ROAD SAFETY PERFORMANCE MEASUREMENT IN SOUTH AFRICA

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1. INTRODUCTION

With resources in the road sector becoming increasingly scarce, the use of performance measurement is becoming more and more important in ensuring the optimal use of these resources for road safety. Accidents, fatalities and injuries provide the most *direct* measure of road safety. Their availability and reliability, however, vary widely. Where fatal accidents are well reported, they are often too few in number to pinpoint any particular group of road users, while random fluctuations make it difficult to identify any meaningful trends. All injury and damage-only accidents, although more appropriate for statistical analysis in terms of number, are often rendered unreliable due to the high degree of under-reporting and poor reporting frequency. Exposure data are seldom available, which makes calculation of risk difficult. It is especially in developing countries that even the most basic data are either not available or reliable enough to develop a picture of the road safety situation. Greater reliance has to be placed on *indirect* measures of road safety that incorporate, among others, descriptors of road user behaviour and road safety awareness.

Much work has been done on direct and indirect performance measurement by especially Sweden and Australia. Despite differences in culture, level of motorisation, infrastructure development and education between these two countries and South Africa, this work can provide a valuable basis from which to develop performance indicators for South Africa.

2. MEASURING ROAD SAFETY

2.1 Primary road safety performance indicators

Basic accident statistics provide the most *direct* indication of the size and nature of the road safety problem in a country (Vägverket, 1999a). Examples of such primary performance indicators include the *absolute numbers* of fatalities, serious and slight injuries, and damage-only accidents. Although this indicator generally has a high validity in terms of its direct relationship with road safety, it often has a low reliability.

The usefulness of primary road safety indicators alone, however, is limited. An element of risk needs to be incorporated by dividing these indicators by some or other measure of exposure. The choice of exposure used depends on the *purpose* of the analysis. There are three basic ways of expressing risk, each revealing specific aspects of the road safety problem. In order to reflect the level of traffic safety or, alternatively, accident risk, any of the primary performance indicators

mentioned in the previous paragraph can be expressed in terms of the *number of registered motor vehicles* in a country (for example the number of fatalities per 100 000 cars). This approach reflects the extent to which road accidents constitute a traffic problem. To reflect the degree of personal safety or risk, the indicators can be expressed in terms of the *number of inhabitants* (for example the number of fatalities per 100 000 population). This approach reflects the extent to which road accidents constitute a public health problem, compared with, for instance, other health problems like Aids and tuberculosis. Lastly, the indicators can be expressed in terms of *total distance travelled* (for example the number of fatalities per 100 million vehicle kilometres travelled) to reflect the level of safety of the whole road transport system and to compare different transport modes.

Each of the above measures of risk has certain limitations. Focusing on only one measure could lead to incorrect conclusions (Silcock *et al*., 1991). For instance, if the rate of increase in motorisation is greater than the rate of increase in fatalities, the fatalities per 100 000 vehicles declines, creating the impression that the roads are getting safer. Expressing risk, instead, as fatalities per 100 000 population reflects that personal safety is, in fact, on the decline. Using only the number of inhabitants to express risk (fatalities per 100 000 population), however, inadequately reflects the level of motorisation of a country, which is important when comparing developing countries with developed countries. In conclusion, there is no all-purpose measure of risk (Evans, 1991). When describing the general level of safety of a country, it is therefore important to use as many measures of exposure as possible.

Exposure for drivers, motorcyclists, cyclists and pedestrians can be expressed either in terms of *number of kilometres travelled*, *number of million hours travelled* or *number of trips*. Although they essentially describe the same journey, they can give very different results when determining risk. For instance, when exposure is measured in terms of number of kilometres travelled, car drivers are at lower risk than cyclists or pedestrians. But when exposure is measured in terms of number of million hours travelled or number of trips, pedestrians are at lower risk than drivers or cyclists. This last measure of exposure is useful when comparing accident risk with risk in other areas (for example in the workplace). Once again the choice of exposure used depends on the purpose of the analysis.

The concept of relative risk can also be used to describe certain aspects of road safety (Vägverket, 1999a), for instance, ratios between numbers of:

- killed *car occupants* and killed *unprotected road users*;
- people killed in *single-vehicle accidents* and people killed in *accidents*;
- people killed on roads in the *daytime* and people killed on roads at *night*;
- people killed on roads in *fine weather* and people killed on roads in *adverse weather*; and
- *young people/adults* killed on roads and *elderly people* killed on roads.

A useful way of indicating the extent of a road safety problem involves graphically depicting three main factors *affecting* road safety, namely: accident rate (risk), accident severity (consequence) and exposure (Figure 2.1) (Road Transport Research, 1997b).

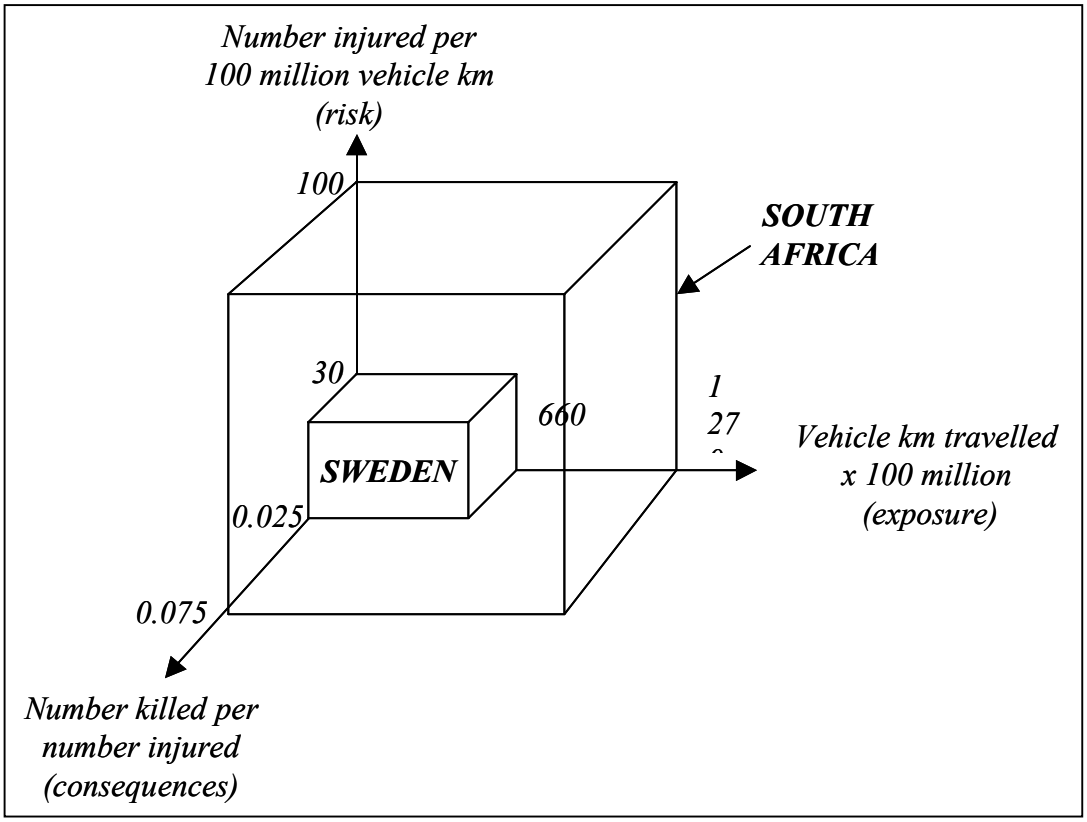

Figure 2.1
A comparison of the road safety problems in Sweden and South Africa, using accident risk, exposure and consequences for 1998.
(Vägverket, 1999b and Central Statistical Service, 1999).

This provides a three-dimensional representation of road safety, where the volume of the cube reflects the magnitude of the road safety problem. This can be mathematically expressed as:

$$\textit{traffic safety problem} = \textit{risk} \times \textit{consequence} \times \textit{exposure} \qquad (1)$$

For example:

$$\textit{fatalities} = \frac{\textit{accidents}}{\textit{exposure}} \times \frac{\textit{fatalities}}{\textit{accidents}} \times \textit{exposure}$$

According to the above hypothetical equation, any countermeasure that reduces any or all of the above factors will improve road safety. A fatality rate can be obtained by multiplying risk and consequence (which also represents the one surface area of the cube). Similarly, the product of risk and exposure gives the number of accidents (which represents the other surface area of the cube). As with the above, road safety can also be expressed as the product of *injury* risk, *injury* consequence and exposure. If exposure data are available for particular road user groups, this type of representation can be used to develop specific road safety "cubes" for car drivers, car passengers, bus passengers, motorcyclists, cyclists and pedestrians. Road safety cubes can also be developed for different age groups of car drivers.

2.2 Secondary road safety performance indicators

In developing countries even the most basic accident, injury and exposure data are either too unreliable to use or unavailable. The only way to gauge the size and nature of the road safety problem then is through the use of *indirect* measures or secondary indicators of road safety (Vägverket, 1999a). Such indicators must still show some correlation with accidents and injuries. Therefore, although they may have a low validity in this regard, secondary indicators generally have a high reliability. The other prerequisite is that these secondary indicators must be *measurable*. Some examples of secondary road safety indicators relate to (Vägverket, 1999a; Road Transport Research, 1997a):

- Road user behaviour
  - traffic law *compliance* rates, traffic offence rates, travel patterns
- Traffic legislation, and its enforcement and surveillance
- Road user awareness of safety problems
  - knowledge, attitudes, opinions
- Road and vehicle standards
  - number and proportion of new vehicles registered each year, median life of vehicles, proportion of two-wheelers among vehicles, proportion of paved roads in the total road network, kilometres of road per car
- Traffic control (including signs, markings and signals)
- Number of near-accidents
- Traffic volume, character and development
- National commitment
  - existence and quality of: road safety organisation and structures, road safety programmes / plans / targets / visions, accident statistics, road safety audits, audits to assess the results of road safety programmes and to measure internal efficiency of road administrations, accident databases and analysis, research, driver training, non-government organisations responsible for road safety, vehicle inspections, safety education at schools and of the public
  - legal framework for road safety, including: traffic laws and regulations, institution and regulation of vehicle inspection and driver training, level of enforcement
  - responsibility and accountability for road safety
  - number of ministries involved with road safety (health, transport etc.)
  - level of cooperation between different departments/organisations/agencies
  - market research (obtaining feedback from road users and incorporating their motivations, attitudes and opinions into policy and programmes)

Secondary road safety indicators are important, even in cases where primary road safety indicators *are* available, in that they provide an added dimension of the road safety picture, which, in itself, is very complex.

2.3 Background indicators of road safety

There are many economic, social and demographic factors that may influence the level of road safety and consequently influence any of the above-mentioned road safety indicators. It is important to take these factors into account when interpreting the primary and secondary road safety indicators. These factors can easily be incorporated into background indicators of road safety. The most important indicators are those that measure the level and speed of motorisation in a country, for example changes in car ownership (cars per 1 000 inhabitants) (Vägverket, 1999a). They provide a broad picture of where a country is positioned with the development of road safety, what level of road safety may be expected in the coming years and which countermeasures will be relevant. These background indicators also show whether changes in motorisation have taken place at a pace that can be sustained by the country's development of road infrastructure and education. Examples of other background indicators are ones that measure population, age distribution of the population, the number of different vehicle types (motorcycles, passenger cars, heavy vehicles), gross domestic product (GDP) and levels of unemployment (Vägverket, 1999a).

3. DEVELOPMENT OF ROAD SAFETY PERFORMANCE INDICATORS FOR SOUTH AFRICA

3.1 Proposed conceptual model for road safety performance indicators in South Africa

The transportation and traffic world is in reality extremely complex. Consequently there exists an extremely large number of possible performance indicators all interrelated in some way. In an attempt to simplify the interrelationships, performance indicators have been grouped together in various ways by making use of conceptual models. A conceptual model proposed for South Africa described below (Figure 3.1) is based largely a model developed by the Swedish National Road Administration (a management-by-results model), while also incorporating aspects of a model developed by the OECD scientific expert group (Stenborg, 1999; Road Transport Research, 1997a). In the proposed model performance indicators have been grouped into five categories according to what they purport to measure:

- the national commitment of Government
- the internal efficiency, effectiveness and productivity of the road administrations
- the quality of products and services
- the short-term effects of the RTS (as reflected by changes in operational conditions within the system)
- the RTS's consequences on society or environment

This incorporates performance indicators at all the different levels of the road transport system, namely inputs, outputs, outcomes and consequences. The quality of the *overall* result is determined by the degree of attainment of *all* the system objectives, as reflected in their respective performance indicators. The road administration uses public funding to provide resources to conduct its activities (*efficiency*) in order to provide products and services (*outputs*) for the users of the road transport system. The products and services result in changes in the operational conditions (*outcome*), which in turn have an overall effect on society (*consequences*).

- ***Government***

Responsibility and accountability for various aspects of road safety occur at different levels of government in South Africa. On a strategic and political level, the National Government (through the Minister of Transport and the National Department of Transport) carries the ultimate responsibility for road safety in the country. It is responsible for providing the general framework within which everything relating to road safety happens and for ensuring the involvement and coordination of other relevant ministries. Performance indicators should consequently be focused at measuring national commitment to road safety. They could include: the absolute numbers of fatalities and accidents; fatality, injury and accident risk; the existence of national road safety strategies, plans, programmes and policies; level of traffic law enforcement, road safety education and road safety-related research.

- ***Road administrations***

On a planning and operational level, the nine Provincial (Road) Administrations are responsible for ensuring the regional and local implementation of national road safety strategies, plans, programmes and policies in the country and for the provision of a safe road environment. Performance indicators should therefore reflect the degree of implementation of road safety strategies, plans, programmes and policies through the measurement of efficiency, effectiveness and productivity. They could include the existence (or quality) of actual methods to assess road safety strategies, plans, programmes and policies and methods to measure vehicle standards, and the existence of road safety audits.

- ***Products and services***

As many products and services relating to road safety in South Africa are provided for by different levels of government (and some by private organisations or agencies in the near future), performance indicators in this model have been separated from those measuring the Provincial (Road) Administrations. Performance indicators should measure the quality of the product and services provided and could include time required to conduct vehicle roadworthy tests, general condition of roads and extent of traffic law enforcement.

- ***Operational conditions***

The products and services invariably have an effect (positive or negative) on the operational conditions within the road transport system. Performance indicators could include the level of noise, driving speed, traffic volume, travel time and cost, vehicle emissions, consumption of petrol, road user attitudes and skills, degree of exposure of vulnerable road users, compliance rates of traffic laws and regulations, and public awareness of road safety issues.

- ***Society or environment***

The operational conditions within the road transport system have an impact on society in general and the environment (and would continue to have an impact for a period of time even if all activity within the system were to cease). Environmental issues in South Africa have to compete with basic needs like housing and the provision of services. Performance indicators

measuring the consequences of the RTS should therefore focus on the very basic environmental issues. They could include existence of air quality standards, existence of inspection programmes for vehicular emissions (government) and emissions per capita for $C0_2$, NO_X and VOC, existence of environmental policy or programmes, and long-term accident consequences in terms of years of employment lost.

As with the Swedish model, the overall result of road safety in South Africa should be determined by the degree of attainment of all the category objectives as reflected by their respective performance indicators.

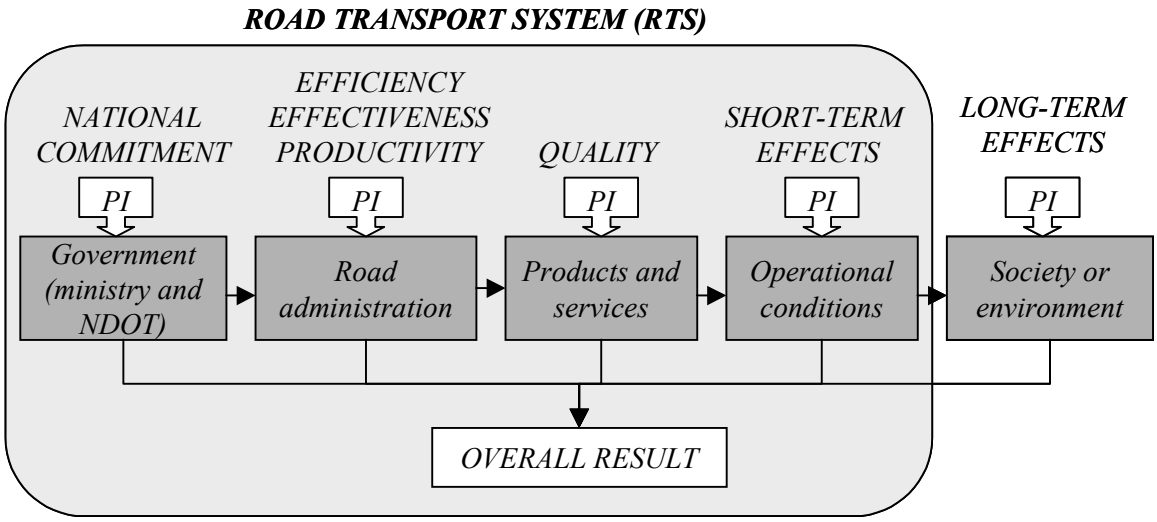

Figure 3.1

A conceptual model proposed for road safety performance indicators in South Africa (adapted from Stenborg, 1999).

3.2 Proposed performance indicators for road safety in South Africa

A number of performance indicators is proposed in this section based on road safety data available in South Africa. The indicators are categorised according to the critical problems areas identified. In this section an indication is given of where the performance indicators fit into the proposed conceptual model outlined in Figure 3.1.

- ***National commitment***

National commitment in South Africa could generally be measured in terms of the amount of money that is being invested annually on road safety in general as well as in terms of specific aspects of road safety like law enforcement, road safety education and research. But it could also be measured by the direct results of its actions in terms of absolute numbers of accidents and casualties, in terms of accident and health risk and in terms of the safety of the road transport

system. The last two-mentioned results could then be compared with other health risks and other transport modes respectively.

- Total annual government spending on road safety (% of GDP)
- Level of traffic law enforcement (manpower resources)
- Number of hours spent at schools on road safety education
- Existence of audit programmes or procedures to assess the results of road safety programmes
- Extent of road safety research (in particular, human behavioural research)
- Absolute numbers of fatalities, and serious and slight injuries
- Absolute numbers of accidents
- Accident risk (traffic safety)
  fatalities per 100 000 cars (registered)
- Health risk (personal safety)
  fatalities per 100 000 population
  fatalities per 100 000 vehicles
- Road transport system safety
  fatalities per 100 million vehicle kilometres

- ***Vulnerable (unprotected) road users***

Pedestrians make up the overwhelming portion of vulnerable road users in South Africa and a significant portion of road users involved in accidents. Measuring exposure and observing behaviour are consequently difficult. Performance indicators should rather therefore focus on measuring pedestrian attitudes and level of awareness of safety issues. The influence of alcohol and/or drugs on pedestrian accidents could be measured by their consequences (in terms of fatalities). The lack of expertise in South Africa and the difficulty in detecting pedestrians under the influence of drugs mean that measurements of blood/alcohol levels will have to suffice as a general indicator of the use (or misuse) of both. The influence of visibility on pedestrian accidents could also be measured in terms of its consequence by comparing daytime accidents with night-time accidents.

- Percentage of road users killed or injured in accidents that are pedestrians
- Ratio between killed car occupants and killed pedestrian road users
- Percentage of pedestrians killed in accidents with blood alcohol levels in excess of 0.08 g/100 ml
- Attitude towards drink-walking
- Ratio of pedestrians killed on roads in daytime and pedestrians killed on roads at night

- ***Overrepresentation of vehicle types and/or drivers in accidents***

The overrepresentation of minibuses in accidents is mostly the result of general unroadworthiness, unlawful driving and overloading, while for buses it is the result of speeding, reckless driving, defective brakes and lights, burst tyres and overloading. Performance indicators could therefore focus on traffic law compliance with respect to vehicle unroadworthiness, reckless and negligent driving, and overloading. Alternatively performance indicators could focus on the consequences of

non-compliance of these, in terms of involvement in and severity of accidents. But preventative road safety actions should also be measured and could include road safety awareness programmes and advanced driver-training courses. A measure of exposure in terms of distance travelled should be included when different types of vehicles involved in accidents are compared with each other.

- Percentage of citation for vehicle unroadworthiness, reckless and negligent driving, and overloading of buses and minibuses
- Percentage of all minibuses involved in accidents
- Percentage of passenger buses involved in accidents
- Number of fatalities resulting from bus and minibus accidents per 100 million vehicle kilometres travelled
- Number of transport industry companies/organisations that has approved road safety programmes

- ***Vehicle condition***

The contribution of vehicle condition to accidents is difficult to determine. Performance indicators should therefore focus on traffic law compliance with respect to vehicle roadworthiness. Vehicle age could also be used as a general indicator of vehicle condition. This should, however, include a measure of exposure in order for risk to be expressed.

- Percentage of vehicles with defective or worn tyres (surveys or vehicle testing)
- Percentage of citations for unroadworthiness
- Median life of vehicles

- ***Legislation***

The existence of road safety legislation is also an important indicator of the government's national commitment towards road safety. Although much has recently happened in South Africa in this regard, legislation must still be introduced regarding child restraint systems, seat-belts for buses and minibus taxis, and compulsory vehicle inspections.

- Existence of legislation regarding the use of child restraint systems
- Existence of legislation regarding the use of seat-belts for buses and minibus taxis
- Existence of legislation regarding compulsory vehicle inspections

- ***Traffic law enforcement (policing)***

Legislation is ineffective unless it is adequately enforced. The general level of traffic law enforcement is in essence an indicator of national, regional and local commitment to road safety. A measure of the level of traffic law enforcement could include total man-hours spent on actual traffic law enforcement on the road. A qualitative measure of these man-hours should also be developed. The level of traffic law enforcement specifically relating to drugs should be measured, as should enforcement measures aimed at combating fatigue of commercial drivers.

- Man-hours spent on actual traffic law enforcement on the road
- Percentage of traffic law enforcement time spent on roadside drug detection
- Number of citations per man-hour spent on traffic law enforcement
- Existence of enforcement/control on driving hours and working conditions of commercial drivers

- ***Traffic law compliance***

In South Africa there is a general disregard for traffic laws and regulations. The most important traffic violations, based on their impact on road safety, are excessive and inappropriate speed, driving under the influence of alcohol and/or drugs, failure to wear a seat-belt, insufficient headway, cargo and passenger overloading, red-light violations, and fatigue-related violations. Performance indicators for these focus on actual compliance rates (surveyed and/or violations), awareness and knowledge of the physical consequences of not complying with traffic laws, and attitudes towards obeying traffic laws. Alcohol sales from liquor retail and hospitality industries appear to have been influenced by the national "***Arrive Alive***" campaign. Alcohol sales could therefore be used as an indirect measure of awareness towards drink-driving.

- Percentage of drivers exceeding the posted speed limit
- Average and 85th percentile speeds
- Attitudes of drivers towards speeding
- Attitudes of drivers towards reducing speed in different weather/road conditions
- Driver awareness and knowledge of the effect of speed
- Percentage of drivers tested / surveyed under the influence of alcohol/drugs
- Percentage of drivers killed in accidents that were under the influence of alcohol and/or drugs
- National alcohol sales
- Attitudes towards the use of seat-belts
- Seat-belt wearing rates
- Average following distance (headway)
- Level of occurrence of cargo and passenger overloading
- Proportion of signal cycles in which a red-light violation occurs
- Knowledge about fatigue
- Ratio of night-time accidents to daytime accidents
- Attitudes towards rest stops (filling-stations)

- ***Adjudication***

For traffic law enforcement to be effective, an effective adjudication system is required. A measure of this effectiveness in South Africa could include the degree to which traffic offenders are successfully prosecuted (that is convictions upheld).

- Percentage of "successful" prosecutions

- ***Road safety education***

As road safety education at especially a young age is generally neglected in South Africa, performance indicators could measure the time spent on road safety education as well as the general availability of qualified teachers/instructors and training material.

- Number of hours spent on road safety education at schools
- Availability of adequately trained road safety teachers/instructors
- Availability of road safety material for training

- ***Engineering measures***

Road safety audits should be the focus of preventative engineering measures and of the general existence and use of accident databases as a measure of reactive engineering measures.

- Degree to which road safety audits form part of planning, design, construction and maintenance of the road network
- Degree to which accident databases have been established and are used for road safety

- ***Road safety research***

The level of road safety research, in particular in the field of driver fatigue and human behaviour, should be measured.

- Level of research being conducted on driver fatigue
- Level of human behavioural research being conducted.

4. CONCLUSIONS

Road safety performance indicators are important tools with which to measure the level of road safety in a country, identify key problem areas and ensure the efficient use of scarce resources through the implementation and monitoring of effective road safety programmes.

In especially developing countries where even the most basic accident, injury and exposure data are either too unreliable to use or unavailable, greater reliance has to be placed on indirect measures or secondary perormance indicators of road safety that incorporate, among others, descriptors of road user behaviour and road safety awareness. Together with primary performance indicators, these also provide an added dimension of the road safety situation.

The work done by OECD member countries (in particular Sweden and Australia) can provide a valuable basis from which to develop performance indicat ors. This has great potential for application in South Africa in the field of road safety but needs to be carefully adapted to local conditions.

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University of Pretoria*:* B Eng (Civil) 1985
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RESEARCH AND PROFESSIONAL WORK

Western Cape Regional Office, Department of Transport (1990 to 1993)
Stefan Lötter was seconded to BS Bergman and Partners as a site agent for a national road construction contract between Worcester and Florence in the Western Cape. His responsibilities included the supervision of: the stabilisation of rock cuttings; minor road construction work; and reinforced concrete bridge construction. He spent a further year and a half at the Cape Town Regional Office in charge of: managing the directional, tourism and advertising signs along all the national routes in the Western Cape. He assisted with a pilot study of a road sign information system of the Oudtshoorn-Mossel Bay-George area, and also initiated and chaired various tourism signs working groups in the Western Cape. He was involved in the preliminary planning, economic evaluation and geometric design of various service roads along the national road in Wilderness.

Directorate Transportation and Traffic, Cape Metropolitan Council (1993 to 1998)
During the initial phase of implementation of the Metropolitan Area Traffic Control System Stefan Lötter assisted with traffic signal design. This included: traffic flow simulations and setting up detail synchronized configuration plans. He was later assigned the task of establishing a transport safety bureau to co-ordinate the traffic safety efforts of 18 local and road authorities in the Cape Town Metropolitan Area. He was also tasked with establishing a metropolitan (GIS) accident database as well as developing independent accident bases for all the metropolitan local authorities. He has conducted various road safety projects and established and facilitated a number of multi-disciplinary road safety forums and committees. Stefan Lötter was involved with the establishment of an incident management system for all the main metropolitan routes. He later then managed the system for two years. During this time his responsibilities included conducting training session and incident debriefings with emergency personnel; facilitating, strategizing and convening steering committee and other meetings; constant liaison with emergency personnel and their heads; monitoring of the system; and attendance of actual incident scenes. He was also involved with the feasibility study and conceptual design of a fog detection and warning system in the Cape Metropolitan Area. Stefan Lötter managed the “Arrive Alive” traffic safety campaign in the Cape Metropolitan Area. This involved: the administration of additional overtime and equipment; monitoring the performance levels of traffic departments; developing procedures and protocols; managing the day-to-day problems; and developing joint law enforcement schedules. He was also involved with the development of provincial and metropolitan policy regarding traffic safety and incident management. Stefan Lötter has also been actively involved in the South African Road Federation where he served as chairman of the sub-committee for traffic legislation and road safety for two years; and as the chairman of the Western Cape Region for a year.

Transportek Division, CSIR, Stellenbosch (1999 -)
Stefan Lötter is currently employed by the CSIR, Transportek as a traffic safety researcher. He has been involved in conducting pedestrian audits as part of the Western Cape Pedestrian Management Plan. He has been involved in various traffic conflict studies in the Western Cape and abroad. He is presently involved in the development of a road safety diagnostic system for Southern African countries for the Swedish International Development Agency.