Lateral distance to nearest hazard, if relevant to crash
	(Passing) sight distance
Road Surface	texture, skid resistance, black ice or other weather related surface concerns
Delineation	Line marking visibility (retro reflectivity)
	Visibility of signage (potential foliage obstructions)
	Signage Adequacy and Comprehensibility/visibility
	Guidance Devices
	Adequate definition of approaching intersection
	Signage location and distance to traffic lane
Roadside (depending on crash	Presence of hazards

type)	
	Average distance to nearest roadside hazard
Design Speed	Design speed, posted speed limit
Intersection	Average number of intersections per length (intersection density)
	Intersection Control
	Consistency of intersection type per length
	Approach angles of intersection legs
	Intersection design and complexity
Visibility	Design Road lighting, sight lines and envelopes
Design Traffic Data	
General	**Specifics**
Design Vehicle volumes	AADT, spot, vehicle volume composition, potential for increase in volumes, lateral position
Operational Traffic Volumes	Annual average,volumes in the vicinity of the crash, road user specific volumes if relevant
Potential presence of Vulnerable Road Users (VRUs)	% of pedestrians, motorcyclists, cyclists and heavy vehicles
Operational Speed	Average speed, spot speeds, free speeds
Potential Conflict with VRUs	Availability of pedestrian facilities, design speed at locations of facilities
Vehicle Factors	
General	**Specifics**
Vehicle Characteristics	Type of vehicles involved (passenger vehicles, pedestrians, motorcyclists, cyclists and heavy vehicles) vehicle make
	Vehicle design (lighting, mirrors, obstruction of visions by A pillars), vehicle technology
	Defects (tyres, brakes, steering, suspension)
Safety Features	ABS, ESC, Safety Restraints systems and Evidence of use, Collision Avoidance Systems, Daytime Running Lights
Human Factors	
General	**Specifics**
Driver Characteristics	gender, age, experience, training, BAC, fatigue,
Driver Behaviour	inattention, speed choice,
Passenger	gender, age
Occupant Position	Pre and post impact position
Site Specific Crash Risks	Crossing animals, unexpected intersection geometry
Crash Details	
General	**Specifics**
Crash frequency	Crash numbers
	Crash types
	Crash date, time, season, annual frequency
	Road users Involved (passenger vehicles, pedestrians, motorcyclists, cyclists and heavy vehicles)
Crash locations (per km)	GPS or chainage detail, intersection or midblock
Crash Outcome	Crash Severity (F, SI, OI)
Site Specific Crash Risks	Crossing animals, unexpected intersection geometry, location prone to severe weather, surrounding land use, skid marks/scuffing, damaged verges etc.

Environmental Factors	
General	**Specifics**
Weather	Wet, Dry
Light Conditions	Dark, Dusk, Day, Dawn

3. Crash factor indicators

Analysed below are three main crash types evident in the literature (Tables 5-7): lateral or cross-traffic crashes, head-on and single-vehicle crashes, and rear-end crashes with some of the road geometry and behavioural features commonly associated with these crash types (Stefan et. al., 2011). Since the literature has revealed that there is a relationship between these elements and road safety it stands to reason that the risk of such crashes occurring can be minimised by ensuring that these features are optimised. For example paved shoulders can help prevent head-on collisions by reducing the number of cross-over accidents resulting from loss of control due to a run-off road incident. Providing vehicles with systems such as ESC, collision warning etc., can also help reduce head on collisions.

Table 5 - Head-on and Single Vehicle Crashes

Infrastructure Design	
General	Specifics
Road Width	Presence of sealed shoulder, wider lanes
Sight Distance	Overtaking sight distance
Driver Expectation	Curvature Change Rate (CCR)
Road Gradient	Vertical gradient
Traffic Control Devices	Presence of curve warning signage, rumble strips, guide posts
Roadside Condition	Presence of hazards near traffic lane, absence of protective barrier
Inadequate Surface Friction	Skid resistance/friction coefficient

Vehicle Factors	
General	Specifics
Vehicle type	Average vehicle fleet data
Daytime Running Lights (DRL)	Average vehicle fleet data
Absence of vehicle technology such ABS, ESC etc	Average vehicle fleet data
Human Factors	
General	Specifics
Involvement by driver age (Old/young)	Driver age distribution
Inattention	Gaze data
Inappropriate speed choice	Speed surveys

Table 6 - Lateral Collisions

Infrastructure Design	
General	Specifics
Presence of traffic signals	Signal presence
Inadequate response time to hazards	Insufficient sight lines to traffic signals
Inadequate sight lines	Intersection envelope
Complex intersection layout and thus gap selection	Number of intersection legs, lane configuration, deflection angle on roundabouts, variety of demands on driver attention
Intersection control type	Control type
Consistency of control type	Consistency index
Presence of controls	Controlled intersection per km
Inadequate visibility	Sight distance, time of day,
Intersection density	Number of intersections per km

Vehicle Factors	
General	Specifics
Absence of vehicle technology such as Collision Warning Systems, ABS	Average vehicle fleet data
Increased risk involvement of motorcycle	Vehicle distribution
Vehicle size differential	Distribution of vehicle type
Absence of vehicle technology such as Collision Warning Systems	Average vehicle fleet Standards data

Human Factors	
General	Specifics
Inattention	Gaze data
Speed Differential	Operating speed differential, Vehicle speed distribution
Older Driver Involvement	Driver age distribution

Table 7 - Rear-end Collisions

Infrastructure Design	
General	Specifics
Signalised Intersections	Presence of traffic signals
Inadequate Warning of Impending Hazards	Stopping distance to hazard, sight distance, time of day, presence of mast arms, and tertiary signal poles
Complex Intersection Layout	Number of intersection legs, site assessment
Inadequate Surface Friction	Skid resistance/Friction coefficient
Inappropriate Speed Limits	Average travel speed measurements, safe braking distance to hazard
High Congestion Intersections	Traffic volumes, traffic flows

Vehicle Factors	
General	Specifics
Higher risk involvement of light goods vehicle	Vehicle distribution
Absence of Vehicle Technology such as Collision Warning Systems, ABS	Average vehicle fleet data

Human Factors	
General	Specifics
Inattention	Gaze data
Inappropriate speed choice	Speed surveys
Tailgating	Measured or visual headway, traffic flow data, site observations

4.1.2 Non-Crash-Based Assessment

In some countries, the relatively high level of safety achieved has resulted in fewer fatal and serious injury crashes and consequently fewer locations with high crash concentrations. Sometimes this is compounded by a relatively poor crash reporting and recording (registration) especially lower severity crashes. In such cases road accidents by themselves are no longer a viable indicator for road safety management. For such cases, surrogate measures such as those listed below provide a safety assessment independent of crash numbers:

- Predicting crashes at the site – identifying the various road design factors that contribute to crash frequency or outcome severity and develop an algorithm to predict the effect these factors would have on crash frequency
- Identifying factors involved in the four main crash types – rear-end, head-on, single-vehicle and side-impact crashes - and estimate reductive effect on these
- Identifying hazardous design aspects
- Identifying hazardous behaviour
- Identifying hazardous vehicle combinations

1. Road safety audits and Road safety Inspections

A road safety audit is a systematic assessment of plans for new road schemes, intended to ensure that new roads are designed and constructed to the highest safety levels given local conditions and features. The audit process aims to avoid future crashes by removing unsafe features before they are actually constructed, making it a proactive measure. State-of-the-art road safety audits are:

- Performed by a team of approved (in some countries formally licensed) auditors who have been formally trained and authorised for the role,
- Performed in a systematic way according to certain procedures and protocols and in which checklists are sometimes used to ensure that all safety related aspects of a design are assessed.
- Organised to ensure that the auditors are independent and have not been involved in the design or planning of the road they are asked to audit,
- Documented in the form of a report written by auditors, containing specific recommendations indicating changes necessary to ensure a road design will be safe when implemented,

Road safety audits require the agency commissioning the audit to give a point-by-point response to auditor recommendations and justify in writing any decision not to comply with the advice of the auditors. See Road Safety Audit – Best Practice Guidelines, Qualification for Auditors and "Programming", Matena, 2008, for further details.

Road Safety Inspections are undertaken on existing roads as a proactive means of crash prevention. (see Road Safety Inspections – Best Practice and implementation, Cardoso, 2008. for details on conducting a road safety inspection). Similar to road safety audits, the inspection concentrates on existing road infrastructure and is a formal inspection of an existing facility. It also relies on the expertise of the inspector/auditor who may make use of checklists during the review (Cardoso, 2008).

Table present the design elements that are commonly assessed whilst conducting a road safety audit or a road safety inspection. The auditor is a road safety expert and makes use of knowledge and experience to visualise the design in operation and to identify potential safety concerns. Generally, auditors make use of (detailed) design drawings supplemented by site visits (usually during daylight and at night) to assess road safety features of an infrastructure project. Sometimes checklists may be used to ensure that all aspects of a design have been addressed (Matena et.al, 2007).

The primary difference between the audit and the inspection is that the audit reviews a planned facility in all its stage of design whereas the inspection reviews an existing facility in operation. In both cases crash data may be used to support argumentation although these are not specific to the location but more of a general nature and describing historical relationships at locations of similar design, layout and operation. Both audits and inspections serve to identify potential safety problems BEFORE they occur.

Table 8- Features that are typically reviewed during Road Safety Audits

Infrastructure Design	
General	**Specifics**
Cross-section	Road width
	Number of lanes
	Width of lanes
	Turning provisions
	Presence of (sealed) shoulders
	Width of shoulders
	Crossfall
Vertical Alignment	Gradient
	Sight distance
	Distance to nearest intersection/hazard
Horizontal Alignment	Curve radius
	Curve density
	Curve change rate, curve density, curve radius
	Passing sight distance
	Lateral distance to nearest hazard
Road Surface	Texture, skid resistance
Delineation	Linemarking visibility (retroreflectivity)
	Visibility of signage (potential foliage obstructions)
	Signage comprehensibility
	Presence of guidance devices
	Signage location and distance to traffic lane
Roadside	Presence of hazards
	Protective devices
	Average distance to nearest roadside hazard
Intersection	Average number of intersections per length
	Intersection control
Visibility	Road design lighting, sight lines and envelopes

Design Traffic Data	
General	**Specifics**
Design Vehicle volumes and speeds	AADT, design and operating speed, vehicle volume composition, potential for increase in volumes
Potential presence of Vulnerable Road Users (VRUs)	% of pedestrians, motorcyclists, cyclists and heavy vehicles
Potential Conflict with VRUs	Availability of pedestrian facilities, design speed at locations of facilities

Road safety inspections tend to focus on infrastructure design. However, as is the case with audits, such inspections must be conducted from the eyes of all road users. The auditor must therefore not only use his/her experience in design and operations but must also be able to view that from the perspective of other road users.

Table 9 – Features that are typically reviewed during Road Safety Inspections

Infrastructure	
General	**Specifics**
Cross-section	Road width
	Number of lanes
	Width of lanes
	Length of road section being inspected
	Cycle lane and side walk standard
	Turning provisions
	Presence of (sealed) shoulders
	Width of shoulders
	Crossfall
	Stopping sight distance
Vertical Alignment	Gradient
	Sight distance (to itnersections, driveways, hazards)
	Distance to nearest intersection/hazard
Horizontal Alignment	Curve radius
	Curve density
	Passing sight distance
	Lateral distance to nearest hazard
Road Surface	Texture, skid resistance,
Delineation	Linemarking visibility (at night, in wet weather)
	Visibility of signage (foliage obstructions, at night, in wet weather)
	Signage ease of understanding
	Presence of guidance devices
	Signage location and distance to traffic lane
Conflict potential	Conflict points, ease of merging
Roadside	Presence of hazards
	Protective devices
	Average distance to nearest roadside hazard
Intersection	Intersections within specified route
	Average number of intersections per length
	Intersection control

Traffic Data	
General	**Specifics**
Vehicle Volumes and speeds	AADT, operating speeds, vehicle volume composition
Traffic Flow	Headways, gaps, capacity
Vulnerable Road Users (VRUs)	% of pedestrians, motorcyclists, cyclists and heavy vehicles
Potential Conflict with VRUs	Availability of pedestrian facilities, operational speed at locations of facilities
Environmental factors	
General	**Specifics**
Weather	Wet, dry
Light Conditions	Dark, dusk, day, dawn

2. Conflict studies

Conflict studies may be useful to quantitatively describe the interaction between different road users. The procedure is well documented (e.g. Elvik and Vaa, 2005, Hauer, 1978, Hyden, 1987 and 1996, SWOV, 2010). Conflict observations concentrate on the interaction between different road users (the traffic streams). The road environment (and the design) may have an influence on the type and frequency of conflicts and therefore it is advisable to also assess this interaction. As is the case with audits and inspections, the infrastructure is reviewed holistically and where elements are considered substandard, these are recorded. The variables listed in Table 10 again serve as an indicator of what the reviewer should consider/have at hand.

Table 10 - Conflict Studies

Infrastructure	
General	**Specifics**
Cross-section	Road width
	Number of lanes
	Width of lanes
	Turning provisions
	Presence of (sealed) shoulders
	Width of shoulders
	Crossfall
Intersection	Average number of intersections per length (intersection density)
	Intersection control
	Intersection design and complexity
Design Speed	Design speed, posted speed limit
Visibility	Road lighting

Table 10 (cntd.)- Conflict Studies

Traffic Data	
General	**Specifics**
Volumes and speeds	AADT, speeds, vehicle volume composition, turning counts
Operational	Headways and following distances, gap acceptance, sight distances;
Vulnerable Road Users (VRUs)	% of pedestrians, motorcyclists, cyclists and heavy vehicles
Conflicts	Between movements; traffic streams and user groups
Potential Conflict with VRUs	Availability of pedestrian facilities, operational speed at locations of facilities, surrounding land use

3. Accident modelling

Accident models are developed by statistically assessing how variation in the numbers of accidents occurring is explained by a range of measured variables and factors, generally using advanced regression techniques. The purpose of accident modelling is to identify factors which significantly influence the number of accidents and to estimate the magnitude of the effects. Accident modelling has been a very active field of research in recent years and important progress in the statistical methodologies has been made. Typical data requirements include geometric characteristics of the road, road surface conditions, composition and volume of traffic, speed. The data that can be included in accident modelling are listed in Table 11). Other data can include time proportion when the pavement is wet, length of the stretch under review etc. (RIPCORD, 2007).

For more detailed information on APMs and examples of different models the reader is referred to various Ripcord-Iserest publications (Eenink, et.al, 2007; Dietze et.al, 2008) and to the recently published Highway Safety Manual (FHWA, 2010)..

Table 11 presents typical data required for accident model analysis. The data required for this tool is highly dependent on the specific accident model being developed. The tool is one of the more data-hungry tools, and the more complex the model, the more data that are required. Many models use combinations of the variables in Table 11 as independent variables in the models. Often these tend to make the models complex, less reliable and very specific to the conditions under which they are developed. A more general approach is to develop models for specific road types whereby certain variables in Table 11 are chosen to describe differences in road types (e.g. roads with common characteristics are grouped and a model for that group developed). In this way, a manageable number of datasets describing the most important differences between road types can be formed to develop APMs. However, it is still advisable to make use of a fairly detailed inventory of geometric properties, traffic conditions, human factors and road accidents.

Table 11 - Accident Modelling (Existing Roads)

Infrastructure Design	
General	**Specifics**
Cross-section	Road width
	Number of lanes
	Width of lanes
	Turning provisions
	Presence of (sealed) shoulders
	Width of shoulders
	Crossfall
Vertical Alignment	Gradient
	Sight distance
	Distance to nearest intersection/hazard
Horizontal Alignment	Curve radius
	Curve density
	Passing sight distance
	Lateral distance to nearest hazard
Road Surface	Texture, skid resistance
Delineation	Linemarking visibility (retroreflectivity)
	Visibility of signage (potential foliage obstructions)
	Signage comprehensibility
	Presence of guidance devices
	Signage location and distance to traffic lane
Roadside	Presence of hazards
	Protective devices
	Average distance to nearest roadside hazard
Design Speed	Design speed, estimated operational speed
Intersection	Average number of intersections per length (intersection density)
	Intersection control
	Consistency of intersection type per length
	Approach angles of intersection legs
	Intersection design and complexity
Visibility	Design Road lighting, sight lines and envelopes
Design Traffic Data	
General	**Specifics**
Design Vehicle Volumes	AADT, spot, vehicle volume composition, potential for increase in volumes
Potential Presence of Vulnerable Road Users (VRUs)	% of pedstrians, motorcyclists, cyclists and heavy vehicles
Operational Speed	Average speed, spot speeds, free speeds
Potential Conflict with VRUs	Availability of pedestrian facilities, design speed at locations of facilities

Crash Details	
General	**Specifics**
Crash frequency	Crash numbers
	Crash types
	Crash date, annual frequency,
	Roadusers involved (passenger vehicles, pedestrians, motorcyclists, cyclists and heavy vehicles)
Crash locations (per km)	GPS or chainage detail
Crash Outcome	Crash severity (F, SI, OI)
Site Specific Crash Risks	Crossing animals, unexpected intersection geometry, location prone to severe weather, surrounding land use

Human Factors	
General	**Specifics**
Driver	Gender, age, experience, training, BAC, fatigue
Passenger	Number of passengers, gender, age

Environmental Factors	
General	**Specifics**
Weather	Wet, dry
Light Conditions	Dark, dusk, day, dawn

4. Road Safety Scoring systems

Road safety scoring systems (such as the SWOV DV-Meter, the EuroNcap Road Protection Score) is primarily an assessment of how forgiving a road is. In Europe, the best-known system is the EuroRAP (European Road Assessment Programme) Road Protection Score. EuroRAP is the sister programme to European New Car assessment Programme (EuroNCAP). Similar scoring systems have been developed in Australia (AusRAP), New Zealand (KiwiRAP), the United States (usRAP) and International Road Assessment Programme (iRAP).

Road features that are relevant to safety are recorded along a road, and a score is assigned that reflects risk. Roads scored according to EuroRAP are assigned a star rating, analogous to the star rating assigned to cars in EuroNCAP. Star Rating results are presented cartographically and are published by motoring organisations, thus informing road users about the relative safety levels of different road sections.

Table 12 presents typical data used in the construction of Road Protection Scores. These include road geometry, such as the road widths and horizontal and vertical alignments, as well as roadside protection, intersection control and traffic volumes.

Table 12 – Typical data for applying Road Safety Scores

Infrastructure Design	
General	**Specifics**
Cross-section	Road width
	Number of lanes
	Width of lanes
	Turning provisions
	Presence of (sealed) shoulders
	Width of shoulders
	Crossfall
Vertical Alignment	Gradient
	Sight distance
	Longitudinal distance to nearest intersection/hazard
Horizontal Alignment	Curve radius
	Curve density
	Passing sight distance
	Lateral distance to nearest hazard
Road Surface	Texture, skid resistance
Delineation	Linemarking visibility (at night, in wet weather)
	Signage comprehensibility
	Presence of guidance devices
	Signage location and distance to traffic lane
Roadside	Presence of hazards
	Protective devices
	Average distance to nearest roadside hazard
Intersection	Average number of intersections per length (intersection density)
	Intersection control
	Consistency of intersection type per length
	Approach angles of intersection legs
	Intersection design and complexity
	Presence/width of median
Visibility	Road lighting, sight obstructions

Design Traffic Data	
General	**Specifics**
Vehicles	AADT, spot, vehicle volume composition
Traffic movement	capacity, headyways, flow rates
Vulnerable Road Users (VRUs)	% of pedestrians, motorcyclists, cyclists and heavy vehicles
Potential Conflict with VRUs	Availability of pedestrian facilities, operational speed at locations of facilities, surrounding land use

5. Road User Behaviour Models

Road User Behaviour models are generated by psychological explanations of human behaviour and especially information processing and decision making on the road network. The models attempt to describe, explain and predict human behaviour on the road considering aspects like behaviour adaptation and workload balance, in an attempt to address the major factor in road crashes – human behaviour. Hierarchical and Control Loop models are regarded as the basis for other theories. See Road User Behaviour Model, Journal, 2008, for a detailed explanation of Road User models, and in particularly, Driver Behaviour models. Also the work done in Ripcord-Iserest is if particular relevance (Weller and Schlag, 2007)

Data often used in Road User Behaviour models are presented in Table 13.

Table 13 - Road User Behaviour

Infrastructure Design	
General	**Specifics**
Cross-section	Road width
	Number of lanes
	Width of lanes
	Turning provisions
	Presence of (sealed) shoulders
	Width of shoulders
	Crossfall
Intersection	Intersection control
Design Speed	Design speed, posted speed limit
Visibility	Road lighting

Design Traffic Data	
General	**Specifics**
Vehicles	AADT, spot, vehicle volume composition
Vulnerable Road Users (VRUs)	% of pedestrians, motorcyclists, cyclists and heavy vehicles
Potential Conflict with VRUs	Availability of pedestrian facilities, operational speed at locations of facilities, surrounding land use

Human Factors	
General	**Specifics**
Driver Characteristics	Gender, age, experience, training, BAC, fatigue,
Driver Behaviour	Inattention, speed, following, seatbelt wearing etc.
Passenger	Gender, age
Site Specific Crash Risks	Crossing animals, unexpected intersection geometry
Road User Views	
General	**Specifics**
Expectations	On the road, from other users
Comprehension	Understanding of road design
Environmental Factors	
General	**Specifics**
Weather	Wet, dry
Light Conditions	Dark, dusk, day, dawn

4.2 Summary - Dataset based on assessment tools

As far as data requirements are concerned, the following three levels of data requirements for applying assessment tools can be made (Elvik, 2011)

1. Tools that can be applied by using available data and standard analyses or tabulations of these data (low data requirements),
2. Tools that require a combination of available data and data that are collected specifically for the purpose of using a specific evaluation tool; customised analyses of these data will normally be required (intermediate data requirements),
3. Tools that require the exclusive use of data collected specifically for the use of an evaluation tool and that require analyses tailored to the tool (high data requirements).

The evaluation tools presented in the Work Package 3 report (Elvik, 2011) differ with respect to data requirements. Road safety audits have low data requirements, as they are based on documents and checklists only. However, it is essential that the audit team is experienced (in road design, traffic engineering and road safety engineering) and independent. Furthermore, one could argue that no audit is complete unless it includes accident studies after a road scheme has been opened (monitoring). Such follow-up studies are however, not routinely made. Road safety inspections may require more data, in particular if accident data and field visits are to be included. Network screening is intermediate with respect to data requirements; in general, no new data are collected specifically for the purpose of performing a network screening, but several existing sources of data may be combined. Accident modelling is intermediate or high in data requirements; sometimes new data are collected, but it is more often the case that data from several sources that form a road data bank are combined. Road data banks will usually contain a number of specialised registries, such as the accident record, a traffic volume record, a speed limit record, a road surface record, a record of geometric data, etc. These registries need to be combined when developing accident models. In some cases, new data will be collected by driving along the roads whose safety is to be modelled (see e.g. Cafiso et al.2010).

Road protection scoring is intermediate or high in data requirements; it relies on video surveillance, specialised recording instrumentation and/or taking careful notes while driving along roads with an instrumented vehicle. Video-imaging and related technology make it possible to automate the collection of many of these parameters. The identification of hazardous road locations as currently practised is low in data requirements, but would require more data if more sophisticated techniques are adopted. Impact assessment, monitoring of road user behaviour, conflict studies and naturalistic driving studies, and in-depth accident analyses are all high in data requirements. These are tools that rely on extensive data collected specifically to enable the use of the tools.

These guidelines focus on a two-fold purpose: to inform the reader of the available state-of-the-art evaluation tools, which were identified from the project team by an international literature review., and to identify the data requirements for each tool. The first section presents the range of data available while the subsequent section categorises the data requirements in relation to the individual tool.

Presented below is the combination of main data requirements for each tool under general categories (Table 14). It must be noted that the application of some of these tools, such as Accident Modelling, is so diverse that the data presented here only consider the basic data.

Table 14 - General Categories of Data Requirement for Individual Tools

Task Definition	Safety Assessment Tool	Specific Tool Benefits	Broad Categories of Required Data										
			No. Crashes	Crash Details	Vuln. Road User data	Road Design Data	Road side Data	Vehicle	Environ-ment	Traffic Data	Human Factors	Speed	Other
Pre-construction Design Safety Checks ensure a robust design in terms of safety	**Road Safety Audits** Systematic safety of pre construction (or post)road design is assessed against road standards and interaction of the design components, highlighting any crash potential	Assessment of combination of various design aspects			x	x	x	x	x	x		x	
Pre-construction In-depth Safety Checks compare one design with another	**Accident Modelling** Algorithms are used to assess effects of common variables on crash likelihood	Desk top analysis possible; detailed interactive effects between various road elements possible	x			x	x	x	x	x		x	
Routine Safety Management - Perform routine, proactive checks to ensure roads are designed and operating in accordance with recognised safety policies	**Road Safety Inspections** Road sections are inspected to identify potential hazards that can play a role in producing a crash or exacerbating the outcome of a crash	Real world assessment, can more easily detect unsafe aspects not evident in design				x	x		x	x		x	
	Safety Performance Indicators Road sections are assessed on general design and road user factors, to highlight areas of high risk	Desk-top analysis possible;provides a system wide assessment of safety; possible to identify effects between various road elements	x		x	x	x	x	x	x	x	x	
Route-Based Safety Improvements - Improve safety levels of a route with an identied poor crash record through the installation of suitable remedial	**Network Screening (Route-based analysis)** Crash occurrence along an identified section of road is statistically analysed to identify crash causal and influencing factors, and so facilitate the selection of more effective countermeasure solutions.	Network impacts on safety can be assessed, crash migration can be addressed	x			x	x						

measures	**Safety Performance Indicators** Road sections are assessed on general design and road user factors, to highlight areas of high risk. Where indicators focus on a common design or operational defect, countermeasure can be identified to address this	Desk-top analysis possible;provides a system wide assessment of safety; possible to identify effects between various road elements	x	x	x	x	x	x	x	x	x	x	
Safety Level Comparison 1. compare road safety levels of one design with another **2. C**ompare relative road safety levels between countries. **3.** Monitor relative road safety levels over time	**Road Protection Scores** Safety is assessed based on predefined criteria, which then is converted to an overall rating.	Standardises assessment of safety providing a basis for comparison contains criteria that then provide an overall rating				x	x			x			
Assessment of Potential for Conflict 1. identify design factors that might contribute to a high risk of crash occurrence **2.** determine the potential conflicts not possible to assess on-site	**Conflict Studies -** use formalised methods to assess the likely conflicts at an intersection using tools such as Time To Collision (TTC).	Predicts crash risk level despite low crash history, realtively simple method	x	x	x	x				x	x	x	
	Accident modelling Algorithms are used to assess effects of common variables on crash likelihood	Desk top analysis possible; possible to identify detailed interactive effects between various road elements	x	x		x	x		x				
	KEMM-Kinetic Energy Management Model. Safety is assessed in a systematic manner by considering five categories of factors such as crash risk, crash injury, potential kinetic energy, kinetic energy transfer	Allows a systematic analysis of the broad categories of crash occurence and injury outcome and provides a basis for exploring the details within each category	x	x	x	x	x	x				x	
Addressing of Human Behaviour Traits Through proactive observation of behaviour identify user behaviour that is not in accordance with design, and has the potential to contribute to crashes	**Monitoring of Road User Behaviour** Road user behaviour is observed and safety impacts assessed based on identified characterstics. Can include the use of conflict studies	Real world data,addressing behvaioural traits otherwise unrecorded	x		x	x			x	x	x	x	

	Driver and Driver Behaviour Models - Road User Behaviour models are generated by psychological explanations of human behaviour and especially information processing and decision making on the road network. The models attempt to describe, explain and predict human behaviour	Identifies human factors that are influential in crash frequency allowing better countermeasure development. Outcomes are potentially more complex than simply on-site behaviour monitoring	x	x		x	x	x	x	x	x	x	x
Attainment of Detailed Crash Knowledge - obtain a more thorough understanding of crashes and causes and ensure that the principal influences on crash occurrence are noted and addressed	**In-depth Analyses of Crashes** Comprehensive analysis of specific crashes is undertaken to ascertain influence of the main criteria on crash occurrence	Detailed analysis of crashes, rather than only the standard factors	x	x	x	x	x		x	x	x	x	
Economic Assessment - Assess economic worth of measures and determine future investment strategies	**Impact Assessment of Investments and Road Safety Measures** Effect of a program is assessed based on economic benefits	Provides a common basis for comparison or combination across various difference factors	x		x					x		x	

5 Framework for a database supporting road safety analysis

Understanding how roadway design factors (e.g. curvature, lane width, roadside design) affect the level of safety requires not only a study of the failures (i.e. crashes) that occur, but also of the successes – the miles of highways with certain design and operational features where the crash rate is either zero or very low (Stefan, et. al. 2011). To achieve this it is desirable to have access to data in a database which includes linkable files of crashes (as recorded and supplemented by in-depth and/or other data), roadway inventory and traffic flow data. In order to run sophisticated analyses, i.e. modelling accidents and the effects of different road safety measures, all data has to be grouped in a way that characteristics of road objects, road user behaviour and accident data can be queried for each single unit. However, an inventory of road safety data among ten EU member countries has indicated that in a large number of countries there are obvious gaps in the data needed for supporting state of the art tools for road safety engineering evaluation. These gaps pertain mainly to infrastructure and vehicle data (Stefan et. al. 2011).

Figure 1 gives an overview of the structure of a sophisticated database capable of supporting all levels of safety engineering analysis. This approach indicates the need for a holistic approach, with vehicle safety, human factors and highway engineering all taken into consideration.

Figure 1: Framework for a database supporting road safety evaluation (Stefan et. al 2011)

5.1 Existing Databases

There are currently some databases internationally that serve a similar purpose of providing road safety data for road stakeholders to enable, among other objectives, conducting road safety assessments. These databases have been described briefly below as examples of the type of data that can be included as well as the varying forms of databases that can serve the purpose of providing road stake holders with easy access to road safety data. It is noted that these databases provide data only in relation to its specific country while RISMET aims to include data relevant to the EU.

SafetyAnalyst

Safety Analyst is used to identify, assess and prioritise potential sites at which safety can be improved through the implementation of safety treatments.

It contains a database that includes data on traffic crashes, road cross section and infrastructure details, road network configuration, intersection and interchange ramps locations as well as costs.

Some typical data include: crash data (e.g. crash severity, crash location, day and time of crash), road condition, weather conditions, and vehicle types involved; road inventory data such as road length, horizontal and vertical alignment, number of lanes, speed, traffic volumes, heavy vehicle proportions; intersection details, such as, layout characteristics, area type (rural/urban), traffic control type, traffic volumes through the intersections; interchange ramp data; cost data

ASB – The German Road Information Bank Protocol

In 1992, the German Federal Ministry of Transport, Building and Urban Development introduced a protocol (general instructions) for a road database (ASB – Instructions for the Road Information Bank) containing a common structure for road networks and infrastructure objects. Over the years, the ASB protocol was updated several times to meet changing requirement profiles of infrastructure and road users.

The ASB German Road Information Bank was created to provide more comprehensive and uniform data on road infrastructure to enable not only evaluations of road safety measures but also to evaluate traffic related improvements within the road network, and monitor environmental impacts. Each section of road is subdivided into identifiable sections and collected data should be referenced to this system. Collected data can include information on traffic, road geometry details such as lanes, road widths, shoulders and intersection configurations; vertical and horizontal alignments; and road and roadside furniture and hazards.

If collected by the Federal Sates these data can be used to categorise roads based on for example design, impacts on traffic flow, environmental impacts and available operational facilities.

If in existence road stakeholders and civil engineers within the national governments can utilise the database to complete in-depth investigations, assessments and improvements within the road network.

GIDAS – German Accident database

GIDAS (German In-Depth Accident Study) is one of the largest accident studies in Germany. It is a cooperation project of the Bundesanstalt für Straßenwesen BASt (Federal Highway Research Institute Germany), Forschungsvereinigung Automobiltechnik e.V. FAT (The Research Association of Automotive Technology) which is represented by the companies Ford, VW, Daimler, BMW, GM, Porsche, Autoliv, TRW, JCI. Furthermore, the Medical University Hannover and the Technische Unversität Dresden are involved.

Data for the GIDAS project are collected in the cities Hannover and Dresden. The project was started in July 1999. Per year about 2.000 accidents are recorded. The headquarters of police, rescue services and fire departments report all accidents to the GIDAS team. Based on a sample plan they decide which accidents will be collected and recorded in detail.

A team to record accident data consists of two technicians, a doctor, and a coordinator. Specially equipped vehicles provide the team with the necessary equipment like cameras and measurement tools. A scaled sketch of the accident location is built based on photogrammetry technique.

Usually data on environmental conditions, road design,traffic control, accident details, crash information (e.g. driving and collision speed, Delta-v and EES, degree of deformation), vehicle deformation, impact contact points for passenger or pedestrians, technical vehicle data and information relating to the people involved are collected.

With the help of professional software and based on these data and known physical principles, accident reconstructions are generated together with the impact event. Furthermore, the accidents are graphically visualized.

These data are used for various aspects of analysis. Legislators study the data to identify and quantify future needs for legislation. The automotive industry and BASt use the data to compare real accidents and crash tests in order to recognize structures causing injuries. Furthermore, the statistical data is also used for developing crash test programs, for supporting and validating computer simulations, recognizing and assessing potential areas of future safety developments and evaluating vehicle safety performance in real world accident situations. Concerning road engineering, the data are used to learn more about accident severity and road equipment or obstacles. Analysis results help to improve guidelines and measurements to increase safety. A main focus is on obstacles and the improvement of constructional measures. For example, results have been taken as a basis for an obstacle crash tests guideline.

HSIS – Highway Safety Information System

The Highway Safety Information System (HSIS) is a US based database that contains data on a large number of crash, roadway, and traffic variables for a number of states from the US. The data are compiled from already existing data. The data from HSIS are used to analyse a large number of safety problems, ranging from the more basic "problem identification" issues, to identifying the size and extent of a safety problem, to modelling efforts that attempt to predict future accident frequencies from roadway characteristics and traffic factors.

All of the selected States maintain basic crash files, roadway inventory files, and traffic files. In addition, individual States also collect other types of data. Depending on the particular problem being studied, files from one or more States may be used by the analyst.

Typical data imported into the database include:

Crash data including accident, vehicle, and occupant information. Examples are crash type, vehicle types, occupant details, crash severity, and weather conditions.

Road characteristics including data on road cross-section and geometry, such as number and width of lanes, presence and type of shoulders and median, vertical and horizontal alignments, rural/urban designation, and functional classification.

Intersection details including intersection type, control type, and intersection layout

Traffic data including annual average daily traffic (AADT).

Vehicle Identification Number (VIN) - Contains VIN data decoded using the VINDICATOR program. Data include make and model of the vehicle, body style, body type, curb weight, and wheelbase.

Interchange/Ramp - Contains information on highway interchanges. Data include interchange type and ramp characteristics.

Barrier data such as barrier type, post type, rail height, and terminal type.

MOLASSESS

The MOLASSES (Monitoring of Local Authority Safety Schemes) database was initiated by the County Surveyors' Society, (CSS), UK in 1991. The main aim of the database was to encourage monitoring of safety schemes. A number of different measures were developed to assess these programs including, percentage change in accidents per annum; average annual accidents saved; expenditure per accidents saved per annum; and first year of return

The operation of this database has since ceased. A replacement database, UK Morse, has since been instigated although it is still in the initial stages of data entry.

MOLASSES had similar objectives to the databases described above, with the main aims of providing data for the road authorities to assist in evaluations and program assessments, and compiling a data bank for record keeping.

The database contained information within categories such as intersection details, horizontal and vertical geometry, pedestrian and cyclist facilities, road network and area wide details

5.2 Proposed Dataset

Based on the results of WP2 and 3 of RISMET as summarised in the earlier chapters, and given the proposed structure for an ideal database (Figure 1), an initial list of essential data to be included in a first generation database for road safety evaluations was compiled (Table 15). This list takes into account that which is currently being collected, that which is needed to be able to use current state of the art tools and that which fits in the earlier structure of an ideal database. An important consideration remains the level of disaggregation. Crashes, traffic and road network data can be disaggregated to the lowest level (i.e. per road section or even per unit length). In order to make use of the other data these should allow for similar levels of disaggregation.

Table 15 provides a list of basic parameters considered essential to conduct a broad assessment of road safety levels. It is suggested that ready access to these data will help facilitate standard, comparable, safety evaluations across the EU.

This set of data differs somewhat to those in Table 2 (Chapter 4). It is not the intention of the guideline to overburden road authorities by demanding vast data sets. Instead, a balance is sought whereby a minimum set of data is proposed that can support the use of various road safety engineering analysis tools without unnecessarily encumbering to road authority. This deliverable attempts to further reduce the "essential" data that need to be collected on a regular basis, to increase the practicality of these being collected. Where Table 2 defines some data as essential based on literature and expert knowledge, Table 15 takes into account current practice and produces a somewhat modified table of what is considered by the authors as the minimum data set. Ideally, road authorities should aspire to collecting the complete dataset listed discussed in Section 7 and in the appendices.

Table 25 - Summary of Base Data Requirements for Selected Tools

Category		Units	Ease of Collection 1-Easy/Visual 2- Moderate/ measurements 3-Intensive/labour intensive	Importance 1-Essential 2- Nice to have 3- Minor relevance
ROAD INFRASTRUCTURE				
Road Design per intersection/stretch of road being considered				
R1	Intersections per km	units/km	1	2
R2	Intersection Control Types	type	1	1
R3	Avg. Road Width	m	2	1
R4	Median treatment/directional separation	Type	1	1
R5	Avg. Width of Lanes	m	2	2
R6	Length of Sealed Shoulders per km	m	2	1
R7	Avg. Curve Radius	m	3	2
R8	Posted Speed Limit	km/h	1	1
Road Condition				
R9	Skid Resistance/Coefficient of friction	mu	3	3
Roadside				
R10	Number of Hazards/km	units/km	2	2
R11	Hazard Protective Devices/km	m/km	2	1
R12	Avg. Lateral Distance to Hazards	m	3	2
Delineation				
R12	Level of Delineation (E.g. Linemarking, Retroreflectivity, guidance Devices)	H/M/L	2	3
HUMAN FACTORS				
H1	Driven speed and % over limit	H/M/L	3	1
H2	Avg. BAC levels	mmol/l	3	2
VEHICLES				
Vehicle design can be used for APM on a case by case basis				
TRAFFIC DATA				
T1	(Projected) Annual Average Daily Traffic and composition	veh/d	2	1
T2	Avg. Speed measurements	km/h	3	1
T3	Proportion of VRUs and HVs	%	3	2
ENVIRONMENTAL DATA				
E1	Weather conditions	Description	1	2
E2	Light conditions	Description	1	2
CRASH DETAILS				
C1	Crash Type, Crash Severity, Location, Detail of Road Users Involved	units	3	1

Note: H/M/L denotes High, Medium and Low

5.3 Sources of Data

The data listed in Table 15 can be sourced in a number of ways. Some data are available via documentation (e.g., road geometry details via engineering drawings, design speed limits) whilst others will have to be obtained from site inspections and measurements (traffic and road user volumes, road user behaviour, roadside hazards etc.). This section will present an overview of potential data sources. In many cases the road authority will know these. In these cases the road authorities are encouraged to find ways to incorporate (or link) these into their (country specific) road safety database. Organisations such as Eranet Roads represent road authorities from many different countries. In many cases these road authorities apply their own data protocols whereby comparisons between countries becomes complicated because of subtle differences in the definitions. For this reason variables in the database should comply with the definitions and attributes aspired to in this guideline.

Most countries have some form of road accident registration and this will be the primary source for data on road accidents. However, since the registration of accidents varies (within and across countries) caution must be exercised when using these data for comparative purposes. Most of the accident registration sets contain similar parameters (such as location, time of day, vehicles involved, crash type etc.) and initiatives such as IRTAD and CARE have made significant strides toward achieving uniformity with respect to road accident data.

In-depth accident investigations are an excellent source for gathering the majority of data shown in Figure 1. However, not all countries conduct in-depth accident investigation as a matter of routine. Countries such as the Netherlands have only recently embarked on a formal programme concentrating on only certain fatal crashes. Consequently, in-depth investigation is a long-term option which will require the active support of EU governments before it becomes a reliable source for filling a database such as indicated in Figure 1. In the shorter term, countries should explore possibilities of setting up such databases making use of existing data and or linking databases currently in use. At the same time, consideration must be given to implementing accident investigation as a standard procedure for all fatal crashes, and possibly all serious injury crashes.

The interest of accident investigation is not only in the consequences of road crashes but also in crash causation, road user behaviour and the effects of road engineering. Much of this information that is necessary to understand these complex issues can only be found at the scene of the crash for a relatively short time after impact. This means that retrospective studies cannot be used to obtain perishable accident data such as trace marks on the highway, pedestrian contact marks on vehicles, the final resting position of the vehicles involved and weather, visibility and traffic conditions. Such information is lost during the clearing of the accident scene and it is only by prompt attendance at the scene of the crash that such information can be reliably obtained.

Road network inventory studies are conducted by a number of European countries. These provide an excellent source of road geometry data although these existing data will need to be checked for quality and compatibility. If these are to be used for comparative purposes across countries, the definitions and attributes of the variables will need to be standardised. A model, based on that developed by the FHWA (Council et al, 2007) for the roadway variables is proposed in Section 7. Road network inventories are the most structured way of building up a complete inventory of the road network. If resources are not available to conduct large scale inventories then ways have to be explored to adopt a phased approach, either by conducting specific inventory studies or utilising other sources (such as road safety inspections, RPS etc)

Road safety inspections and Road Protection Scoring are another potential source for obtaining road geometry data. However, since both these instruments have a slightly different aim, it will be vital to provide a uniform set of definitions and attributes to the inspection teams (see also Chapter 7 and the appendices).

Most countries have some form of traffic counting or monitoring programs. These data will need reviewing to see how complete they are (i.e. in terms of coverage of the road network, how actual are the counts; how complete are the counts etc). Traffic monitoring programs seldom cover the entire network and therefore road authorities will need to explore ways in which to obtain and capture traffic count data collected as part of traffic studies, transportation planning studies, incidental counts etc. Furthermore, ways to expand the traffic-monitoring network may be an option.

Human factor data are very specific and are best obtained from observational studies. However, most countries have records of general demographic data (population distribution; age, sex, etc.) and these can be useful for general analyses. Speeding, seat belt wearing, alcohol use etc. are traffic behaviours that are monitored by most countries and are useful provided they can be disaggregated to the same level as the road and traffic data. For speeds, data disaggregated to the level of road links may be sourced from existing traffic monitoring data. Data pertaining to other road user behaviour are best sourced from specific studies and can be applied to situations with similar road and traffic conditions.

Data collection sources vary so only the general sources are indicated in Table 16 (essential data) and 17 (extended dataset, see Section 7 and the appendices). In some cases, the same data can be obtained via two sources and so have been included in both. Details on data collection methods are considered beyond the scope of this report. The reader is encouraged to source other literature that provides detail of such collection methods.

Table 16 - General Sources for essential data

On-Site Measurements	**Design Drawings**	**Road Authority/Local Council**	**Other Authorities**
Road Infrastructure			
R1-R12	R1-R7		
Traffic and environmental data			
T1-T3		T1-T3	E1-E2
Crash Details			
			C1 (Police Reports)
Human Factors			
			H1-H2 (Police)

Note : R1 etc refers to the numbering in Table 15 and Appendix A.

Table 37 - General Sources for extended data

On-site Measurements	On-site observational Studies	Design Drawings	Expert Knowledge	Road Authority/ Local Council	Other Authorities
Road Infrastructure					
R27-R44 (measurements and site recordings)		R1-R26 (design details)			
Vehicles					
			V1-V13 (vehicle details)		V1-V13 (vehicle details) individual vehicle companies
Traffic Data					
T2, T4-T8 (speed measurements)				T1, T3 (estimates from regular counts)	
Crash Details					
C11, C12	C10		C13 (vehicle expert)	C1-C9 (Police Reports)	
Human Factors					
	H3, H9-H11		H5, H7, H9-H11	H4	

6 Data collection

The principle purpose of this guideline is to provide an overview of the data that are required to support state-of-the-art road safety evaluation tools in use today. The intention is to try to achieve some uniformity across EU member countries so that cross-country comparisons can be facilitated. To support this, comparable sets of data, based on the same data definitions and attributes, will need to be collected in participating countries. The backbone allowing the linking of various data is the road network. Traffic (particularly AADTs) and crash data provide the basic relationships. Since organisations such as IRTAD and CARE concentrate on providing some uniformity with respects to crashes and crash data, RISMET concentrates primarily on providing a uniform methodology for collecting road geometric data and traffic volumes (RISMET, Detailed Work Plan, 2009).

This chapter will provide an overview of data collection techniques and strategies for road network inventories and traffic counts. However, this guideline is not a manual of traffic engineering studies and the guideline only serves to provide the essential elements required for the various data collection components. It also serves to emphasize the importance of quality control in the data collection process. The guideline assumes that the reader is au fait with traffic engineering studies specifically and safety engineering analyses in general.

6.1 Road network inventory

Road (network) inventory studies serve to collect data describing the road network in terms of the actual cross-sectional elements and the vertical and horizontal alignment. These data are essential for network (Asset) management and are extensively used for managing road rehabilitation programs, maintenance of signing and marking (incl. Inventory management) etc. Furthermore, descriptive data of the road network is also extensively used in traffic safety analysis, more specifically in describing the relationship between geometric criteria, traffic volumes, road crashes and/or driver behaviour. These data can be collected in a number of ways:

- Manually. Field workers complete inventory sheets describing the cross-section, the alignment, roadside furniture, condition of road surface, markings and signs, condition of verges and clear roadside area, visibility and any other data required by the road authority. This is an extremely labour intensive method and is time consuming, prone to high degrees of error (also due to subjective interpretations). Generally, a description of the cross-sectional elements is captured every 100m or there where there is a distinct change in one of the elements. The horizontal and vertical alignments are generally captured per curve (radius, curve ratio; gradient etc). Intersections are inventoried separately and each intersection approach is described (number of lanes, lane widths, configuration etc.). Often manual inventories make use of design drawings, photo's and other visual aids to control observed data.
- Automated. Currently there are various automated road inventory systems available on the market. These vary from relatively simple handheld data capturing units on which all data parameters have been coded and are entered by an observer in a moving vehicle, to complex fully automated systems combining video, photographic, skid resistance measurements (e.g. Scrim) and other measurement technologies to capture the data. The latter systems are capable of capturing data at relatively high speeds (80km/h) and at intervals of 5m along any road section. These data can automatically be linked to GIS systems for analysis. An example of a state of the art system is that being developed as part of the Eranet-Road EuRSI project which is

developing a LiDAR based system to collect road inventory data.

- Remote sensing. This is a relatively new technique whereby LIDAR data is used to derive estimates of the data and including elements such as cross-fall, curvature and gradient.

Due to the relatively high cost, road network inventories are only carried out sporadically and not by all road authorities (Stefan, et. al 2010). Furthermore, where these inventories are carried out, the data are not generally available or used to maximum benefit. These inventories are predominantly used by road engineers responsible for maintenance and operation. Since these data can be useful in safety analysis, road authorities are encouraged to make these data more generally available. In addition, there is the possibility of collaboration with other departments, for instance a road safety unit may want to conduct road safety inspections that are a perfect means to collect/update/validate road network inventory data.

For the purpose of conducting road safety analyses, it is recommended that:

- All Eranet (EU) member countries set up a digital inventory of their primary road networks. This inventory should include at least the minimum data set presented in this manual and in the longer term have the ambition to expand this to include a full set of road characteristics such as included in systems as Safety Analyst, the Highway Safety Information System (Stefan et. al, 2010) and the MMIRE (Council, et. al, 2007). Road authorities that have more extensive road data are encouraged to make these data generally available to also road safety engineers and practitioners.
- Initially all primary roads (roads with regional or higher importance) are to be included in the inventory. The inventory will be based on observing/recording cross-sectional elements at intervals of 100m or less whereas horizontal and vertical alignment will be recorded as they occur. The data will contain GPS co-ordinates and be compatible with current state of the art GIS systems. A proposed data format is presented in Section 7.
- Once an initial road network inventory has been set up, periodic reviews will be necessary. It is recommended that, apart from when changes to road segments or intersections are introduced, road network inventories be carried out on all sections of a road network at least once in every 5 years.
- To reduce costs for road network inventories and seeing that the EU Directive for road safety Management (EU, 2008) calls for the introduction of road safety inspections, it is advisable to combine these two aspects into one data collection protocol for inspections and inventories.

6.2 Traffic data

Traffic data are essential for any traffic or safety engineering analysis. Apart from providing general details regarding traffic flow variations, directional splits, traffic composition, gaps and headways, etc. they also provide insight in some behavioural aspects such as speed, gap acceptance criteria, overtaking behaviour etc. These data are needed to determine for example volume to capacity ratios; traffic delays; number of stops; flow rates etc. For safety analyses, these data give insight into exposure levels and are vital for calculating accident rates, developing APMs, gaining insight into certain behavioural aspects etc.

Traffic data are collected manually or automated. Manual counts refer to visual observation of traffic flows and are generally applied for short-term purposes or where the traffic situation is complex (e.g. at intersections). Automated counts are generally longer term and make use of pneumatic tubes, inductive loops or infrared sensors linked to traffic counters to measure various traffic data. These counters range from fairly simple axle counters to complex devices capable of measuring individual vehicle data.

Traffic counts are generally of two types, permanent or secondary where permanent means that traffic is monitored for 24 hours per day and 365 days per year. Permanent traffic counts provide data for a number of applications including:

- On line traffic management and surveillance (queue and shock wave detection, incidents, LOS, delays etc)
- Traffic demand and network planning (V/C ratios, bottlenecks etc)
- Pavement management and maintenance
- Traffic forecasting
- Travel demand management
- Etc.

Permanent traffic counts are fully automated and usually conducted on the primary road network. Most European countries have permanent traffic counting stations as part of their freeway surveillance systems on all road links of freeways and motorways. However, not all roads form part of the freeway network where continuous surveillance is essential for providing the necessary throughput and safety. On these remaining primary roads, a number of permanent counting stations are provided per road to allow for the monitoring of traffic volumes in order to establish traffic growths, seasonal and other variations on the major network. These data are used for many different types of analyses ranging from transport planning studies and maintenance scheduling to air quality control studies and facility planning. Furthermore, these permanent counts form the basis by which secondary counts can be expanded to represent Average Annual Daily Traffic (AADT).

Secondary traffic counts are conducted manually or using automated traffic counters. The duration of secondary counts, vary from sample counts during peak and off peak hours to 24-hour counts over a full week. Secondary counts are especially useful for as input for making traffic engineering improvements (i.e. updating traffic signal timings, for determining V/C ratio's, for assessing intersection and road link performance, safety improvements etc.). Examples of secondary counts include:

- Classified Intersection turning counts
- Screen line cordon counts
- Classified traffic volume counts (generally on road links)
- Origin-Destination surveys
- Pedestrian and cycle counts
- Etc.

Road authorities should wherever possible keep records of traffic data and report these annually. For permanent traffic counting stations, these traffic data should include:

- Average annual daily traffic

- Average annual weekday traffic
- Average annual weekend traffic
- Peak hour volumes (including date and time of peak hour)
- Peak period volumes (including the time and duration of the peak period)
- 30th highest hour volume (Design hour)
- % HGV and volumes
- (Hourly) traffic flows over a typical weekday
- Day of week factors
- Seasonal adjustment factors
- Growth factors

For the purpose of general safety analyses the AADT, peak hour volumes, percentage HGV and distributions over time are of particular interest. For specific analyses, data that are more detailed may be necessary (e.g. 15 minute counts, speeds, etc.) and generally these are collected for purpose. However, in some instances it is possible to obtain disaggregated data of this sort from the permanent count data (e.g. Ireland are presently conducting a pilot study into the possibility of adding traffic counter and traffic speed collection to variable message signs on the network alerting drivers of bad bends ahead, or of a school ahead. This information will be relayed automatically (by mobile phone) back to the server at headoffice in Dublin. This will give access to more AADT and traffic speed information on single carriageway road in Ireland).

Secondary count stations record only short-term traffic volumes over time. The following data need to be recorded and reported:

- Average annual daily traffic (estimated from short term count and using factors from adjacent permanent counting stations)
- Average annual weekday traffic (estimated from short term count and using factors from adjacent permanent counting stations)
- Average annual weekend traffic (estimated from short term count and using factors from adjacent permanent counting stations)
- Peak hour volumes (including date and time of peak hour)
- Peak period volumes (including the time and duration of the peak period)

Not all traffic-counting stations are equipped for speed and related measurements. However, it is desirable to have speeds recorded at a number of counting stations locations along each road. As a rule of thumb, at least one speed measurement per road/route number should be carried out annually. On particularly long routes, more speed measurements should be carried out (1/50km of road). The following data should be reported for typical week and weekend days and split by direction (and lanes where relevant):

- Average speed by time of day (hourly or peak/off-peak) and by vehicle class
- Standard deviation of speed by time of day by vehicle class
- Speed distributions by time of day and vehicle class

Where speeds are recorded by individual vehicle (as opposed to recording frequencies in speed bins), it is useful to also report average headways and vehicle lengths.

6.2.1 Deriving reliable estimates from short term counts

Apart from using AADT for forecasting and pavement design, it is extensively used to describe exposure in safety analyses. However, traffic-monitoring programs seldom cover entire road networks and consequently it is inevitable that estimates of traffic volumes need to be derived from (combinations of) secondary or permanent traffic counts.

As mentioned earlier, most road authorities have traffic monitoring programs and in most cases, these have been designed to give the best possible coverage of the road network using a combination of permanent and secondary counting stations. However, in many countries this is not the case and especially the lower order (secondary) network is poorly covered whereas the primary network is only partially covered. For a comprehensive traffic-monitoring programme the following is recommended:

- Ultimately road authorities should aim to have recent traffic counts on all segments of their road networks (primary and secondary; national, provincial and local authority roads). All major intersections (grade separated and all intersections between major roads) should have traffic turning counts available. In the case of road segments these data come from three sources, permanent or secondary counts or from validated traffic models. Intersection counts are derived from secondary counts or from validated traffic models.
- The road network should be segmented in such a way that there are no large traffic sinks or sources between counting stations. As a rule of thumb, on major roads with limited or full access control traffic volumes between counting stations should not differ by more than 10%. From a cost point of view it may well be attractive to provide as few counting stations per road/route (according to number) as possible but this may compromise the reliability of subsequent estimates (especially where there are roads/intersections generating relatively high volumes of traffic between adjacent counting stations). On lower order roads it will probably suffice to maintain a definition of at least one counting station between intersections with roads of the same class.
- The monitoring programme should comprise a combination of permanent and secondary counting stations. The permanent counting stations are counted and reported each year whereas the secondary stations are counted periodically (at least once per 5 years). The road network should be divided (stratified) into logical road segments and representing the different road classes. Road segments that have variable traffic flows or are near to large traffic generators/attractors should have permanent counting stations. Secondary count stations are placed to ensure that all road segments in the network are counted at least once per 5 years.
- The duration of temporary counts is dependant on the type of detectors being used. Generally is it recommended that temporary counts be conducted over a continuous 7-day period. However, if pneumatic tubes are being used it is unlikely that these will operate reliably for 7 continuous days. Consequently the use of pneumatic tubes is restricted to low volume locations not subject to high traffic variability. In these instances shorter-term counts of 48hours will suffice.
- Traffic counting equipment should be able to record and report at least hourly volumes per vehicle class.

Short duration (temporary) traffic counts do not take into account factors such as daily, weekly, monthly or seasonal variations. By applying factors (weekday, seasonal etc.) from adjacent permanent counting stations, short-term counts can de used to estimate AADT. Should the reader require more information, extensive literature is available on this subject (e.g. FHWA, 2001; ITE, 2010; Larsson, 2008).

7 DATA SPECIFICATIONS

This section provides definitions and attributes for the various data elements proposed in Tables 15 and 16 (Section 5). The roadway data elements are presented for roadway segments, for intersections and for the alignment and have been derived from the Model Inventory of Roadway elements (MIRE; Lefler, et. al, 2010).

7.1 Data variables describing roadway segments

1A: **SEGMENT LOCATION**

1. **District Name**

Definition: The name of the province/district where the road segment is located.

Attributes: Alphanumeric characters describing the name

2. **Ownership**

Definition: Description of the owner/controller of the road segment

Attributes: Alphanumeric characters describing the name e.g.

National roads agency

Provincial road agency

Municipal road agency

Water board

Private

Railways

Toll operator

Defence Force

Forestry department

Other

etc

3. **Specific Ownership**

Definition: The specific owner of the road segment.

Attributes: Alphanumeric characters describing the name of the road authority responsible for the road (e.g. name of city; province etc)

4. **Route and section number**

Definition: The listed route (and where relevant section) number.

Attributes: Alphanumeric characters describing the route number and unique section number of the relevant roadway segment.

5. Route/Street Name

Definition: If different or supplementary to the route number, the route or street name

Attributes: Alphanumeric characters describing the name of the route or street

6. Description Begin Point of Segment

Definition: Location information defining the exact location of the beginning of the segment.

Attributes: Segments are by definition homogenous (i.e. have the same essential characteristics over the entire length) and therefore begin and end points are chosen there where a change in the cross-section occurs, an intersection or other discontinuity forms a natural break point. These points are defined by the responsible road authority. The begin point can be either described by a Linear Reference System (official mileposts), by a spatial data system (i.e., GPS co-ordinates) or, in urban areas by a street address. This coding MUST be compatible with crash data location coding.

7. Description End Point of Segment

Definition: Location information defining the exact location of the end of the segment.

Attributes: Segments are by definition homogenous (i.e. have the same essential characteristics over the entire length) and therefore begin and end points are chosen there where a change in the cross-section occurs, an intersection or other discontinuity forms a natural break point. These points are defined by the responsible road authority. The end can be described either by a Linear Reference System (official mileposts), by a spatial data system (i.e., GPS co-ordinates) or, in urban areas by a street address. This coding MUST be compatible with crash data location coding.

8. Segment Length

Definition: The length of the segment.

Attributes: Numeric characters describing the length of the road segment in metres

9. Direction of Inventory

Definition: Direction of inventory

Attributes: Reference compass direction at the begin point and description of direction of travel (e.g. towards XYZ)

IB. SEGMENT CLASSIFICATION

10. Functional Class

Definition: The functional class of the segment.

Attributes: An alphabetic description of the road segment i.e.

- National motorway/freeway
- Provincial motorway/freeway
- Major rural distributor
- Minor rural distributor
- Major rural access road
- Minor rural access road
- Major urban distributor
- Minor urban distributor
- Major urban access road
- Minor urban access road
- Other

11. Rural/Urban Designation

Definition: The rural or urban designation based on country urban boundary and population census data.

Attributes: Description of the designated area in which the road section is located

12. Access Control

Definition: The degree of access control.

Attributes: Description of the type of access control applied to the road segment

- Full access control (no direct access to the road segment other than at designated intersection/interchanges; use restricted to fast motorised traffic)
- Partial access control (some access from adjacent property along segment; certain road users prohibited from use;
- No access control (direct access from properties; all road users permitted)

IC. **SEGMENT CROSS SECTION**

13. Surface Type

Definition: The surface type of the segment.

Attributes: Description of the road surface i.e.

- Unpaved
- Brick paved
- Bituminous
- Open graded asphalt
- Concrete
- Other (specify)

14. Total Paved Surface Width

Definition: The total paved surface width.

Attributes: Numeric value describing the width of the paved roadway surface in metres and measured from edge to edge

15. Skid resistance (or surface friction and texture depth/pavement roughness)

Definition: The average skid resistance of the road segment.

Attributes: Numerical value of the measured (using pendulum tester/scrim or similar) skid resistance (SRV) on the segment. An indication of the number of measurements over the road section must be given (s-single; m-multiple). Where measurements are not available a general description of the wet surface friction can be given (high, medium low).

16. SRV date

Definition: Date the skid resistance value was last recorded

Attributes: mm/dd/yyyy

17. Pavement Roughness/Condition

Definition: The numeric value used to indicate pavement roughness.

Attributes: International Roughness Index (IRI), reported as an integer (cm/km)

18. Pavement Roughness Date

Definition: Date pavement roughness (IRI) was collected.

Attributes: mm/dd/yyyy

19. Number of Through Lanes

Definition: The total number of through lanes (i.e. per carriageway) on the segment and excluding turning lanes, acceleration/deceleration lanes; passing or climbing lanes, shoulders etc

Attributes: A numeric value (1-4)

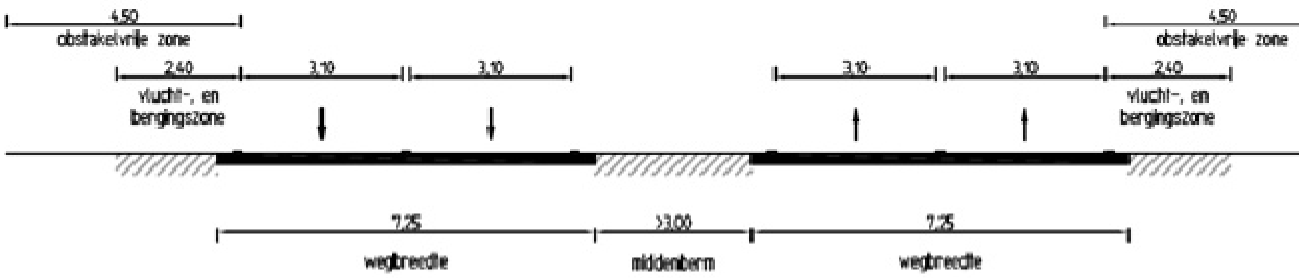
20. Outside Through Lane Width in direction of inventory (see Figure 2)

Definition: Width of the outside through lane (kerb lane) :

- In case of paved shoulders, measured from the inside of the edge line to the inside of the centreline (or lane dividing line where more than one lane per direction) and excluding parking and bicycle lanes.
- In case of unpaved or narrow paved shoulders (<30cm) and broken edge marking near road edge, measured from the road edge to the inside of a centreline marking or centre of lane dividing line (multilane)

Attributes: numerical value in (centi)metres

Figure 2: Example of cross-sectional elements (Province South Holland, 2009)



21. Inside Through Lane Width in direction of inventory (see Figure 2)

Definition: Lane width of inside through lane and excluding inside shoulder. For a two-lane road, leave this element blank.

- In case of paved inner shoulders, measured from the inside of the centreline (or lane dividing line where more than one lane per direction) to the inside of the edge marking
- In case of a narrow paved inner shoulder (<30cm) and broken edge marking near road edge, measured from the inside of a centreline marking or of lane dividing line (multilane) to the road edge.

Attributes: numerical value in (centi)metres

22. Outside Through Lane Width in opposing direction of inventory (see Figure 2)

Definition: Width of the outside through lane (kerb lane) :

- In case of paved shoulders, measured from the inside of the edge line to the inside of the centreline (or lane dividing line where more than one lane per direction) and excluding parking and bicycle lanes.
- In case of unpaved or narrow paved shoulders (<30cm) and broken edge marking near road edge, measured from the road edge to the inside of a centreline marking or centre of lane dividing line (multilane)

Attributes: numerical value in (centi)metres

23. Inside Through Lane Width in opposing direction of inventory (see Figure 2)

Definition: Lane width of inside through lane and excluding inside shoulder. For a two-lane road, leave this element blank.

- In case of paved inner shoulders, measured from the inside of the centreline (or lane dividing line where more than one lane per direction) to the inside of the edge marking
- In case of a narrow paved inner shoulder (<30cm) and broken edge marking near road edge, measured from the inside of a centreline marking or lane dividing line (multilane) to the road edge.

Attributes: numerical value in (centi)metres

24. Auxiliary Lane Presence/Type

Definition: The presence and type of auxiliary lane present on the segment.

Attributes:

- Climbing lane
- Passing lane
- 2+1 lane configuration
- Exclusive continuous right turn lane
- Deceleration lane
- Acceleration lane
- Other

25. Auxiliary Lane Length

Definition: Length of auxiliary lane and excluding any taper.

Attributes: numerical value in metres

26. Presence/Type of Bicycle Facility

Definition: The presence and type of bicycle facility on the segment.

Attributes: Description of type of facility

- None – no bicycles permitted
- None – bicycles on roadway
- Wide kerb lane with no bicycle markings
- Wide kerb lane with bicycle markings
- Separate marked parallel bicycle path
- Other (name)

27. Width of Bicycle Facility

Definition: The width of the bicycle facility, either as located adjacent to the lanes or on the separate path.

Attributes: Width in metres

28. Right Shoulder Type

Definition: The predominant shoulder type on the right side of road in the direction of inventory.

Attributes: Description of shoulder type:

- None
- Wide surfaced shoulder (>1m)
- Stabilized shoulder (stabilized with concrete elements, gravel or other granular material)
- Combination shoulder (shoulder width has two or more surface types; e.g., part of the shoulder width is surfaced and part of the width is earth)
- Earth (soft) shoulder

29. Total Width Right Shoulder

Definition: The total width of the right shoulder including both paved and unpaved parts measured from the centre of the edge line outward and excluding parking or bicycle lanes. Note the predominant width in cases where the width fluctuates over the segment length.

Attributes: width (centi)metres

30. Right Paved Shoulder Width

Definition: The width of paved portion of right shoulder measured from the centre of the edge line to the edge of the road surfacing. If there is adjacent parking or bicycle lanes DO NOT include these in the paved shoulder width measurement.

Attributes: width in centimetres

31. Left Shoulder Type

Definition: The predominant shoulder type on the left side of road in the direction of inventory.

Attributes: Description of shoulder type:

- None
- Wide surfaced shoulder (>1m)
- Stabilized shoulder (stabilized with concrete elements, gravel or other granular material)
- Combination shoulder (shoulder width has two or more surface types; e.g., part of the shoulder width is surfaced and part of the width is earth)
- Earth (soft) shoulder

32. Total Width left Shoulder

Definition: The total width of the left shoulder including both paved and unpaved parts measured from the centre of the edge line outward and excluding parking or bicycle lanes. Note the predominant width in cases where the width fluctuates over the segment length.

Attributes: width (centi)metres

33. Left Paved Shoulder Width

Definition: The width of paved portion of left shoulder measured from the centre of the edge line to the edge of the road surfacing. If there is adjacent parking or bicycle lanes DO NOT include these in the paved shoulder width measurement.

Attributes: width in centimetres

34. Sidewalk Presence (SWP)

Definition: The presence of a paved sidewalk alongside the road segment.

Attributes: Where relevant assign distance codes(1- directly adjacent; 2-within 5m; 3- 5 to 10m; 4-greater than 10m)

- None
- Continuous left-side
- Discontinuous left-side
- Continuous right-side
- Discontinuous right-side
- Continuous both sides
- Discontinuous both sides

35. Cycle path Presence (CPP)

Definition: The presence of a paved cycle path alongside the segment.

Attributes: Where relevant assign distance codes(1- directly adjacent; 2-within 5m; 3- 5 to 10m; 4-greater than 10m)

- None
- Continuous left-side
- Discontinuous left-side
- Continuous right-side
- Discontinuous right-side
- Continuous both sides
- Discontinuous both sides

36. Kerb Presence

Definition: The presence of kerb along the segment.

Attributes:

- No kerb
- Kerb on left
- Kerb on right
- Kerb on both sides

37. Kerb type

Definition: The type of kerb present along the segment.

Attributes:

- No kerb
- Mountable kerb
- Non-mountable or barrier kerb

38. Median type

Definition: The type of median present on the segment.

Attributes:

- No median (Undivided)
- Flush paved median (at least 100cm in width)
- Raised median
- Depressed median
- Two-way left turn lane
- Divided (separate carriageways) without vertical elements (crossover possible)
- Divided (separate carriageways) with vertical elements (Crossover not possible)
-

39. Median Width

Definition: The width of the median, including inside shoulders and measured from the centre of edge line to centre of edge line on inside edges of opposing through lanes).

Attributes: width in centimetres

40. Type Median Barrier

Definition: The presence and type of median barrier along the segment.

Attributes:

- None
- Flexible elements (non protective)
- Kerbed
- Rigid barrier system (i.e. concrete/New Jersey barrier)
- Semi-rigid barrier system (i.e. guardrails, box beam, W-beam strong post, etc.)
- Flexible barrier system (i.e., cable, W-beam weak post, etc.)
- Rigidity unspecified

41. Width of paved median (Inner) Shoulder (only on roads WITH median)

Definition: The width of the paved shoulder on the inner (median) side of the roadway on a divided roadway measured from the centre of the edge line outward.

Attributes: width in centimetres

42. Median Side slope (only on roads WITH median)

Definition: The side slope in the median adjacent to the median shoulder or travel lane. If the side slope varies along the segment, code the predominant side slope.

Attributes: Numeric percentage of the side slope (+ or -)

43. **Median Side slope Width (only on roads WITH median)**

Definition: The width of the median side slope adjacent to the median shoulder or travel lane.

Attributes: numerical value in centimetres

44. Median Crossover/Left Turn Lane Type (only on roads WITH median)

Definition: The presence and type of opposing left turn bays in the median along the segment.

Note: This element is intended to capture the typical median characteristic along the segment at non-intersection locations. Information on intersection-related turn lanes will be coded in the Intersection File.

Attributes:

- None
- Break in median, no left turn bay
- Median crossover, left turn bay in direction of inventory
- Median crossover, left turn bay in opposite direction of inventory

- Median crossover, left turn bays in both directions (unprotected)
- Median crossover, left turn bays in both directions (protected)

45. Roadside Clear zone Width (RCW)

Definition: The clear zone width is the total roadside border area, starting at the edge of the roadway, available for safe use by errant vehicles. This area may consist of a shoulder, a recoverable slope, a non-recoverable slope, and/or a clear run-out area free of obstacles. Note, if there is a foot or cycle path directly adjacent to the roadway then the RCW is measured from the edge of the roadway to the edge of the foot or cycle path)

Attributes: width measured in centimetres

46. Right Side slope

Definition: The side slope on the right side of the roadway immediately adjacent to the lane, shoulder edge or drainage ditch in direction of inventory.

Attributes: Numeric percent (+/-)

- Not applicable – protected by roadside barrier
- Not applicable – other (e.g., city centre street)

47. Right Side slope Width

Definition: The width of the side slope on the right side of the roadway immediately adjacent to the lane, shoulder edge or drainage ditch in direction of inventory.

Attributes: Width in centimetres

48. Left Side slope

Definition: The side slope on the left side of the roadway immediately adjacent to the lane, shoulder edge or drainage ditch in direction of inventory.

Attributes: Numeric percent (+/-)

- Not applicable – protected by roadside barrier
- Not applicable – other (e.g., city centre street)

49. Left Side slope Width

Definition: The width of the side slope on the left side of the roadway immediately adjacent to the lane, shoulder edge or drainage ditch in direction of inventory.

Attributes: Width in centimetres

1D OTHER SEGMENT DESCRIPTORS

50. Major Driveway Count

Definition: Count of major driveways in segment servicing 50-100 parking spaces.

Attributes: Numeric value

- Commercial properties
- Industrial properties
- Residential properties
- Agricultural properties
- Other (name)

51. Minor Driveway Count

Definition: Count of major driveways in segment servicing less than 50 parking spaces.

Attributes: Numeric value

- Commercial properties
- Industrial properties
- Residential properties
- Agricultural properties

52. Terrain type

Definition: The basic terrain type for the segment.

Note: This variable is only included as a last resort where there are no data available on curvature, grade and the nature of the roadside.

Attributes:

- Mountainous - Any combination of grades and horizontal or vertical alignment that cause heavy vehicles to operate at crawl speeds over relatively long distances or at frequent intervals.
- Rolling - Any combination of grades and horizontal or vertical alignment that cause heavy vehicles to reduce their speeds substantially below those of passenger cars but that does not cause heavy vehicles to operate at crawl speeds.
- Level - Any combination of grades and horizontal or vertical alignment that permits heavy vehicles to maintain the same speed as passenger cars; this generally includes short grades of no more than 2 percent.

53. Number of intersections in Segment

Definition: The number of at-grade intersections within the segment. Include at-grade intersections at entrances to shopping centres, industrial parks, and other large traffic generating enterprises (more than 100 parking spaces).

Attributes: Numeric value (count)

- Signalised intersections
- All way stop controlled
- Priority controlled (side roads with stop or yield control)
- Roundabouts
- Uncontrolled

1E SEGMENT TRAFFIC FLOW DATA

54. **Average Annual Daily Traffic (AADT)**

Definition: AADT value to represent the current data year. For two-way facilities, provide the AADT for both directions. If separate carriageways or directionally split, provide directional AADT

Attributes: Numeric value - Vehicles per day

55. AADT Year

Definition: Year of AADT.

Attributes: Numeric value - Year

56. AADT Annual growth

Definition: Annual percent growth in AADT. Calculate average AADT in 5-year period before AADT year and use that as base year.

Attributes: Numeric value – percentage growth

57. Percentage Heavy Goods Vehicle (HGV) or Average Annual Daily Truck Traffic (AADTT)

Definition: Percentage HGV or AADTT.

Attributes: Percent or numeric count

58. Total Daily Two-Way Pedestrian Count/Exposure

Definition: Total daily pedestrian flow along roadway in both directions (or if separate footpaths directionally separated). unless directional segment). Where there are no crossing counts available this could be used as a surrogate measure.

Attributes: Numeric value - Average daily pedestrian count

59. Bicycle Count/Exposure

Definition: The total daily bicycle flow in both directions along the roadway (or if separate cycle paths directionally separated).

Attributes: Numeric value – average cycle counts

60. Peak hour and 30th highest hour volume

Definition: Average peak hour traffic volume and 30th highest hour (design hour) volume

Attributes: Numeric value (average peak hour AADT and 3oth highest hour)

61. Directional Factor

Definition: Proportion of peak hour traffic in the predominant direction of flow.

Attributes: Percentage value

IF SEGMENT TRAFFIC OPERATIONS AND CONTROL DATA

62. One/Two-Way Operations

Definition: Indication of whether the segment operates as a one- or two-way roadway.

Attributes:

- One-way
- Two-way
- One direction of divided roadways

63. Speed Limit

Definition: The posted speed limit applicable to the section

Attributes: Numeric value, speed in km/h, where relevant separate for

- Passenger cars
- Trucks
- Mopeds

64. 85th Percentile Speed

Definition: Average traffic speed exceeded by 15 percent of the vehicles in the flow for this section.

Attributes: Numeric value, speed in km/h

65. Average Speed

Definition: The arithmetic mean (average) of all observed vehicle speeds in the segment (i.e. the sum of all spot speeds divided by the number of recorded speeds).

Attributes: Numeric value in km/h

66. Roadway Lighting

Definition: The type of roadway lighting present along the segment.

Attributes:

- None
- Spot on one side
- Spot on both sides
- Continuous on one side
- Continuous on both sides

67. Edge line marking

Definition: Presence and width of edge line.

Attributes:

- No marked edge line
- Solid 100mm edge line
- Broken 100mm edge line
- Solid 150mm edge line
- Broken 150mm edge line
- Solid 200mm edge line
- Broken 200mm edge line
- Other (name)
-

68. Centreline marking

Definition: Presence and width of centreline.

Attributes:

- No marked centreline
- Single solid centre line
    - 100mm
    - 150mm
    - 200mm
- Double solid centre line
    - 100mm
    - 150mm
    - 200mm
- Single broken centre line
    - 100mm
    - 150mm

    - 200mm
- Double broken centre line
    - 100mm
    - 150mm
    - 200m

69. Centreline rumble strip

Definition: Presence and type of centreline rumble strips on the segment.

Attributes:

- None
- Milled adjacent to centreline
- Rolled adjacent to centreline
- Milled or rolled on/under centreline (e.g., rumble stripes)
- Centreline-rumble strip combination (e.g., raised/inverted thermoplastic profile marker)

70. Passing zone

Definition: Proportion of length where overtaking is allowed.

Attributes: Numeric value, Percentage

- In direction of inventory
- Opposing direction

7.2 Variables describing roadway alignment

IIA HORIZONTAL CURVE DATA

71. Curve Identifiers And Linkage Elements

Definition: All elements needed to define location of each curve record and all elements necessary to link with other files.

Attributes:

Route and location descriptors (e.g., Route number, milepost begin and end; spatial coordinates).

72. Curve type

Definition: Type of horizontal alignment feature being described in the data record.

Attributes:

- Horizontal angle point (i.e., joining of two tangents without a horizontal curve)
- Independent horizontal curve

- Component of compound curve (i.e., one curve in compound curve)
- Component of reverse curve (i.e., one curve in a reverse curve)

73. Horizontal Curve Degree or Radius

Definition: Degree or radius of curve.

Attributes: Numeric, radius in metres

74. **Horizontal Curve length**

Definition: Length of curve including spiral.

Attributes: Numeric, length in metres

75. Curve Super elevation

Definition: Measured super elevation rate or percent.

Attributes: Numeric value, Rate/percent

76. Horizontal Curve direction

Definition: Direction of curve in direction of inventory.

Attributes:

- Right
- Left

IIB. VERTICAL GRADE DATA

77. Grade Identifiers and Linkage Elements

Definition: All elements needed to define location of each vertical feature

Attributes: Route/linear reference system descriptors (e.g., route, beginning and ending mile points; spatial coordinates).

78. Vertical Alignment Feature Type

Definition: Type of vertical alignment feature being described in the data record.

Attributes:

- Vertical angle point (i.e., joining of two vertical gradients without a vertical curve)
- Vertical gradient
- Sag vertical curve (i.e., vertical curve that connects a segment of roadway with a segment of roadway that has a more positive grade)
- Crest vertical curve (i.e., vertical curve that connects a segment of roadway with a segment of roadway that has a more negative grade)

79. Percent of Gradient

Definition: Percent of gradient. Leave blank if record concerns a sag or crest vertical curve.

Attributes: Numerical value, %

80. Grade Length

Definition: Complete only when a vertical gradient (see 78). Length does not include any portion of a vertical curve. Leave blank if record concerns a sag or crest

Attributes: Numerical value, length in metres

81. Vertical Curve Length

Definition: Vertical curve length if type is sag or Crest vertical curve (see 78)

Attributes: Numerical value, length in metres

7.3 Variables describing intersections

IIIA: GENERAL DESCRIPTORS

82. Unique Junction Identifier

Definition: A unique junction identifier/number.

Attributes: User defined (e.g., node number, GPS co-ordinates etc.)

83. Type of Intersection

Definition: Type of Junction described in the data record.

Attributes:

- Systems interchange (interchange ramp terminal between freeways)
- Interchange (intersection between normal road and freeway)
- Roadway/roadway (not interchange related)
- Roadway/pedestrian crossing (e.g., midblock crossing, pedestrian path or trail)
- Roadway/bicycle path or trail
- Roadway/railroad grade crossing
- Other

84. Location Identifier for Road 1 Crossing Point

Definition: Location/co-ordinates of the centre of the junction on the first intersecting route (e.g. route-milepost).

Attributes:

Route and location descriptors (e.g., route and mile point or route and spatial coordinates).

85. Intersection/Junction Number of Legs

Definition: The number of legs entering an at-grade intersection/junction.

Attributes: Numeric value

86. Intersection/Junction Geometry

Definition: The type of geometric configuration that best describes the intersection/junction.

Attributes:

- T-Intersection
- Y-Intersection
- Cross-Intersection (four legs)
- Five or more legs and not circular
- Roundabout
- Other circular intersection (e.g., rotaries, neighbourhood traffic circles)
- Non-conventional intersection
- Midblock pedestrian crossing

87. Intersecting Angle

Definition: The measurement in degrees of the smallest angle between any two legs of the intersection. This value will always be within a range of 0 to 90 degrees (i.e. for non-zero angles, always measure the acute rather than the obtuse angle).

Attributes: Angle in degrees

88. Intersection/Junction Offset Distance

Definition: Offset distance between the centrelines of the intersecting (minor road) approaches.

Attributes: Numeric (Note: when there is no offset this value is zero)

89. Intersection Traffic Control

Definition: Traffic control present at intersection/junction.

Attributes:

- Uncontrolled
- Two-way stop
- All-way stop
- Yield sign
- Signalized (with pedestrian signal)
- Signalized (without pedestrian signal)
- Railroad crossing, gates and flashing lights
- Railroad crossing, flashing lights only
- Railroad crossing, stop-sign controlled
- Railroad crossing, crossroad signs only
- Other

90. Signalization Presence/Type

Definition: Presence and type of signalization at intersection/junction.

Attributes:

- No signal
- Uncoordinated fixed time
- Uncoordinated vehicle actuated
- Progressive coordination (with several signals along either road)
- System coordination (e.g., real-time adaptive UTC systems)
- Railroad crossing signal (includes signal-only and signal and gates)
- Other

91. Intersection/Junction Lighting

Definition: Presence of lighting at intersection/junction.

Attributes:

- Yes
- No

IIIB. **AT-GRADE INTERSECTION APPROACH DESCRIPTORS (PER APPROACH)**

92. Intersection Identifier for this Approach

Definition: The unique numeric identifier assigned to the specific intersection (See 82). This element provides linkage to the basic intersection information and to all other approaches.

Attributes: The intersection identifier entered in Element 82 (Unique Junction id).

93. Unique Approach Identifier

Definition: A unique identifier for each approach of an intersection.

Attributes: Any identifier that is unique for each approach within a single intersection (e.g., sequential numbers or letters, compass directions etc).

94. Approach AADT

Definition: The Annual Average Daily Traffic (AADT) on the approach leg of the Intersection/junction.

Attributes: Numeric value (vpd)

95. Approach AADT Year

Definition: The year of the Annual Average Daily Traffic (AADT) on the approach leg of the intersection/junction.

Attributes: Numeric value - year

96. Approach Directional Flow

Definition: Indication of one-way or two-way flow on approach.

Attributes:

- One-way
- Two-way

97. Number of approach lanes

Definition: Total number of lanes on the approach road to the intersection (number of lanes on road segment prior to intersection, i.e. sum of both directions)

Attributes: Numeric value

98. **Number and configuration of Approach Lanes**
Definition: Total number and configuration of lanes on approach entry (at stop line)

Attributes: Numeric value no of lanes plus description of movement

- No. of dedicates left turn lanes
- No. of dedicated through lanes
- No. of dedicated right turn lanes (non slip lane)
- No of shared lanes
  - Left turn, through and right turn
  - Left turn and through
  - Through and right turn
- No. of slip lanes (right turn)

99. **Number and configuration of exit lanes**
Definition: Total number of lanes on approach exit

Attributes: Numeric value no of lanes

- At stop line
- Merging lanes from intersecting road

100. Left turn treatment

Definition: Type of left turn lane(s) that accommodate left turns from this approach.

Attributes:

- No dedicated left turn lanes
- Conventional left turn lane(s)
- U-turn followed by right turn
- Right turn followed by U-turn
- Right turn followed by left turn (e.g., jug handle near side)
- Other

101. Right Turn Channelisation

Definition: Right turn channelisation on approach.

Attributes:

- None
- Painted island with receiving lane
- Painted island without receiving lane
- Raised island with receiving lane
- Raised island without receiving lane

102. **Traffic Control of Exclusive Right Turn Lanes**

Definition: Traffic control of exclusive right turn lanes on approach.

Attributes:

- Signal
- Yield sign
- Stop sign
- No control (e.g., free flow)

103. **Length of Exclusive Left Turn Lanes**

Definition: Storage length of exclusive left turn lane(s) (not including taper).

Attributes: length in metres

104. **Length of Exclusive Right Turn Lanes**

Definition: Storage length of exclusive right turn lane(s) (not including taper).

Attributes: Length in metres

105. **Median Type at Intersection**

Definition: Median type at intersection separating opposing traffic lanes on this approach.

Attributes:

- Undivided
- Flush paved median (at least 1.2m in width)
- Raised median with curb
- Depressed median
- Two-way left turn lane
- Other divided

106. **Approach Traffic Control**

Definition: Traffic control present on approach.

Attributes:

- Uncontrolled
- Stop sign
- Yield sign
- Signalized
- Railroad crossing, gates and flashing lights
- Railroad crossing, flashing lights only
- Railroad crossing, stop-sign controlled
- Railroad crossing, signs only
- Other

107. **Approach Left Turn Protection**

Definition: Presence and type of left turn protection on the approach.

Attributes:

- Unsignalised
- Signalised with no left turn protection (i.e., permissive)
- Protected, all day
- Protected, peak hour only
- Protected permissive, all day
- Protected permissive, peak hour only
- Other

108. **Signal control**

Definition: Signal control on approach.

Attributes:

- No signal
- Uncoordinated fixed time
- Uncoordinated vehicle actuated
- Progressive coordination (green wave with several signals along same road as approach road)
- System coordination (e.g., real-time adaptive UTC systems)
- Railroad crossing signal
- Other

109. **Crosswalk Type**

Definition: Presence and type of crosswalk crossing this approach.

Attributes:

- No crossing allowed
- Unmarked crosswalk
- Marked crosswalk
- Marked crosswalk with supplemental devices (e.g. flashers, in-pavement warning lights, pedestrian bulb outs, etc.)
- Marked crosswalk with refuge island
- Marked crosswalk with refuge island and supplemental devices
- Marked crosswalk with signals
- Marked crosswalk with signals and refuge
- Other

110. **Crossing Pedestrian Count/Exposure**

Definition: Count or estimate of average daily pedestrian flow crossing this approach.

Attributes: Numeric – pedestrian count (peds/day)

111. **Turn Prohibitions**

Definition: Signed left or right turn prohibitions on this approach.

Attributes:

- No left turns permitted at any time
- No left turn permitted during certain portions of the day
- No right turns permitted at any time
- No right turns permitted during certain portions of the day
- No right or left turns permitted at any time
- No right or left turns permitted during certain portions of the day
- No U-turns

112. **Turning counts**

Definition: Count or estimate of average daily turning movements or percent of total approach traffic (Note: This could also be captured for peak-periods only or by hour of day.)

Attributes: Numeric value (veh/time unit) or % of entry approach volume

- Vehicles turning left
- Vehicles through
- Vehicles turning right

113. **Year of Count**

Definition: Year of count or estimate of average daily left turns or percent of total approach traffic turning left.

Attributes: Numeric value -year

III.C INTERCHANGE AND RAMP DESCRIPTORS

114. **Unique Interchange Identifier**

Definition: A unique identifier for each interchange.

Attributes: User defined (e.g., node number, exit numbers, etc.)

115. **Location Identifier for Road 1 Crossing Point**

Definition: Location of midpoint of interchange (e.g., crossing route) on the first intersecting route (e.g. route-milepost, GPS coordinates).

Attributes: Route and location descriptors (e.g., route and mile point or spatial coordinates).

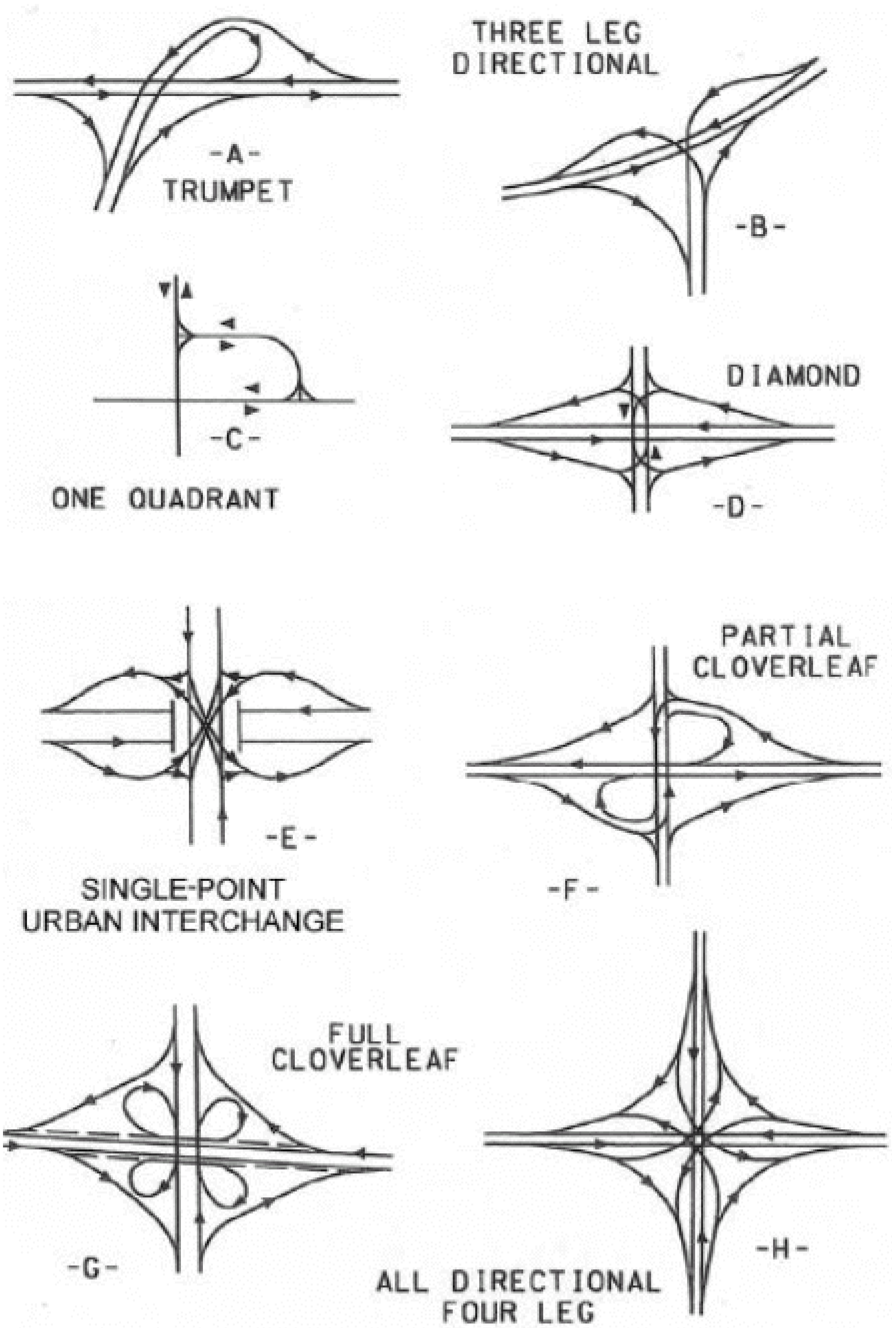
116. **Interchange Type (see Figure 3)**

Definition: Type of interchange.

Attributes:

- Diamond
- Full cloverleaf
- Partial cloverleaf
- Trumpet
- Three-leg directional
- Four-leg all-directional
- Semi-directional
- Single entrances and/or exits (partial interchange)
- Single point interchange (SPI)
- Other

Figure 3: Interchange types



117. Interchange Lighting

Definition: Type of interchange lighting.

Attributes:

- None
- Full interchange-area lighting (high mast)
- Full interchange-area lighting (other)
- Partial interchange lighting
- Other

118. Interchange Entering Volume

Definition: Sum of entering volumes for all routes entering interchange. For each entering route, this is counted at a point prior to the first exit ramp.

Attributes: Average daily volume

119. Interchange ramp Identifier (per ramp)

Definition: The unique numeric identifier assigned to the interchange that this ramp is part of. This provides linkage to the basic interchange information and to all other ramps.

Attributes: The interchange identifier entered in Element 114.

120. Unique Ramp Identifier

Definition: An identifier for each ramp that is part of a given interchange. This defines which ramp the following elements are describing.

Attributes: Alphanumeric (e.g., each set of ramps could begin with 1 or A, each ramp could be identified by its route and exit number, etc.)

121. Ramp Length

Definition: Length of ramp.

- Ramp connecting to an at-grade intersection - measured from painted nose of gore to intersection curb line.
- Ramp connecting to another ramp or a freeway - measured from painted nose of gore to painted nose of gore.

Attributes: Numeric value, length in metres

122. Ramp Acceleration Lane Length

Definition: Length of acceleration lane, excluding any taper.

- Tapered ramps - measured from point of tangency of the last ramp curve to the point where the ramp lane width becomes less than 3,5m.
- Parallel ramps - measured from nose of painted gore to beginning of taper.

Attributes: Numeric value, length in metres

123. Ramp Deceleration Lane Length

Definition: Length of deceleration lane, excluding taper.

- Tapered ramps - measured from the point where the ramp lane width becomes less than 3,5m to the point of curvature of the initial ramp curve.
- Parallel ramps - measured from end of taper to nose of painted gore.

Attributes: Numeric value, length in metres

124. Ramp Number Of Lanes

Definition: Maximum number of lanes on ramp.

Attributes: Numeric value

125. Ramp AADT

Definition: AADT on ramp.

Attributes: Numeric value, veh/day

126. Year Of Ramp AADT

Definition: Year of AADT on ramp.

Attributes: Numeric value, year

127. **Ramp Advisory Speed Limit** (if different to connecting roadway)

Definition: The advisory speed limit on the ramp.

Attributes: Numeric value, km/h

8 Discussion and conclusion

Unsafe road designs can produce life-threatening injury through road crashes. More often however, the defects of the design do not produce a tangible outcome but rather lie dormant over a period, triggered only when combined incompatibly with human error, inappropriate speed, or uncompromising weather features.

To then assess the effect that each of these has on the final goal – to prevent a crash – is not necessarily easy. A number of tools have been highlighted in this report as potential means of assessing the level of road safety: the likelihood of a crash occurring and the likelihood that the outcome is serious. Assessment can focus on immediate safety levels, or be a comparison over time, or over two geographical locations. Similarly, safety levels can be relative, when compared with a common datum point or it can be compared to ideal conditions. Safety standards themselves vary greatly from country to country, and even region, blurring the primary point of comparison.

Most importantly, the quality of the data and the operator of the assessment tool heavily influence the final accuracy of the assessment.

As a result, definition of ‘safety’, and the rating of safety levels can be somewhat subjective. Calibration of some form can help address this by alleviating any shortfalls of an isolated assessment of a road stretch.

Secondly, one of the goals of the project was to seek tools that possess predictive capabilities, so that more proactive measures can be implemented to address design defects of the future. It was additionally anticipated that robust tools would also be able to assess safety at a global level, and not just local. To meet this requirement entails a level of sophistication within the tool that considers combined effects of a complex road network, with variable road user volumes - current and future, a myriad of vehicle shapes and sizes, and a near indefinable range of human behaviour.

While the more complex accident models attempt to address some of these concerns, a visual drive-through assessment of a network, for example, is unlikely to accurately define the interplay between these factors and provide a safety rating on a global scale.

This highlights a gap between some of the requirements of safety assessment tools and the current set of assessment tools available. Additionally it cautions against a heavy reliance on one tool as the final indicator of safety. Nevertheless, underlying all this is the assumption that there are reliable and accurate data available in terms of the road accidents, the road network, traffic volumes, vehicles and road user behaviour. Unfortunately, this is generally not the case.

This guideline proposes a set of data to be collected in support of future road safety engineering analysis tools aimed at improving road safety management in Europe. It is a first attempt at providing a uniformly defined set of road geometric and traffic related data. The recommended data set is by no means exhaustive but is at this point deemed the basic set needed to be able to apply the various state of the art safety engineering analysis tools. Although this dataset in not as complete as others already in use (e.g. HSIS/MIRE, Safety Analyst; German ASB), it should be viewed as the backbone of an evolving database which can be expanded as the need arises. This need will be driven by the use and relevance of the data in such a database. Obviously, road authorities must derive benefits from collecting data; it must be relevant, applicable and serve current needs. It is therefore also the responsibility of road authorities to provide feedback to ERANET-Roads regarding the relevance of the proposed variables in future road safety management and/or to suggest additional variables to be included. It is likely that this will vary from country to country although that is in itself no major problem. More important is that those data that are collected, share a common definition and are collected and stored in the same manner. However, before this can materialise, European road authorities will have to set resources aside to investigate the feasibility of setting up such a database. This will require the collaborative effort of engineers (roads, traffic and safety), planners, data specialists and other key personnel.

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Appendix A : Summary of Crash Data Requirements for List of Safety Assessment Tools

ROAD INFRASTRUCTURE		
	Road Design	Units
R1	Intersection Presence/Intersection per km	Units/km
R2	Intersection Control type	type
R3	(Unexpected) Intersecting Roads/driveways	Units
R4	Road Width	m
R5	Number of lanes	units
R6	Width of lanes	m
R7	Turning provisions	Y/N
R8	Presence/width of median	Y/N
R9	Cross fall	mm/m
R10	Longitudinal distance to intersection hazard	m
R11	Emergency/hardened shoulders	m
R12	Shoulder width	cm/m
R13	Shoulder drop-off	cm/m
R14	Depth and slope of ditches, gutters, etc.	m
R15	Road verge/slope	m/m
R16	Road section Gradient	m/m
R17	Stopping Sight Distance	m
R18	Passing sight distance	m
R19	Curve radius	m
R20	Curve Density	curves/km
R21	Presence of Guidance Devices/km	Units/km
R22	Design Speed limit	km/h
R23	Posted speed limit	km/h
R24	Other	
Road Condition		Units
R25	Texture/material	Type

VEHICLES		
	Vehicle Design	Units
V1	Type of Vehicle	type
V2	Obstruction from A pillars	mm
V3	Vehicle Lighting, mirror, general road worthiness	Y/N
V4	Defects (tyres, brakes, steering, suspension)	Various
V5	Driving Direction	NSEW
V6	Other	
	Safety Features	Units
V7	ABS	Y/N
V8	ESC	Y/N
V9	Collision Avoidance Systems	Y/N
V10	Air bags	Y/N
V11	Safety restraint systems	Y/N
V12	Other vehicle safety technology	Y/N
V13	Other	

TRAFFIC DATA		Units
T1	(Projected) Annual Average Daily Traffic	veh/d
T2	Av and Spot speed measurements	km/h
T3	Traffic Volume at the time of Crash	veh/hr
T4	Vehicle Type Composition (including VRUs and HGVs)	%
T5	Capacity, Headway, Flow rates	various
T6	Lateral Lane Position	m
T7	Potential Conflict with Pedestrians (Availability of pedestrian facilities, operational speed at locations of facilities,	various

road ERA net

R26	Skid Resistance/coefficient of friction (mu)	-
R27	Presence of black ice	Y/N
R28	Other	
Roadside		Units
R29	Presence of hazards	type/km
R30	Presence of Protective Devices/Barriers	m
R31	Hazard Locations (lateral distance to specific hazards)	type/km
R32	Av distance to nearest roadside hazard	m
R33	Crossing of Animals	Y/N
R34	Other	
Visibility		Units
R35	Road Lighting	lux
R36	Sight Obstructions (sight lines, envelopes)	type/km
R37	Other	
Delineation		Units
R38	Line marking visibility (at night, in wet weather, retro reflectivity)	cd/lx/m2
R39	Signage comprehensibility	Y/N
R40	Presence of guidance devices	type/km
R41	Signage location visibility and distance to traffic lane	m
R42	Other	

T8	surrounding land use)	km/h
T9	Operational Speed, Free Speed	
	Other	
CRASH DETAILS		Units
C1	Crash Numbers	units
C2	Primary Crash Type	DCA
C3	Secondary Crash Type	DCA
C4	Crash Frequency	units/year
C5	Crash Location	GPS data
C6	Pre and Post Impact Location of vehicle	GPS data
C7	Roadusers involved	%
C8	Road User detail (age, gender, BAC, fatigue)	various
C9	Crash severity (F, SI, OI)	%
C10	Point of impact on vehicle	mm
C11	Length of skid marks	m
C12	Impact speed	km/h
C13	Evidence of safety system activations	various
C14	Other	

HUMAN FACTORS

Driver		Units
H1	Training	Y/N
H2	Experience	years
H3	Observable Behaviour	Defined Criteria
H4	Socio demographic data	various
H5	Pre and post impact occupant position	mm
H6	Other	

Passenger		Units
H7	Pre and post impact position	mm
H8	Other	
Vulnerable road user		Units
H9	Clothing Details (material, covered regions)	Description
H10	Conspicuity	Description
H11	Safety Equipment (helmet, protection etc)	Description
H12	Other	