# Data Systems for the Effective Implementation of a Safe System Approach

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## Abstract

Fundamental to the effective translation of Safe System knowledge into action is the existence of underlying data systems consistent with this approach. Important functions of a data system include permitting assessment of the extent to which the Safe System has been applied across the road system, allowing for monitoring of the progress of road safety strategies created under the System and assisting road safety managers in developing future policy in accordance with Safe System principles. This paper outlines conceptual frameworks defining an ideal data system based fully on the Safe System approach. It then presents an examination of two Australian jurisdictions, namely Western Australia and Victoria, the current status of the data systems in each state and how these compare with the ideal system, and discusses the potential of improved data systems to enhance the translation of Safe System knowledge into practice.

## Keywords

Data, Safe System

## Introduction

The Safe System approach to road safety is now widely accepted in jurisdictions across Australasia. Key elements addressed include Safer Road Users, Safer Roads and Roadsides and Safer Vehicles. Fundamental to the effective translation of Safe System knowledge into action is the existence of underlying data systems consistent with this approach. Important functions of a data system include permitting assessment of the extent to which the Safe System has been applied across the road system, allowing for monitoring of the progress of road safety strategies created under the System and assisting road safety managers in developing future policy in accordance with Safe System principles. A review of data systems currently in place in various jurisdictions revealed that in general they are only partially capable of collecting, compiling and allowing access to information critical to the successful implementation of a Safe System approach. Critically, none of the systems have been specifically designed for this purpose.

The aim of this paper was to provide the framework for an ideal data system based fully on the Safe System approach. It starts by outlining conceptual frameworks defining the ideal data system. It then presents an examination of two Australian jurisdictions, namely Western Australia and Victoria, in relation to the way in which the respective road safety strategies have been formulated under a Safe Systems approach, the current status of the data systems in each state and how these compare with the ideal system, and finally the work that has been undertaken in each jurisdiction to bring their respective collection processes and data systems into line with the ideal system. It then discusses the potential of the improved data systems to enhance the translation of Safe System knowledge into practice.

## Conceptual Frameworks Defining an Ideal Data System

The starting point for establishing a data system based on the Safe System approach involved defining an ideal, comprehensive and integrated road safety data system. At the core of the ideal system is the "Road Trauma Chain" enhanced to ensure that all elements of the "Road Safety Target Hierarchy" were included. These conceptual frameworks are outlined below. This core was then partitioned by the key elements of the Safe System, specifically Safe Users, Safe Roads, Safe Vehicles and Safe Speeds.

The Safe System

The Safe System is a philosophy which addresses at its core the limited ability of humans to tolerate physical force. In Australia, the Safe System concept was first highlighted as an overarching national framework as part of the Australian Transport Council's National Action Plan for 2005 and 2006 [1]. This plan outlined the key road transport system components under the Safe System approach as Safer roads and roadsides, Safer speeds and Safer vehicles, with the foundation of the Safe System approach being Safer road users.

The Safe System framework is shown in Figure 1. Safer road users are compliant with the rules that reflect design standards for safety in the system and allow for some human error. Safer road user behaviours depend on:

- Compliance with rules – a commitment from road users to safer/driving or pedestrian activity.
- Admittance to the system – obtaining and retaining a licence, and observing licence conditions such as graduations and sanctions.
- Support for driving and travelling – information and education, backed by enforcement, to minimise high-risk road user behaviour and to encourage community support for safer road use.

The other key supporting component of the Safe System is adequate and thorough analysis of crash risks.

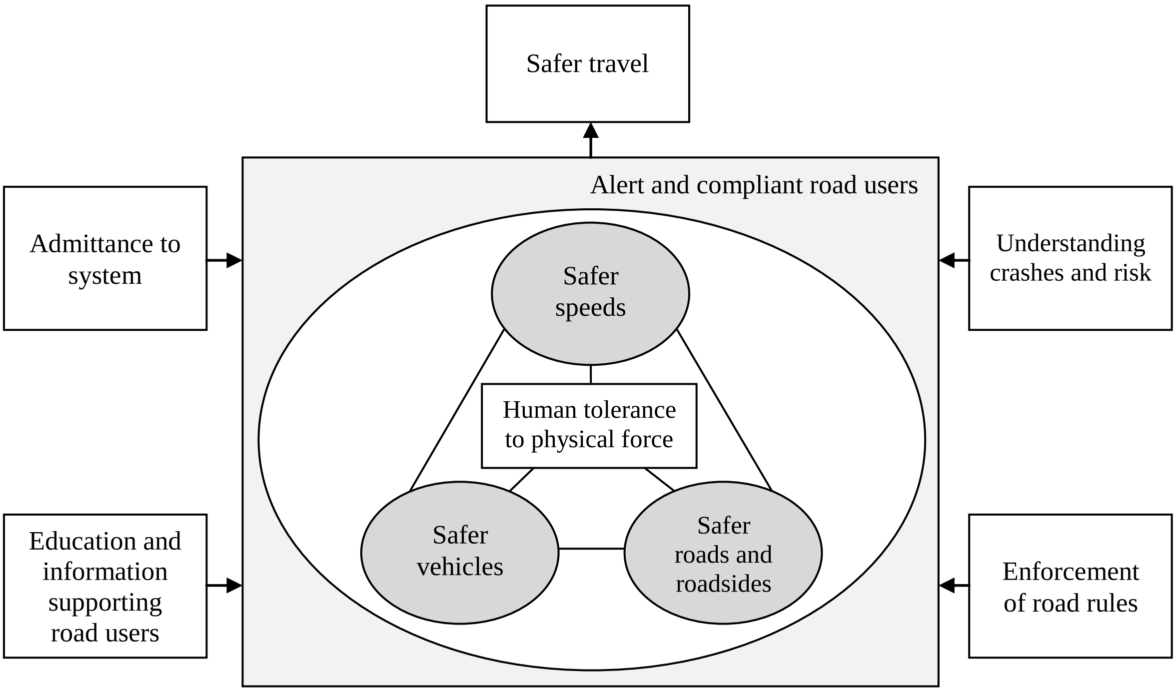


**Figure 1:** The Safe System Framework [1]

The Safe System aims to manage the interaction between road users, roads and roadsides, travel speeds and vehicles. It recognises that it is probably not possible to prevent all crashes due to the inherent propensity of humans to make errors of judgement but aims to prevent those that result in death and serious injury by managing the crash energies that lead to these outcomes. It recognises that human error in the system is inevitable so requires designers to provide a road system that increasingly prioritises safety outcomes to cater for the mistakes people make when using the road transport system within the parameters dictated by the regulations [2].

The Road Trauma Chain

The Road Trauma Chain is shown in Figures 2 and 3. It was originally developed by Cameron [3] to assist in the development of road safety countermeasures through the identification of links where the chain leading to traumatic injury can be broken. It was chosen as it was developed exclusively within the road safety field and was designed to provide the highest level of detail with regards to the breakdown of risk on the road network. It has also been used by Thoresen et al. [4] to provide a framework to conceptualise the principal place(s) in the Chain that could be affected by each major economic, social and road safety factor considered to have influenced the Victorian road toll. Cameron [3] describes how associated with various steps or links in the chain are probabilities or risks of one or more steps. In Figure 2, four different risks of crash involvement are shown depending on the starting point from where the risk is measured. The existence or participation of an entity at a starting point is known as "exposure to risk". In Figure 3, the risks associated with the steps after the crash has occurred are shown. For the injury risks the starting point is crash involvement and this event represents "crash exposure" to injury risk. Another starting point is injury and here the risk is associated with severe injury or death and the exposure to this risk is called "injury exposure" to severe injury.

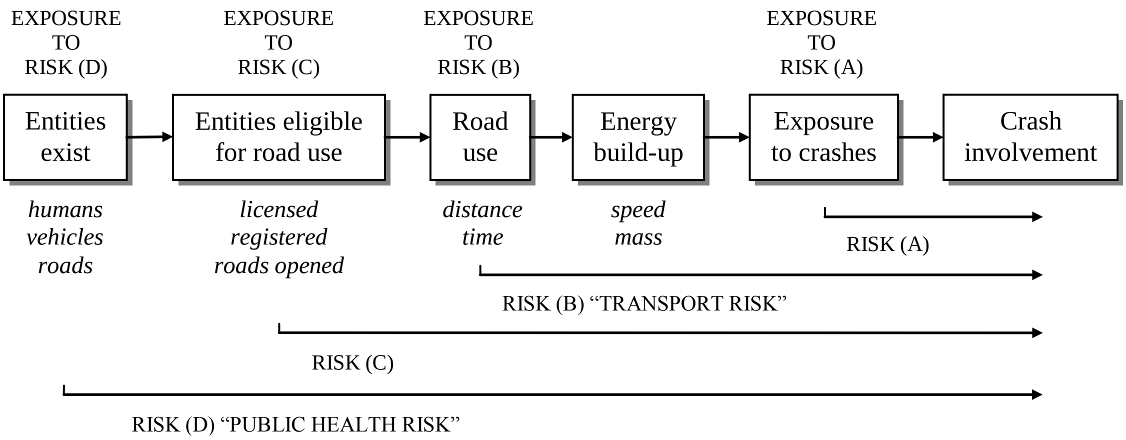


**Figure 2:** The Road Trauma Chain (Pre-Crash)

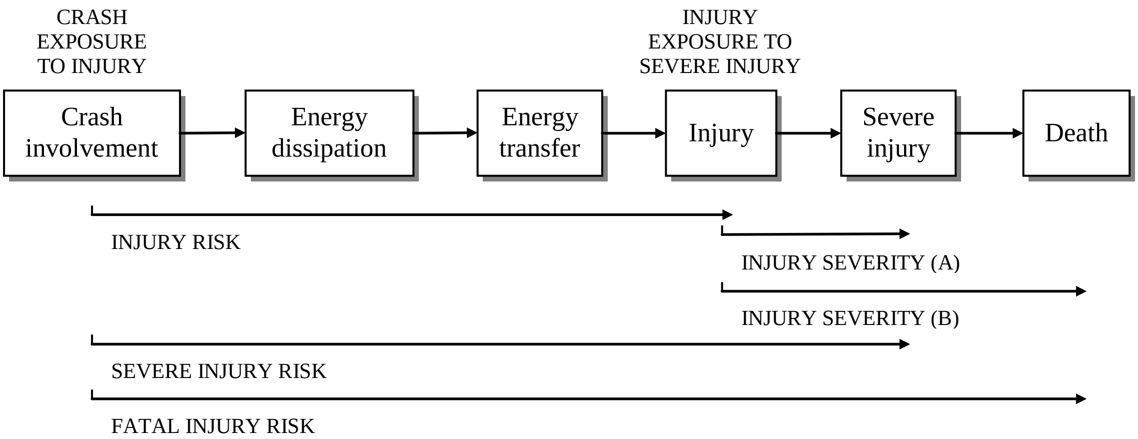


**Figure 3:** The Road Trauma Chain (Crash & Post-Crash)

The Chain defines steps at which one requires measurements of the road system, and it shows the risks that can be measured having defined the steps. In other words, it defines the steps at which measurements of the road system are required to achieve a full understanding of risk on the road network.

The Road Safety Target Hierarchy

Jurisdictions across the world set road safety targets in order to quantify the results they wish to achieve. In addition to crash-based targets, some jurisdictions also utilise intermediate targets. An intermediate indicator is one that is used in addition to accidents or injuries to measure changes in road safety outcomes. There should be a demonstrated causal relationship between each intermediate measure and accidents or injuries.

The role of road safety targets was first illustrated in New Zealand's Road Safety Strategy 2010 consultation document [5]. Targets were defined as road safety outcomes that are accepted by the community and endorsed by government at the highest level. A basic target hierarchy was developed and the key elements are presented in Figure 4. Targets at each level contribute to those at the next level up with social cost at the top. The consultation document defined each level as follows:

- Social Cost is the aggregate measure of all costs that crashes inflict on the community. It generally includes not just material losses but also pain and suffering.

- Final Outcomes consist of fatalities, serious injuries and fatal & serious injury crashes. They are what we seek to avoid and are the main components of social cost.

- Intermediate Outcomes are not desired for themselves but for what they entail – better final outcomes and a link between action and outcome. They include measures of behaviour and environment such as average traffic speeds, the proportion of drunk drivers, the seatbelt-wearing rate, the physical condition of the road network, and the standard of the vehicle fleet. We measure intermediate outcomes both because it is easy to do so and because they are generally reliable indicators of how well our road safety interventions are working.

- Outputs represent physical deliverables, for instance the number of police patrols and the amount of advertising delivered. Alternatively they correspond to milestones showing that a specified task has been completed.

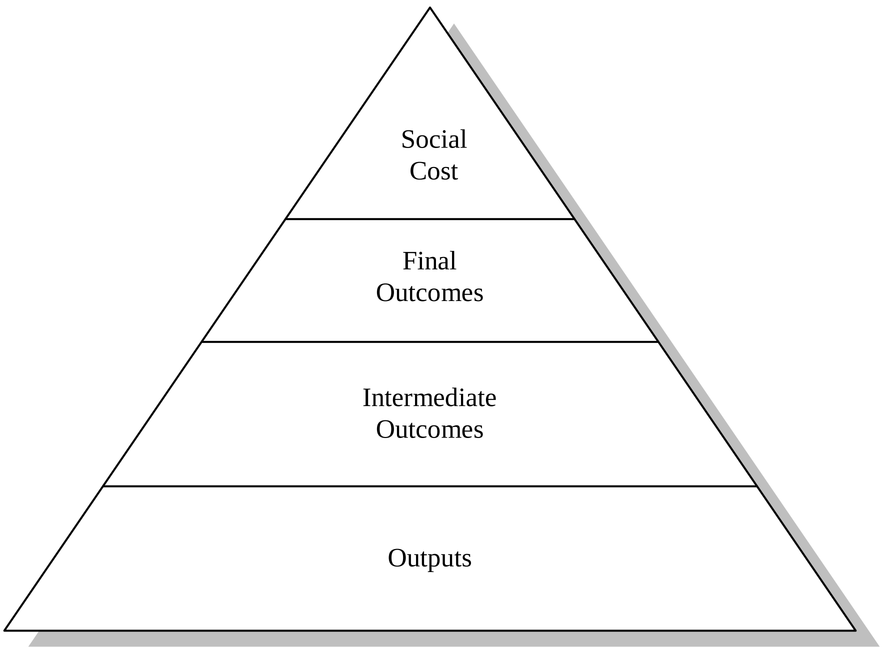


**Figure 4:** Target hierarchy developed for New Zealand's Road Safety Strategy 2010

Outputs are associated as much as possible with intermediate outcomes (e.g. alcohol, speed, restraints) that are necessary to achieve final outcomes (reductions in deaths and serious injuries). Social cost represents the total burden of injury, and can be broken down by road-user groups and regions. This strategy uses an "outcomes management" framework that links what we do (outputs) to what we are trying to achieve (outcomes) [6].

The Ideal Data System

The 2008 report "Towards Zero: Ambitious Road Safety Targets and the Safe System Approach" [7] examined the need for comprehensive crash and road safety performance data collection which it stated needs to include crash statistics, but should also extend to other factors including demographic data, traffic volume data, intermediate outcome measures (or Safety Performance Indicators) and infrastructure factors. It stated that those countries that have already moved, or are currently moving, to a Safe System approach monitor an increasing range of indicators that are pivotal to achieving safe travel. This includes the proportion of drivers travelling at safe speeds, the occurrence of certain crash types and the severe crash outcomes in relation to road infrastructure characteristics, the levels of compliance with seat belt and helmet wearing requirements and blood alcohol limits by drivers and riders and the presence of specific safety features and levels of crashworthiness in the vehicle fleet.

These ideas highlight the need for a data system based on the Safe System approach addressed by the definition of an ideal system presented in this paper. As stated earlier, at the core of the ideal system is the Road Trauma Chain. The Chain allows risk in the road system to be measured through the identification of links where the chain leading to traumatic injury can be broken. Data collected on this basis would enable a full understanding of risk on the road network and when partitioned by key elements of the Safe System would allow road safety managers to monitor relevant trends and to respond with appropriate countermeasures. Such countermeasures would be implemented using Safe System principles, and their effectiveness would also be monitored, thus the data system would facilitate the translation of Safe System knowledge into practice.

As described above, a comprehensive data system needs not only to collect crash statistics, but also other factors, the collection of which is critical for jurisdictions operating under a Safe System. Given the importance of jurisdictional target setting, an ideal data system should collect information at all levels of the Road Safety Target Hierarchy (Figure 4). The ideal system presented in this paper, with the Road Trauma Chain at its core, was developed taking this into account. Firstly, the core was enhanced to include road safety "Activities" (Pre-Crash and Crash & Post-Crash) under which outputs may be listed. The Chain was then modified at Risk (A) from "Exposure to crashes" to "Exposure to hazards". This still enables specific crash risk to be calculated, but also allows for the inclusion of intermediate outcomes as broad measures of risk given they are linked causally to crashes. The Chain already includes final outcomes and social cost (derived from crash data).

**Definition of the Ideal Data System**

Table 1 (Pre-Crash) and Table 2 (Crash & Post-Crash) define the elemental compartments of an ideal data system for the effective implementation of the Safe System approach. Relevant information and examples of measures that should be collected are shown. Items marked with an asterisk (*) relate to Safe Speeds. In addition to crash-related data, a review of the road safety literature identified many intermediate outcomes and outputs utilised as targets across various jurisdictions that could be used to populate the framework.

| | | SAFE SYSTEM | | |
|---|---|---|---|---|
| | | SAFE USERS | SAFE ROADS | SAFE VEHICLES |
| > | ROAD TRAUMA CHAIN (Pre-Crash) | * SAFE SPEEDS | | |
| | **Exposure to risk** | | | |
| > | Entities exist | Population | Length of roads | Number of vehicles/motorcycles |
| > | Entities eligible for road use | Number of licensed drivers/riders | Length of opened roads | Number of registered vehicles/ motorcycles |
| > | Road use | Vehicle Kilometres Travelled (VKT) by road user type | Vehicle Kilometres Travelled (VKT) by road type | Vehicle Kilometres Travelled (VKT) by vehicle type |
| > | Exposure to hazards | e.g. Number of pedestrian crossings | | |
| | INTERMEDIATE OUTCOME MEASURES | e.g. * Proportion of vehicles exceeding the speed limit | e.g. VKT on non-Safe System roads | e.g. Average primary and secondary safety of the light vehicle fleet |
| | **Activities** | e.g. * Speed related enforcement | e.g. Road improvements | e.g. Promotion of vehicle safety features |
| | OUTPUTS | e.g. * Number of speed related infringements | e.g. Number of black spot sites treated | e.g. Level of advertising related to vehicle safety features |

**Table 1:** Definition of the Ideal Data System (Pre-Crash)

| | | SAFE SYSTEM | | |
|---|---|---|---|---|
| | | SAFE USERS | SAFE ROADS | SAFE VEHICLES |
| > | ROAD TRAUMA CHAIN (Crash & Post-Crash) | * SAFE SPEEDS | | |
| | **Exposure to injury** | | | |
| > | Crash involvement | Crash involvement by user type<br><br>e.g. Number of pedestrian crash involvements | Crash involvement by road type | Crash involvement by vehicle type |
| > | Injury | Number of casualty crashes<br>/Number of casualties<br>by road user type | Number of casualty crashes<br>/Number of casualties<br>by road type | Number of casualty crashes<br>/Number of casualties<br>by vehicle type |
| > | Severe injury | Number of serious injury crashes<br>/Number of persons seriously injured<br>by road user type<br><br>Number of serious injury crashes<br>* that involved speeding | Number of serious injury crashes<br>/Number of persons seriously injured<br>by road type | Number of serious injury crashes<br>/Number of persons seriously injured<br>by vehicle type |
| > | Death | Number of fatal crashes<br>/Number of persons killed<br>by road user type<br><br>Number of fatal crashes<br>* that involved speeding | Number of fatal crashes<br>/Number of persons killed<br>by road type | Number of fatal crashes<br>/Number of persons killed<br>by vehicle type |
| | **Activities**<br><br>OUTPUTS | e.g. Trauma management<br><br>e.g. Average response time of Emergency Services | | |

**Table 2:** Definition of the Ideal Data System (Crash & Post-Crash)

**Jurisdictional Analysis**

The ideal data system as represented by Tables 1 and 2 can be used to assist jurisdictions in determining their road safety data system requirements under the Safe System. It does this through outlining the information that is critical to the successful implementation of a Safe System approach thus allowing for identification of the data that is not collected and highlighting the data that is. It also facilitates assessment of existing jurisdictional data systems and their interconnectivity in the context of content, linkage and access which should lead to enhanced usability and the ability to produce appropriate reports and derive relevant measures.

An examination of two Australian jurisdictions, namely Western Australia and Victoria, has found that the collection of data on injuries and crashes (final outcomes) is reasonably adequate, i.e. Table 2 is reasonably well populated, however many measures relating to exposure to risk (Table 1) are not collected. This also includes intermediate outcomes measures. For crashes, it should be noted that at the "Crash involvement" step of the Road Trauma Chain, Victoria only collects information on casualty crashes, i.e. it does not collect any information on non-injury crashes. In addition, it does not collect information on contributory factors in crashes that could be used to easily compile measures such as the "Number of serious injury crashes that involved speeding." For the step "Severe injury", issues relating to the definition of serious injury in Police-collected crash data necessitates the linkage of injury information from hospital data. With regards to exposure to risk, information at the step "Road use" is quite sparse, whilst appropriate measures at the step "Exposure to hazards" are lacking. Ultimately this lack of information means that in many instances we do not know whether final outcomes are a result of high exposure, high crash risk or high injury severity. For example, with regards to vehicles we may not know whether the problem lies at the level of unsafe vehicle exposure, primary vehicle safety or vehicle crashworthiness. Clearly an understanding of where the problem lies is required if we wish to find an effective solution. Quantifying risk requires that information at all steps of the Chain shown in Tables 1 and 2 is collected. This information is important as its allows risk associated with the road network to be monitored so that appropriate road safety countermeasures may be implemented in the short to medium-term in order for long-term road safety targets to be achieved. This requires the road safety strategy of each jurisdiction to include target setting at all levels of the Target Hierarchy (Figure 4) and the collection of data based on the ideal system should enable this to occur.

Western Australia's Road Safety Strategy 2008-2020 "Towards Zero" [2] was developed using a Safe System approach, aiming to improve road safety through the four cornerstones: Safe Road Use; Safe Roads and Roadsides; Safe Speeds and Safe Vehicles. It outlines key initiatives under each cornerstone and lists some performance indicators that will be used to monitor and report on progress. These mainly relate to crashes but also include several measures at the intermediate outcomes and outputs level of the Target Hierarchy. Targets do not appear to have been set at this stage. In Victoria, the *arrive alive 2008-2017* road safety strategy is formulated based on the Safe System approach. Within the approach, three critical elements are addressed, namely Safer Roads and Roadsides, Safer Vehicles and Safer Road Users. Details of the strategy including related initiatives and action plans can be found at www.arrivealive.vic.gov.au. Targets have only been set at the final outcomes level of the Target Hierarchy.

Each jurisdiction does not as yet have in place the data systems and knowledge that would enable a full understanding of the state of risk on the road network under a Safe System. Clearly the data systems in each State were not designed for this purpose however work is being undertaken to varying degrees in each jurisdiction that would bring their respective data systems closer to that of an ideal system. In Western Australia, it is intended that the definition of an ideal system outlined above be applied across the collected data including Police-collected crash data, licensing and registration data, insurance data and hospital data, and for appropriate links between datasets to be developed. In Victoria, aside from the usual collaboration that occurs with regards to data sharing and assessment of data quality by the various road safety agencies namely VicRoads, the Transport Accident Commission, Victoria Police and the Department of Justice, there is currently no specific effort to apply the ideal system across the information held. However, there has been some recent activity focussed on the collection of a broader range of measures relevant to a Safe System including intermediate outcomes and outputs.

Moving towards an ideal data system requires that jurisdictions review their current data systems including content. The way in which data is compiled and stored would be examined and the extent to which different data sources can be linked assessed. The development of appropriate links between datasets is an important part of the process of moving towards the ideal system. This should occur through the use of geo-spatial, road user and vehicle linking keys. Prior to moving towards the ideal system however, a review of the discrete data systems that exist in a jurisdiction and the interconnectivity that exists between these systems is required. Clearly, the linkage of data sources would firstly require issues surrounding ethics and privacy of personal information to be resolved. Other issues such as update frequency and consistency of the data from year to year and the feasibility of providing data in different forms, e.g. disaggregated into categories such as crash circumstances, road user characteristics and crash location could also be reviewed. The creation of a road safety data access system for use by road safety managers and policy makers would follow. In addition, the application of an ideal data system would allow targets to be set at all levels of the Target Hierarchy and the available data would allow for the full monitoring of risk on the road network, an understanding of which would enhance the translation of Safe System knowledge into practice.

**Conclusion**

This paper defines an ideal, comprehensive and integrated road safety data system for the effective implementation of the Safe System approach. Such a data system is critical for the proper monitoring of road safety strategies created under the Safe System, in allowing for the evaluation of the effectiveness of various countermeasures and assisting road safety managers in developing future policy in accordance with Safe System principles. These tasks ultimately allow Safe System knowledge to be translated into practice.

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