Submission to the Road Safety Committee of the Victorian Parliament

INQUIRY INTO SERIOUS INJURY

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TABLE OF CONTENTS

1 BACKGROUND .......................................................................................................................... 6

2 HISTORICAL MEASUREMENT OF SERIOUS INJURY FROM ROAD CRashes IN VICTORIA ... 6

2.1 CURRENT DEFINITIONS OF SERIOUS INJURY FROM ROAD CRashes IN VICTORIA ... 6

2.2 TRENDS IN ROAD CRASH DATA IN VICTORIA AND LIMITATIONS WITHIN THE CURRENT SYSTEM .................................................................................................................. 7

2.2.1 Trends in Serious Injury .................................................................................................. 7

2.3 OVERVIEW AND COMMENT ON DATA SYSTEMS SUPPORTING THE CURRENT MEASUREMENT OF SERIOUS INJURY IN VICTORIA ........................................................................ 11

3 POSSIBLE ALTERNATE MEASURES OF SERIOUS INJURY AND THEIRCalcULATION ........ 14

3.1 MEASURES .......................................................................................................................... 14

3.1.1 Resource Use Measures ............................................................................................... 15

3.1.2 Threat to Life Measures ............................................................................................... 15

3.1.3 Burden of Injury .......................................................................................................... 17

3.2 GENERAL DATA REQUIREMENTS TO CALCULATE EACH INJURY SEVERITY MEASURE. ................................................................................................................................. 18

3.2.1 Resource Use ................................................................................................................ 18

3.2.2 Threat to Life ................................................................................................................ 19

3.2.3 Non-Fatal Burden of Injury .......................................................................................... 20

4 A VICTORIAN ROAD SAFETY DATA SYSTEM TO SUPPORT THE CALCULATION OF NEW MEASURES OF SERIOUS INJURY .................................................................................................................. 21

4.1 THE LINKED TAC-RCIS-TIS SYSTEM (THE MUARC ROAD INJURY DATASET) ....... 21

4.2 A POTENTIAL FUTURE INTEGRATED ROAD SAFETY DATA SYSTEM .................. 23

5 RECOMMENDATIONS ON SERIOUS INJURY MEASURES TO ADOPT IN VICTORIA AND DATA SYSTEM REQUIREMENTS TO SUPPORT THEIR CALCULATION ........................................... 26

6 COSTING SERIOUS INJURY ................................................................................................. 27

7 ADDRESSING THE SERIOUS INJURY PROBLEM IN VICTORIA: REDUCTIONS IN ROAD TRAuma RESULTING FROM DIFFERENT COUNTERMEASURES ............................................... 28

7.1 SAFE ROADS AND ROADSIDES .................................................................................... 30

7.2 SAFE VEHICLES .............................................................................................................. 31

7.3 SAFE SPEEDS ................................................................................................................. 31

7.4 SAFE ROAD USE ............................................................................................................ 32

7.6 SUMMARY OF CONSIDERATIONS FOR IDENTIFYING ROAD SAFETY COUNTERMEASURES TO ADDRESS A NEW MEASURE OF ROAD SAFETY ........................................... 32

8.0 REFERENCES ...................................................................................................................... 33
EXECUTIVE SUMMARY

Serious injury resulting from road crashes for the purpose of reporting official statistics in Victoria is currently defined as an injury resulting in admission to hospital. This is considered to be a very insensitive measure since it encompasses a very wide range of injury outcome from those that can be recovered from fully in a short time period to those that result in a high degree of incapacitation for life. Measuring serious injury using the current metric has the potential to divert resources from those road safety problems that cause the most debilitating injuries. Furthermore, the lack of specific information on injury outcomes including the body region affected can hamper efforts to develop countermeasures best targeted to the injury problems being observed and to fully evaluate their effectiveness. Accurate and consistent measurement of the current measure of serious injury is being hampered by systematic deficiencies in the current key road safety data systems currently in use in Victoria, namely the Victoria Police Traffic Information System (TIS), the VicRoads Road Crash Information System (RCIS) and the Transport Accident Commission injury claims database.

International research has identified a number of potential alternative measures of serious injury that would address the deficiencies noted with the current measures and could be used in the Victorian road safety context. Recommending a single alternative measure of serious injury is a difficult task. Each of the alternate measures which are accessible based on the availability of required data have strengths and weaknesses. Based on the utility of the available measures and their ability to be readily calculated from the available data sources, the International Classification for Diseases (ICD) injury code based Injury Severity Score (ICISS) is recommended as the preferred measure representing threat to life from injuries sustained. It is also recommended that the use of the Disability Adjusted Life Year (DALY) be considered as a measure of long term injury consequences but will require expert and community debate about whether it reflects societal values in relation to the treatment of age at injury in the measure. In addition it is recommended that the underlying ICD based injury coding data from which both ICISS and DALY are calculated should also be made available in road safety data systems to allow a wide range of potential analyses with a very specific focus in body region and severity of injury for relevant countermeasures to be undertaken.

Having a comprehensive road safety data system from which to calculate the recommended measures of serious injury is vital to ensure the accuracy and consistency of the measures. A key requirement of the new data system is the inclusion of ICD coded injuries from the Victorian Admitted Episodes Database (VAED) linked to police reported crash data either directly or through the TAC claims system. A linked TAC-RCIS–TIS data system already established by the Monash University Accident Research Centre in collaboration with TAC forms a sound basis from which to build the new system. It is also important that a management and data repository system be established for the new enhanced road safety data system.

The issue of costing any new measure of serious injury to be used in Victoria can only be properly addressed when the measure or measures of serious injury that are to be used in Victoria for monitoring road safety performance are established. A decision on whether to base the costing on a human capital or willingness-to-pay cost basis needs to be made with the latter more commonly used internationally.

Adopting new measures of serious injury for Victoria will have clear implications for determining the mix of countermeasures to be included in road safety strategies that will
best reduce fatalities and serious injury as defined by the new measures. The new measure will have to be adopted across all road safety systems and activities. This will include adopting the new measures as the focus of key target setting in road safety strategies and explicitly evaluating the effects of road safety countermeasures on the measures adopted. Consequently, METS style modelling approach used over the last decade to formulate Australia’s national and state road safety strategies will be based on the new measures of serious injury when defined.
1 BACKGROUND

The Parliament of Victoria Road Safety Committee is conducting an inquiry into the nature and extent of serious injury in motor vehicle accidents in Victoria. The Committee is seeking submissions from relevant government and non-government agencies, research and academic organisations and the community, addressing the Terms of Reference which are as follows:

(a) determine the appropriate methodology to identify the cost of a serious injury to the Victorian community and economy;
(b) identify processes, including the exchange of data and information between agencies, that will facilitate accurate, consistent and timely reporting of road related serious injuries;
(c) consider best practice definitions and measures of road related serious injury and injury severity, and recommend how road related serious injuries and their severity should be identified and reported in Victoria;
(d) determine the correlation between reductions in fatalities and serious injuries (including for different levels of severity) resulting from different road safety countermeasures;
(e) identify cost effective countermeasures to reduce serious injury occurrence and severity; and
(f) identify best practice in managing long term reductions in serious injury including raising the profile of the serious injury burden.

The Monash University Accident Research Centre (MUARC) was established in 1987 and over the past 20 years has become the peak Victorian road safety research agency. Over its history, MUARC has undertaken a range of research projects both directly and indirectly related to the terms of reference of the inquiry. Through this research work MUARC has also gained an extensive understanding of the processes within the Victorian agencies which support the collection, processing and access of key data sources which inform and facilitate the measurement and reporting of serious injury in Victorian road crashes. This knowledge and experience and the outcomes of relevant research projects undertaken by MUARC have been used to prepare this submission relating to Terms of Reference of the Inquiry.

2 HISTORICAL MEASUREMENT OF SERIOUS INJURY FROM ROAD CRASHES IN VICTORIA

2.1 CURRENT DEFINITIONS OF SERIOUS INJURY FROM ROAD CRASHES IN VICTORIA

Measurement of the severity of injury sustained in road crashes in Victoria for the purpose of monitoring the road toll and trends in road trauma relies largely on the classification of injury outcome by police when reporting a crash. In the process of their requirement for reporting of road crashes in Victoria, police report injury severity on a 5 point scale (killed, injured admitted to hospital, medically treated injury, injury not requiring medical treatment and not injured) with the addition of a field indicating whether a person was admitted to hospital from their injuries. This is collapsed to a 4 point scale (killed, seriously injured – admitted to hospital, other injury, not injured) in the official state road crash statistics held in the VicRoads administered Road Crash Information System (RCIS) which forms the basis of information on road crashes available to the public via the online VicRoads system.
CrashStats (VicRoads, 2013). The seriously injured category in the police-reported crash data is defined as resulting in the crash-involved person being admitted to hospital as a result of injuries sustained in the crash. Along with fatalities, serious injuries from road crashes as defined in the police crash report forms the basis for target setting in Victoria’s road safety strategy (Victorian Government, 2013).

Victoria’s approach to defining serious injury from road crashes based on hospital admission status is similar to that used in the majority of jurisdictions across Australia and internationally. In the Australian context, for many years, aggregate statistics on hospital admissions from police-reported crashes were used to collate national statistics on serious injury from road crashes in Australia (FORS, 2005). Reporting of serious injury on a national level became problematic, however, when New South Wales began to classify non-fatally injured road users in a single category labelled “injured” from 1998 after changes to the NSW police crash recording process. This resulted in additional difficulties in classifying hospital admission. Consequently, the only recent national trends in serious injury from road crashes have been collated directly from the analysis of hospital admissions data collated by the state health departments (AIHW, 2012). Moreover, a number of States have questioned the accuracy of their definitions and accuracy of classification of hospital admissions from road crashes recorded by police.

The use of broad injury outcomes as recorded by police in reporting road crashes is common world-wide. Similarly, the definition of serious injury based on hospital admission status is commonly used albeit with some small variations. For example, in Great Britain, serious injury includes not only hospital admissions but also other injuries such as bone fractures and deep lacerations which may not have resulted in a hospital admission (TSO, 2011). In general, the basis for serious injury in most countries centres on hospital admission.

Like in Australia, concerns have also been expressed in other jurisdictions about the accuracy of police-reported serious injury. For example, in the UK, matching police-reported cases of hospital admission to official Hospital Episodes Statistics (HES) collected from the UK hospital system identified many discrepancies not only with police coded hospital admissions not appearing in the HES data, but also HES recorded admissions for those classified as minor injuries in the police data. These comparisons demonstrate the need to examine the definition of serious injury from road crashes and particularly the data systems which support its collection.

2.2 TRENDS IN ROAD CRASH DATA IN VICTORIA AND LIMITATIONS WITHIN THE CURRENT SYSTEM

Systematic problems have been identified by MUARC in Victoria’s current road safety data system collection, collation and management which have led to problems in the measurement of serious injury due to road trauma.

2.2.1 Trends in Serious Injury

The previous Victorian road safety strategy arrive alive 2008-2017 sets a target of reducing deaths and serious injuries in Victoria by 30% over the 10 year life of the strategy. Whilst the definition of a fatality is clear, the definition of serious injury has been problematic in Victoria as it has been in many other jurisdictions. Although never formally documented, over the past years, the definition of serious injury in Victoria, as derived from police crash reports, has changed from being admitted to hospital to being taken to hospital and back again. The use of the ‘taken to hospital’ definition was a reflection of acknowledged poor follow up by Police in establishing hospital admittance. However this was also subject to
operational biases. For example, the widespread use of mobile phones means ambulances are routinely called to crash sites and patients are then more often transported to hospital as a precautionary measure. There are also issues of privacy raised by the hospitals. It is understood that these trends have resulted in further difficulties for police in Victoria in following up the hospital admission status of road crash victims.

Changes to the Victoria Police crash reporting system with the introduction of the Traffic Incident System (TIS) in December 2005 casts further doubt on the accuracy of the current serious injury measure. This statement stemmed from a review of data in the new system which found that it is not possible to directly compare data in the old system with that in TIS and a major discontinuity in the serious injury data reported was noted. The size of the discontinuity is significant as demonstrated in Figure 2.1 which plots the number of police-reported casualty crashes in Victoria by injury severity level. In response, Victoria Police has advised that since 2006 coding of serious injury changed again to being derived from a combination of taken and admitted to hospital with attempts to validate the hospital admission status through follow-up and other data sources.

VicRoads note these problems in their presentation of police-reported crash data in the public CrashStats system:

“In December 2005, a new data collection process and system was introduced by the police. As a result, a discontinuity in the data series has occurred. Non-fatal data from 2006 onwards should not be compared to previous years’ data when undertaking time-series trend analysis, due to the discontinuity in the data series. It is still valid, however, to use post-2005 data to look at the aggregate 5-year values for problem identification and analysis.”

As a consequence of the on-going changes to the serious injury definition and crash data systems, trends in the serious injury measure over time, the key outcome measure of performance in the Victorian road safety strategy (Victorian Government, 2013), may not reflect real serious injury trends even by the current definition of hospital admission and may not reflect the effectiveness of the strategy.
In crashes, a variation exacerbate admissions of the consistent found Transport and reported to (2012), this time.

Figure 2.1: Police reported casualty crashes in Victoria

In an attempt to validate the accuracy of police-reported trends in serious injury from road crashes, a MUARC investigation by Hoareau et al. (2006) analysed injury severity trends in Transport Accident Commission (TAC) claims data between 2000 and 2004 inclusive and found that hospital admission (as coded in the TAC claims data) did provide a consistent measure of serious injury over time. It was noted that serious injury as derived from police-reported crash data was over-reported and that the over-reporting generally increased over time. Figure 2.2 shows TAC hospital admissions, serious injuries from police crash reports and total number of TAC claims from 2000 to 2009 inclusive reported in D’Elia and Newstead (2012), an extension of the analysis of Hoareau et al. (2006). It can be seen that TAC hospital admissions and police-reported serious injuries track closely at the start of the series with variation occurring as described above from mid-2002 through to 2009 where trends seems to track more closely again. In terms of road trauma outcomes over time, it is clear that, for this period, hospital admission as derived from TAC claims data provides a more reliable and consistent measure of serious injury than that derived from police crash reports.

In summary, research evidence shows police crash reports cannot be relied upon to provide a consistent and accurate measure of the number of hospital admissions from road crashes, the current measure of serious injury. Furthermore, administrative changes to the recording of police crash data, and specifically the introduction of the TIS system, have only served to exacerbate the problem of inconsistency and inaccuracy.
In addition to the noted problems with consistency and accuracy of recording, the use of hospital admission as a measure of serious injury from road trauma has a number of associated problems. Further analysis of TAC claims data used in D’Elia and Newstead (2011b) shows that injuries from road crashes resulting in hospitalisation can have an extremely broad range in both hospital admission duration as well as the likely long term consequences. For example, injuries requiring hospitalisations can range from a mild concussion requiring a day admission to hospital from which the patient will generally make a full recovery in a short time period to major traumatic brain injury that will leave the patient severely disabled and requiring high care for the rest of their life. Clearly there are some injuries currently classified as serious that have a far greater consequence for the individual and society more broadly than others. In other words, the current definition of serious injury has low discriminatory power largely since it is based on information with a lack of any detail.

Lack of detail in the data currently used to derive Victoria’s measure of serious injury from road crashes has also caused problems in the research context. These problems are particularly acute in research focusing on road safety countermeasures that target particular human body regions or injury types. As an example, in an evaluation of the effectiveness of Victoria’s bicycle helmet wearing law introduced in 1992 (Newstead et al, 1994; Carr et al, 1995), use of police-reported serious injury data proved inadequate to properly assess the impact of the legislation. Instead the analysis focused on both TAC claims data and hospital admissions data from the Victorian Admitted Episodes Database (VAED) in order to be able to identify the impact of the legislation specifically on head injury rates amongst bicyclists. A more recent study of the effectiveness of vehicle side airbag systems (D’Elia, Scully & Newstead, 2012) further highlights this problem. Analysis of side airbag effectiveness based on police crash reported injury level alone was unable to identify any injury reductions associated with the technology. In contrast, use of detailed injury outcomes data by body

**Figure 2.2: Road trauma injury trends**
region from TAC claims data was able to identify significant reductions in the risk of head and thorax injury associated with side airbag fitment in vehicles.

Road safety research is increasingly focused on specific injury outcomes related to particular body regions to measure robust associations between road safety countermeasures and injury outcomes. The current measure of serious injury used in Victoria and the data from which it is derived are becoming increasingly inadequate to service this need. Furthermore, as shown by MUARC's side airbag study, reductions in serious injury risk attributable to certain countermeasures are not necessarily being reflected in the current measure of serious injury.

2.3 OVERVIEW AND COMMENT ON DATA SYSTEMS SUPPORTING THE CURRENT MEASUREMENT OF SERIOUS INJURY IN VICTORIA

Understanding the underlying processes by which the road safety data is assembled in Victoria, including serious injury data, is critical to understanding the reasons for the quality and detail deficiencies noted in the previous section. It also helps to understand the other data items that the current serious injury measure is linked with and the critical nature of these data items to road safety research, monitoring and policy development. The information presented in this part of the submission has been gathered through MUARC's research experience as well as through interaction with the key road safety agencies in Victoria who have a role in road safety data collection.

As noted previously, Victoria Police have the responsibility of reporting core information on road crashes in Victoria. It is mandatory for a road crash to be reported to police in Victoria when someone is injured or if property is damaged and the owner not present. Up until the end of 2005, crashes were reported by the use of the Victoria Police 510 form which had details about the people involved in the crash, the vehicles they were driving and crash circumstances. With the move to the Traffic Information System (TIS) at the end of 2005, use of the 510 form was abandoned and replaced by an in-station on-line reporting system. This did not change the basic items covered in the crash reports greatly. However, as noted in the previous section, it changed the consistency, and by implication the likely quality, of the data significantly. Anecdotally, police members applied a range of strategies for recording crash data at the scene including continued use of the 510 form or the use of simple notebooks. Inconsistency in methodology for at-scene documentation of crash information combined with the delay between attendance of the crash and entering into the on-line system are both likely to have led to data quality issues. System changes affecting the quality of crash reporting are not unique to Victoria. Similar problems resulted in New South Wales excluding classification of serious injury on Police report forms around 1998 in Queensland acknowledging data quality issues and long delays in processing and reporting the data around 2006, which have still not been resolved.

A further issue that is reported to have affected the accuracy of police reporting of serious injury in Victoria is the ability of police to verify hospital admission status of road crash victims. Police have reported increasing problems with hospitals not being willing to confirm patient admission status for crash reporting when asked by police, allegedly due to reasons of privacy. It is understood that Victoria Police are working with both VicRoads and the TAC to cross validate hospital admission status although the effectiveness of this process is not known by MUARC.
It is the understanding of MUARC that road crash data from TIS is not available widely for access by non-government agencies and also has some limitations in its value for research and analysis due to the coverage of data fields. Crash data for public and research access is generally provided by VicRoads. VicRoads receive data from TIS after which they validate and code certain fields such as accident type (DCA), vehicle registration and driver licensing information and enhance the data with other information such as crash location and road network details. The data are then stored in the Road Crash Information System (RCIS) where they are used internally for police development and outcomes monitoring, accessed by the public through CrashStats, and made available for research purposes. It is important to note here that although the police have historically collected data from crashes where no injuries have been sustained, RCIS only includes information on crashes in Victoria where someone has been injured (i.e. casualty crashes).

MUARC views the VicRoads police-reported crash database as the official set of police reported crashes in Victoria and the majority of its road safety analytical work is carried out on this data. The enhancements VicRoads make to the data are critical to facilitate many research projects. Furthermore, VicRoads also manages many of the other key research databases necessary to facilitate good road safety research including road network inventory data (and a range of other important spatial information) and the registration and licensing databases. VicRoads, through its Information Service Division also provides the capacity to service data requests from external agencies which is critical to facilitating good road safety research.

By its own description, there are potential problems with the completeness of police reported crash data held in RCIS. According to the CrashStats web site:

“When a crash record is processed within TIS, it is assigned a unique status such as 'Draft or 'Ready for Review' or 'Approved'. An 'Approved' incident means that the record has been finalised and is ready for coding and analysis by VicRoads. VicRoads can only process 'Approved' incidents and these records are subsequently loaded into CrashStats. Unfortunately, not all incidents are available within CrashStats. i.e. The data is 'incomplete'. Various reasons for this include:

- an incident has not yet been approved by Victoria Police, perhaps due to ongoing investigation and/or prosecution via the courts.
- an incident has been approved but cannot be processed by VicRoads, due to incorrect and/or missing information.
- the incident record has been returned to Victoria Police for amendment.”

The magnitude of the incompleteness of the data is often difficult to ascertain and hence so is the impact on its use in various research projects.

Although the TAC does not play a pivotal role in the assembly of the RCIS data, MUARC has found the TAC claims data to be highly valuable for road safety in ways that are directly relevant to this Parliamentary Inquiry. Because of this, it is important to comment on collection of TAC claims data and its interaction with the TIS and RCIS data systems. Data are held by the TAC on all claims made to it for compensation for injuries sustained in transport accidents in Victoria. As the monopoly transport injury compensation insurer in Victoria it includes data on all such claims made. It has been an on-going requirement that TAC claimants provide evidence to substantiate their claim in the form a police crash report. The TAC has access to the police TIS data system to validate the crash reports provided.
Important data available in the TAC claims database relating to this Parliamentary Inquiry, as will become evident in later sections of this submission, is detailed information on the types of injuries sustained by claimants. There are a number of sources of this information. In the process of reimbursing the Department of Health for claimant hospital admission costs, the TAC obtains data from the Victorian Department of Health (DH) on the injuries to each claimant recorded at admission. These injuries are coded using the International Classification for Diseases, Revision 10 Australian Modification (ICD-10-AM), coding system with a separate code for each injury diagnosed. These codes are part of the broader database on hospital admission held by DH called the Victorian Admitted Episodes Database (VAED). For non-hospital admission claimants, the TAC codes in-house injuries diagnosed and recorded on returns for non-hospital medical treatment using an injury coding system known as SNOMED. As will be outlined later both SNOMED and ICD-10-AM codes can be used to derive key measures of injury severity. The TAC also has access to RCIS data which they have merged onto their claims information for internal research purposes although RCIS is not a component of the TAC claims database.

Both TIS and the TAC claims data are essentially administrative databases which have been capitalised on for the purposes of road safety. Only the information in RCIS held by VicRoads has as its primary purpose use for road safety policy setting and research. Some recent research and some administrative changes by both Victoria Police and the TAC highlight the potential fragility of the system by which Victorian road safety data are gathered which has significant impacts for the measurement of serious injury. Recent research undertaken by MUARC has examined the potential of linking TAC claims data with TIS and RCIS information for the purposes of enhancing injury outcomes with a higher resolution measure of injury outcome (D’Elia and Newstead, 2012). In undertaking this study it was identified that, as intended by the TAC claims validation process, the vast majority of TAC claims matched with a police crash report held in TIS. It was also established that in the order of 30% of TAC claims did not match with a crash record in RCIS, the reason for this being was that these cases had originally been coded in TIS as not resulting in injury and had hence not been included in RCIS. The original TIS coding was clearly erroneous since a claim for injury compensation was subsequently made to and accepted by the TAC. It appears that there is no effective feedback loop to include crash information for crashes wrongly identified in TIS as non-injury in RCIS. Consequently, it seems that RCIS currently underestimates injury crash numbers.

It is understood that for administrative efficiency reasons, Victoria Police recently decided not to enter information on non-injury crashes in TIS. It is understood that this has had a significant impact on the TAC’s ability to validate claim eligibility. In response the TAC has relaxed its requirement for a police crash report to be furnished with the claim. Where there had been potential in the system in the past to rectify the problem with the under-reporting of injury crashes in RCIS through a feedback loop via the TAC claims system, this potential has now been lost due to the recent administrative changes.

In summary, the material presented in this section of the submission has attempted to highlight the systematic problems that exist in the current Victorian road safety data systems that should be examined and rectified before any complete and accurate measure of serious injury from Victorian road crashes can be derived. Furthermore, it also highlights that simply measuring trends in serious injury is not sufficient. Whatever measure of serious injury is adopted in Victoria in the future, it needs to be comprehensively linked to the range of available data on factors determining crash risk and injury severity. Through effective
research such comprehensive data will facilitate a sound evidence base on factors determining serious injury outcomes, allowing good evidence-based policy and practise to be developed to effectively address the problem.

3 POSSIBLE ALTERNATE MEASURES OF SERIOUS INJURY AND THEIR CALCULATION

3.1 MEASURES

Approaches to defining serious injury vary according to the perspective taken – societal, health care system, road transport system, injured individual. For example, an injury defined as minor by the health care system because the treatment required was not extensive, and the costs minimal, may well be defined by the injured individual as serious because he/she is a self-employed manual labourer and they are unable to work at all for several months, unable to perform their normal parenting duties and unable to participate in their regular sporting activities. Further, the definition of a ‘serious’ injury can be problematic because the severity of an injury can be measured in a number of ways. The more simple methods involve considering a person as seriously injured if they are admitted to hospital or, once admitted, length of stay can be used as a proxy for severity (e.g., an injury requiring a stay of greater than 3 days could be considered serious). While these methods can be readily applied, using these simple methods based on health care requirements can be misleading as they can be influenced by extraneous factors unrelated to the severity of an injury such as hospital policy or practices, or socio-demographic factors. Defining a serious injury based on the actual injury diagnosis is less likely to be influenced by such factors.

There is a significant body of research describing a range of alternate measures of serious injury with a number of these already in common use internationally. There are a range of these measures that could potentially be used as a new measure of serious injury from road crashes. MUARC work by D’Elia and Newstead (2011b) considered alternate measures or measures of serious injury that could potentially be calculated consistently over time for use in road safety performance monitoring and for research. It included a review of available measures of injury severity that could potentially be calculated from Victorian road safety data sources. The following were recommended as potential measures grouped by their underlying philosophical derivation:

Resource Use
- Hospitalisation (the current serious injury measure in Victoria)
- Probability of hospital admission given crash involvement
- Length of hospital stay.

Threat to Life
- Abbreviated Injury Scale (AIS) injury severity score and associated scores
  - Maximum AIS across all body regions
  - Injury Severity Score (ISS); and
- ICD Based Injury Severity Score (ICISS).

Burden of Injury
- Disability-Adjusted Life Years (DALY).
3.1.1 Resource Use Measures

Resource use measures are based around the simple premise of counting the number of people utilising a health resource. The current measure of serious injury by counting the number of hospital admissions is an example of a health resource measure. Variations on this measure can include measures set around length of stay in hospital, presentation at an emergency department and any other measure that can be made by observing usage of an aspect of the health system.

In general, measures relating to resource use are popular because they are relatively simple to calculate (notwithstanding the problems noted in the Victorian road safety data systems) and they provide a reasonable, albeit somewhat coarse, indication of injury severity. They have some significant weaknesses however including the potential of being affected by hospital admission policy and changes to funding models and the previously noted problem of often being non-specific with a wide variety of injury outcomes often encompassed within a single resource use measure. This means that in some instances trends in serious injury measured from resource use may vary over time with no underlying change in real injury rates whilst at other times the measure might be invariant to real changes in certain important injury types.

3.1.2 Threat to Life Measures

Broadly speaking, threat to life measures of injury severity provide a measure of the probability that a patient will die from the injuries sustained. There are a number of different measures in common use that could be adopted as measures of serious injury from road trauma in Victoria.

Abbreviated Injury Scale (AIS)

The AIS, first published in 1971 by the Association for the Advancement if Automotive Medicine (committee on Medical Aspects of Automotive Safety, 1971), was designed to catalogue anatomic injuries sustained in motor vehicle crashes. Its primary role was to aid in crash investigations by providing detailed anatomical descriptions of occupant injury (O’Keefe et al, 2001). The AIS has two components: (1) the injury descriptor which is a unique numerical identifier for each injury description; and (2) the severity score. The severity score ranges from 1 (minor) to 6 (maximum). An AIS 1 injury will generally not require hospital treatment, whereas an AIS 6 injury is almost certainly fatal (Stephenson et al, 2003). The actual scores to be assigned to various types of injury were derived by consensus among a wide variety of medical specialists (Petrucelli et al, 1981). Detailed information about the injury diagnosis is required to assign an AIS severity score e.g., for a lower leg fracture, the exact type of fracture and the specific bones that are fractured is needed. As trauma patients commonly have more than one injured body part, the severity score for the most severe injury is often used – this is termed the Maximum AIS (‘MAIS’).

The AIS has long been regarded as the injury coding ‘industry standard’ with respect to its ability to describe the actual injury diagnosis (Stephenson et al, 2003). However, the AIS severity score has limitations. It does not address the effects of multiple injuries within one particular body region and scores are not necessarily comparable across body regions (e.g., a brain injury given an AIS score of 4 may represent greater mortality risk than an injury to the lower extremity given the same AIS score) (O’Keefe et al, 2001). As a result of these, and other, limitations, the AIS has undergone many revisions and several scoring systems have also been developed to overcome these shortcomings, including some derived from the AIS.
**Injury Severity Score (ISS)**

The Injury Severity Score (ISS), created in 1974 and based on the AIS, was developed as a means for describing patients with multiple injuries using a single severity score (Baker et al, 1974). To calculate an ISS for an injured person, the body is divided into six body regions (head or neck, face, chest, abdomen or pelvic contents, extremities or pelvic girdle, external injuries) and only the highest AIS severity score in each body region is used. The 3 most severely injured body regions have their score squared and added together to produce the final ISS. While the ISS is thought to give a better fit between overall severity and probability of survival than the AIS or MAIS, it does have several limitations. These include its inability to account for multiple injuries to the same body region and limiting of the total number of contributing injuries to only 3 and consequently, the possible omission of significant injuries altogether (O’Keefe et al, 2001).

**New Injury Severity Score (NISS)**

A modification of the ISS, the New Injury Severity Score (NISS) was developed in 1997 to address the issue of multiple injuries in the same body region (Osler et al, 1997). It is very similar to the ISS except it scores the three most severe AIS scores regardless of their body region location, therefore, multiple injuries within a body region can be accounted for in the calculation of a NISS. The change from ISS to NISS aimed at increasing the predictive value of the index and simplifying its calculation. Research has demonstrated that it is better able to predict survivors from non-survivors (Osler et al, 1997; Brenneman et al, 1998) and is a more accurate predictor of post injury organ failure than the ISS (Balogh et al, 2000).

**International Classification of Diseases Injury Severity Score (ICISS)**

The previously described injury severity scores are all consensus-derived as they are based on the severity score of the Abbreviated Injury Scale (AIS) which was assigned by clinical experts. The International Classification of Disease Injury Severity Score (ICISS) is data-derived and, in contrast to the classifications mentioned previously, is based on the actual average fatality rate for a specified injury calculated using a given large trauma database.

Originally defined in 1996 the ICISS is a score between 0 and 1 and is a “threat-to-life” method that involves estimating probability of death for each ICD injury diagnosis code (Osler et al, 1996). Determining an ICISS score involves calculating a survival risk ratio (SRR) for each individual injury diagnosis, using a large sample of injured people. An SRR is the proportion of cases with a certain injury diagnosis in which the patient does not die, or in other words, a given SRR represents the likelihood that a patient will survive a particular injury. Each patient’s final ICISS score (survival probability) is calculated by multiplying the probabilities of surviving each of their injuries individually. This may be a single SRR, as in the case of a patient with a single injury, or it may be multiple SRRs, as in the case of a patient with multiple injuries (Osler et al, 1996).

A severity threshold can then be used to classify hospital admissions as either “serious” or “non-serious”. For example, serious non-fatal injury can be defined using a severity of injury threshold less than or equal to 0.941 with those cases with an ICISS score greater than 0.941 considered to be “non-serious” (Cryer et al, 2006). An ICISS score of less than or equal to 0.941 is equivalent to selecting patients whose injuries give a survival probability of 94.1% or a probability of death of at least 5.9%.

There are many benefits to using the ICISS such as: scores derived from ICD coding have been shown to provide a reasonable estimate of injury severity; it accounts for multiple
injuries; it is not dependent on a specific version of the International Classification of Diseases (ICD) codes; scores can be calculated directly from the injury codes contained in a given dataset; and, it can be applied retrospectively. Overall, the ICISS appears to be a better predictor of survival than the ISS (Osler et al, 1996).

Numerous limitations or problems with direct estimation using ICISS have also been documented. SRRs generated in one country may not be applicable to another due to different health care systems, and SRRs within countries, or even within areas in countries, may become less reliable due to changes in case outcomes over time. Further limitations of the ICISS include: inclusion of only deaths which occur in hospital could make severity estimates unreliable; the inability to identify individuals who underwent more than one separation within a given study period could result in an overestimation of survival; and, exclusion of non-injury diagnoses means comorbidity is not taken into consideration.  

Recent studies have addressed some of these issues and methods of developing ICISS seem to be continually improving. For example, recent research from Australia (Henley & Harrison, 2009) and New Zealand (McKenzie et al, 2009) investigated the predictive ability of ICISS by comparing different methods of calculating ICISS. These studies found the inclusion of comorbidity and mortality data apparently improves the performance of ICISS markedly.

3.1.3 Burden of Injury

A comprehensive review of burden of injury measures was undertaken in a recent MUARC PhD thesis (Watson, 2005). It identifies only three measures that have been used to estimate the burden of injury employing routinely generated epidemiological data. These are disability adjusted life-years (DALYs) and quality adjusted life-years (QALYs), which can both be estimated directly from ICD injury codes, and the Functional Capacity Index (FCI) based on AIS. It describes these as health gap measures as they represent the loss of health due to injury from an ideal or reference state. It further describes the DALY as the culmination of the evolutionary process supported by a collaboration of the World Bank and the World Health Organisation. DALYs were first introduced in 1993 and a second version was developed for the highly influential 1996 Global Burden of Disease (GBD) Study (Murray and Lopez, 1996). Given the international recognition of the methodology and the availability of data to support its calculation, D’Elia and Newstead (2011b) recommended the DALY as a potential alternative measure of serious injury from road crashes.

**DALY**

As described by Murray and Lopez (1996), one DALY can be thought of as one lost year of “healthy” life. DALYs accrued across a population for a disease or health condition (such a road trauma related injuries) are calculated as the sum of the Years of Life Lost (YLL) due to premature mortality and Years Lost due to Disability (YLD) for incident cases of the health condition. YLL is calculated as the sum of the difference between the life expectancy at the age at which death occurs and the age of the person at death for each fatality summed over all fatal cases. The basic formula for YLD for an individual is the following:

\[ \text{YLD} = DW \times L \]

where:

- \( DW \) = disability weight from 0 (perfect health) to 1 (dead)
- \( L \) = average duration of the injury or disease until remission or death (years)
Total YLD for the population is calculated by summing the values across injured individuals. Clearly, calculation of the DALY requires a number of key data items including an agreed disability weight for each injury being scored, a measure of the average duration of the injury or disease until remission or death and an estimate of the average expected remaining lifetime specific to age at injury.

Watson (2005) noted that DALYs were developed solely for use at the population level by the WHO in characterizing the global burden of disease and injury. This raises some questions about the appropriateness of using DALYs assigned to an individual as a measure of injury severity as would be necessary in the road safety context. However, it was also noted that DALYs provide an inexpensive, efficient but “broad-brush” approach to estimating disease burden and the impact of interventions. The use of the measure by the WHO has given it credibility and a wide acceptance with the measure being applied in many countries including Australia to support policy development by federal and state governments. Despite its acceptance, severe criticism has been levelled at almost every aspect of development and application of the DALY although Watson (2005) dismissed many of these criticisms as being somewhat unjustified. She noted that the development of the DALY is an ongoing process and several methodological revisions have been carried out over time to refine the process and address criticisms. Importantly, D’Elia and Newstead (2011b) note that measuring the non-fatal burden of injury in road safety would be of significant interest but measures such as the DALY still require appropriate validation prior to use within the road safety context. In particular, the validity of using the WHO derived disability weights and estimates of time to recovery or death in the Victorian context needs to be carefully assessed.

3.2 GENERAL DATA REQUIREMENTS TO CALCULATE EACH INJURY SEVERITY MEASURE

In order to operationalize the calculation of each of the key injury severity measures detailed in the previous section there are specific data requirements. Requirements are considered in relationship to what data are currently available in Victoria or likely to be reasonably available in the future.

3.2.1. Resource Use

This information can be obtained directly from the Victorian Admitted Episodes Database (VAED) collected by the Victorian Department of Health (DS). The DH collects coded data on all admitted patients from Victorian public and private acute hospitals including rehabilitation centres, extended care facilities and day procedure centres. This data forms the VAED. Hospital admissions from road traffic crashes can be identified in the VAED using the External Causes of Morbidity and Mortality chapter of the ICD codes in the VAED. Transport accidents are grouped in this chapter according to the characteristics of the injured person (pedestrian, motorcycle rider, car occupant etc.). Importantly, the VAED includes persons injured in crashes regardless of whether a TAC claim has been made or whether the crash was reported to the police. However, without linking the VAED data to the TIS or RCIS data, no other details of the crash important for research and policy development are known.

As described previously, hospital admission information is also available from the TAC claims data for those cases which make a TAC claim for hospitalisation. Admission status is sourced by the TAC from the VAED.
3.2.2 Threat to Life

AIS, ISS and New ISS

AIS is a specialised trauma classification of injuries based mainly on anatomical descriptors of the tissue damage caused by the injury. It has two components, namely the injury descriptor and the severity score (1-6) assigned to each injury descriptor. AIS codes can be assigned directly to road crash injury data by experienced coders who have the clinical details of each injury sustained, a highly time consuming and specialist process. Historically, AIS coding of road crash information has only been used in in-depth crash investigations and is almost never seen on mass data records on hospital admissions. None of the road crash data sources currently available in Victoria include AIS injury coding.

Detailed description of injury in the available Victorian administrative data sets uses the International Classification of Diseases coding introduced previously in this submission, the base source of this information being the VAED data for hospital admissions. For the period 1988/89-1997/98 the VAED data were coded to the International Statistical Classification of Diseases and Related Health Problems, Ninth Revision, Clinical Modification (ICD-9-CM) (Commission on Professional and Hospital Activities, 1989) and from July 1, 1998 data has been coded to the Tenth Revision of this classification system with Australian Modifications (ICD-10-AM) (National Centre for Classification in Health, 1998). ICD codes do not incorporate an explicit severity dimension like AIS codes.

AIS and derivative scores (ISS and NISS) can be derived from ICD codes through complex mapping processes and computer programming to convert the codes for the injury diagnoses into an injury severity score. There is currently no system to directly map ICD-10-AM injury diagnosis codes to AIS scores. There is, however, a method for translating ICD-9-CM codes to AIS scores via the proprietary software package ICDMAP-90 (MacKenzie & Sacco, 1997). Therefore, to apply AIS scores to the ICD-10-AM codes held in the VAED and TAC claims data VAED, injury diagnosis codes first need to be ‘back-mapped’ from ICD-10-AM to ICD-9-CM. While this is possible there is not always direct mapping between ICD-10-AM and ICD-9-CM codes so specificity of some codes would be lost. Specificity would again be lost when translating the generated ICD-9-CM codes to AIS scores as ICD-9-CM diagnosis codes do not, in all situations, correlate well with the AIS injury classification. The consequences of this loss of specificity at several steps in this process are that i) an injury severity score would not be able to be assigned to some injuries, and ii) inaccurate scores could be assigned to others. The resulting severity scores produced through this process would therefore need to be considered to be conservative measures of injury severity, and would be subject to a certain degree of error.

ICISS

ICISS scores are calculated by direct mapping of ICD-10-AM codes to Survival Risk Ratios (SRRs) for each ICD code and then multiplying the SRRs for all injuries sustained by a case together to form ICISS. The Victorian Injury Surveillance Unit at Monash University has calculated ICISS for injured cases in the VAED for the years that are coded to ICD-10-AM (1998/99-2011/12). A set of Australian SRRs published in 2003 was used. These SRRs were calculated from ICD-10-AM coded Australian data for the period from 1 July 1999 to 30 June 2001. The relevant Australian SRR was assigned to each injury diagnosis in the VAED, and the ICISS was then generated for each record on the VAED. VISU generally uses the previously defined threshold defined by Cryer & Langley (2006) for a serious injury i.e., if the ICISS is less than or equal to 0.941 – meaning the injured person has a probability of death (when admitted) of at least 5.9%.
While the application of published SRRs to the VAED to define serious injuries is a more direct process than applying the AIS, the limitations with the direct method of calculating SRRs need to be considered and addressed. Namely, the published Australian SRRs are outdated, and may not necessarily be accurate for Victoria. Furthermore, inclusion of comorbidity and mortality outcomes would markedly improve the performance of ICISS. VISU used the published SRRs to generate ICISS as a measure of injury severity because it was the most readily available method and was applicable to the VAED. This does not necessarily mean it is considered the best measure of injury severity.

Like the AIS measure, use of ICISS as the definition for a serious injury means that hospital data either directly or in the TAC claims data could be used to examine trends in serious road injury. Regularly updated SRRs would need to be calculated to account for changes in survival over time, addressing the limitations in the current methods for calculating the SRRs and ICISS. A number of other jurisdictions around Australia, including News South Wales and Western Australia, have expressed an interest in using ICISS as a measure of serious injury from road crashes and have contemplated the process of producing an updated set of SRRs for use in Australia (D’Elia & Newstead, 2011a).

### 3.2.3 Non-Fatal Burden of Injury

Calculation of the DALY measure requires a number of items of data including the normal life expectancy of a person based on their age at time of injury, disability weights associated with each injury type and the average duration of the injury until recovery or death. The Australian Bureau of Statistics (ABS) regularly produces life expectancy tables that can be used for calculating DALYs. Access to the other two measures is more problematic.

For the original Global Burden of Disease (GBD) study conducted by the WHO, health experts produced tables of injuries and associated estimates of disability weights and duration of disease or injury (Murray, 1996). In the case of injury, the many ICD-9 (and more recently ICD-10) ‘nature of injury’ codes were collapsed into 33 categories of injury and experts were asked to estimate the average duration of treated and untreated forms of each nature of injury category, for each of five age-groups. Disability weights for “average” short-term and long-term outcome health states for each injury category were also derived.

Watson (2005) notes that most of the GBD assumptions are based on expert opinion rather than evidence since there are very few follow-up studies on the ‘natural history’ of injuries. She also notes that in developing national or local estimates of the burden of injury, it is recommended that the assumptions made in the GBD should be discussed with local trauma experts and the results of any local outcome studies be considered.

Studies of the Australian and Victorian Burden of Disease used the GBD generated tables to estimate DALYs in these regions due to disease and injury (Mathers, Vos et al. 1999; Vos and Begg 1999). The approach used here was to make judicious use of the best available information, without undertaking extensive primary data collection.

Like AIS or ICISS measures, calculation of DALYs also requires ICD coded injury data that can be obtained directly from the VAED or TAC claims data. Like the Victorian Burden of Disease study, the GBD derived disability weights and time to recovery or death estimates for the 33 ICD groupings could be used in conjunction with ABS life expectancy tables to calculate DALYs associated with road crashes. Ultimately local disability weights and time to recovery or death estimates could be established through the use of local experts and data sources although this would be a longer term goal.
An intrinsic property of the DALY that is important to consider in its implication for road safety policy is that it weights death and disability more highly for younger people than for older people. Use of the DALY as a measure of road safety performance could have the impact of giving less weight to countermeasures which target older road users than those targeting younger road users. The impact of this consequence would have to be carefully considered.

4 A VICTORIAN ROAD SAFETY DATA SYSTEM TO SUPPORT THE CALCULATION OF NEW MEASURES OF SERIOUS INJURY

The previous section articulated the data requirements to calculate the identified alternative measures of serious injury that could potentially be adopted in the road safety domain. As evident, the majority of these are calculated from the base ICD injury codes obtained from the VAED. As noted before, there are many factors relevant to road injury that are not included in hospital data such as detailed information regarding the actual road incident (crash circumstances, locations, vehicle details) as well as information about patients’ post hospital outcomes. Therefore associations of injury severity with these outcomes cannot be described using the VAED alone, nor could trends in these associations over time be monitored using the VAED. This means the detailed understanding needed for accurate targeting of prevention strategies would not be available. For example, the age of vehicles or the specific features of vehicles associated with more serious injuries could not be identified; or specific road configurations associated with more serious injuries could not be identified.

As described in previous sections, these factors are recorded in other datasets (such as the TAC claims and police-reported TIS or RCIS crash datasets) and ideally, these datasets and the hospital data would be linked. The MUARC has collaborated with the TAC in order to establish a long-term on-going linked TAC claims and police-reported crash dataset that can provide the basis from which to estimate a range of alternative serious injury measures and to facilitate the detailed analysis of injury outcomes by body region.

4.1 THE LINKED TAC-RCIS-TIS SYSTEM (THE MUARC ROAD INJURY DATASET)

Motivated by problems with the current road safety data systems with respect to measuring injury outcomes documented in this submission, MUARC (D’Elia and Newstead, 2010) explored the feasibility of establishing a linked road injury dataset including police-reported crash data, TAC claims data, hospital admissions data and in-depth crash inspection data. Due to the enormity of the task of gaining approvals to link these data sets using personal identifiers, the project used de-identified linkage methods. Results showed linkage of police-reported crash data from RCIS with the TAC claims dataset was feasible and resulted in a combined dataset more capable of measuring detailed injury outcome consistently over time.

An important finding of this project was that the de-identified linkage of hospital admissions data was not found to be feasible, concluding that successful linkage would require identifying information. Although hospital admissions from traffic accidents can be generally identified in the VAED through use of the ICD External Causes codes and the TAC claim status recorded, there was found to be not enough other information to enable a reliable match without using personal identifiers. This was not considered a fundamental flaw as the
critical VAED injury code information is already passed to the TAC and included in their claims data. The limitation it creates is not being able to identify VAED road crash cases that did not lodge a TAC claim.

A subsequent study conducted by D’Elia and Newstead (2011b) saw MUARC collaborate with the TAC to establish a long-term on-going linked TAC-RCIS-TIS database. The capability for measuring detailed injury outcomes comes primarily from the ICD injury codes in the TAC hospitalised claims data which was derived from the VAED via the process of the TAC recompensing the Department of Health for hospital costs. The future potential for assigning ICD codes to non-hospitalised claimant injury data through mapping the SNOMED codes used for these injuries onto the ICD scale using maps developed internally by the TAC was also identified.

Adding the VAED to the linked TAC-RCIS-TIS data would offer a number of additional benefits. Not only would linking all of these datasets improve the validity of the ICISS (by potentially identifying deaths outside of the hospital setting) but would provide a much richer amount of information all in the one data source. It would provide a more complete picture of serious road crash injuries than is currently available as the VAED includes i) persons injured in crashes that would not be recorded in other road injury datasets, ii) persons who have not made a Transport Accident Commission (TAC) claim, and iii) persons injured in crashes that may not have been reported to police.

However, the incremental benefit of linking the VAED with the linked TAC and police-reported crash dataset would need to be assessed in order to judge the merit of including the VAED. Depending on the final definition of serious injury, it could be the case that a very large proportion of serious injuries are already captured in the linked TAC and police-reported crash dataset, and the extra coverage that linking the VAED would provide might not be worth the investment required to overcome the technical and other issues associated with that linkage.

The further project conducted by D’Elia and Newstead (2011b) also aimed to establish the use of TAC claims data linked to police-reported crash data as a way of providing a consistent measure of trends in serious injury in Victoria. In particular, the broad objectives of the project were to establish:

1. an on-going linked dataset of police-reported crash records and TAC claims data for use in a broad range of research requiring injury outcome information; and

2. a measure or measures of serious injury derived from the linked dataset that can be calculated consistently over time for use in road safety performance monitoring and as for base research.

As mentioned earlier, the first aim was achieved through MUARC collaborating with the TAC in order to develop a linked TAC-RCIS-TIS dataset. This included specifying the content of the dataset and establishing an on-going linkage process by the TAC noting that the TAC have linked claims data with Police crash records over many years. To achieve the second aim, the injury coding practices of the TAC were reviewed and issues such as the use of multiple coding systems and their potential translation into a single system were examined.

The TAC linked dataset included information from the following sources described previously:
In order to allow for the broadest possible research uses, the linked dataset included as many relevant variables from each data source as possible after taking into account privacy considerations.

The project made recommendations for the on-going assembly, administration and access of the linked dataset including that:

- the TAC produce an on-going linked dataset covering a sufficiently long time span able to be used for road safety research and for the monitoring of serious injury in Victoria;
- the linked file be held by the TAC and updated every six months;
- the relevant organisations are able to apply to use the linked dataset for research purposes through a data licensing agreement that stipulates how the data may be used and its obligations with respect to data security and privacy.

A current project is examining the test calculation of a number of the alternative serious injury measures outlines in Section 3 including Hospital admission, AIS, ISS, ICISS and DALY.

The findings of the set of MUARC research projects have been significant in the context of this inquiry as they demonstrate that that the underlying data to support the measurement of a range of alternative measure of serious injury has already been developed. This data system not only supports the calculation of these new measures but also contains all the other required information to facilitate the range of monitoring, policy and research uses that will need to be carried out using whichever new measure or measures of serious injury is adopted.

### 4.2 A POTENTIAL FUTURE INTEGRATED ROAD SAFETY DATA SYSTEM

The linked TAC-RCIS-TIS data system is seen as the first step in an integrated road safety data system including more specific measures of serious injury that can enhance the ability of Victoria to develop future road safety policy based on leading edge data and research. In Western Australia, the Road Safety Council (RSC) was interested in developing an enhanced road safety data system to improve the quality, relevance and timeliness of road crash and injury data collection, including the consistency of information from various sources and elimination of bias due to organisational responsibilities. The system would have the capacity to quickly answer current road safety questions and potential unasked queries and provide information on road crashes and injuries including trends in serious injury. It would also enable access to information on intermediate behaviours, road use, road safety program and other relevant agency inputs and socio-economic factors. The system would be available for use by the key Western Australian agencies interested in road safety.
MUARC conducted a project (D’Elia and Newstead 2011c) that aimed to identify and undertake the fundamental groundwork required prior to the establishment of a road safety database access system. Specifically, the project aimed to define the content and scope of an ideal road safety data system based on the current “Safe System” paradigm for developing road safety policy and countermeasures, to compare this with the current road safety data systems available in Western Australia and to map a path for translating the current system into the ideal one. The project developed a conceptual framework for defining an ideal, comprehensive and integrated road safety data system to support the Safe System paradigm and determined specific road safety data system requirements in the Western Australian context from the conceptual framework. It then reviewed existing road safety data systems available in Western Australia including current linkages between these datasets and identified key requirements for moving from the current Western Australian road safety data system to the ideal system specified including additional data requirements and requirements for additional linkages. Importantly, the conceptual framework also included all the elements required to calculate the measures of serious injury defined in this report. The final recommended system is depicted in Figure 4.1.
Figure 4.1: Elements of Western Australia’s Ideal Road Safety Data System

DLU – Data Linkage Unit
HMDS – Hospital Morbidity Data System
IIPS – Image and Infringement Processing System
IMS – Incident Management System
IRIS – Integrated Road Information System
OCRF – Online Crash Reporting Facility
RUM – Road User Movement
TEACEIS – Traffic Enforcement And Crash Executive Information System
TRELIS – Transport Electronic Licensing Information System
WA DLS – Western Australian Data Linkage System

**Figure 4.1: Elements of Western Australia’s Ideal Road Safety Data System**
The Western Australian Government is now using the outcomes of this project as the blueprint for development of its road safety data systems. Developing a new measure of serious injury in Victoria presents an opportunity for Victoria to also review its broader road safety data system in order to achieve the best possible resource to support work in achieving future reductions in Victorian road trauma. Adaptation of the blueprint provided to Western Australia to the Victorian context would provide and excellent start to this process in Victoria.

5 RECOMMENDATIONS ON SERIOUS INJURY MEASURES TO ADOPT IN VICTORIA AND DATA SYSTEM REQUIREMENTS TO SUPPORT THEIR CALCULATION

Recommending a single measure of serious injury from road crashes to replace the current resource use-based measure of hospital admission is a difficult task. Each of the alternate measures which are accessible based on the availability of required data have strengths and weaknesses.

The current resource use-based serious injury measure in hospital admission is considered a weak measure of serious injury. It is insensitive to changes in the injury severity of hospital admitted road trauma patients and hence will not fully reflect the success of road safety countermeasures which are particularly effective at targeting serious injuries with devastating long term consequences and high cost to society such as spinal cord injuries and acquired brain injuries. It is easy however to calculate and should continue to be calculated at least in the short term to provide a reference to any newly adopted measures.

Threat to life measures appear to be the most appropriate alternatives to the resource use measures as they quantify the severity of injury on a much finer scale. They are reasonably straight forward to calculate from ICD injury coding data which is available in the current Victorian data sources. The process of mapping ICD codes to AIS has a number of difficulties related to the relevance of the existing conversion maps and there are also some questions about how AIS, and the associated ISS, measure the impact of multiple injuries. In comparison, ICISS better accommodates multiple injuries and is well supported by a set of Australian developed and hence locally relevant Survival Risk Ratios associated with the ICD-10-AM codes found in the VAED. Calculation of ICISS on the VAED has also successfully been demonstrated by VISU. On this basis, and consistent with previous MUARC recommendations (D’Elia & Newstead, 2011a), ICISS is recommended as the preferred threat to life measure. Other jurisdictions including Western Australia, New South Wales and the Northern Territory are all understood to be giving some consideration to the use of ICISS. Interest from multiple jurisdictions also means there will be impetus for pooling mortality and morbidity data to produce regular local updates of the required SRRs.

Burden of injury measures potentially encompass both threat to life and long term injury outcomes, the latter being an important aspect of serious injury not necessarily measured well by the threat to life measures. MUARC research identified the DALY as the most appropriate burden of injury measure for road injury. Although there appears to be the amenity to calculate DALYs using the available data, this has not yet been demonstrated on road injury data directly although it has been demonstrated in the Victorian Burden of Disease study. There remains some academic debate about the definition of the DALY and questions about the appropriateness of using the disability weights and duration of injury to recovery formulated by the WHO in a specific local context. The final question mark hanging over the DALY is a philosophical one about the way in which the DALY gives higher weight to
those injured at a younger age. As noted, in the road safety context this has the potential to divert road safety countermeasures away from the elderly. Whether this is appropriate remains to be debated amongst the broader community.

Based on these observations about the available injury severity measures, it is recommended that ICISS be adopted in the short term as a more specific measure of injury severity and serious injury from road crashes. It is also recommended that the use of the DALY be considered carefully including an expert and community debate about whether it reflects societal values in relation to the treatment of age at injury in the measure. A good compromise might be to use both ICISS and the DALY as a measure of injury severity and to give preference to road safety countermeasures that produce the best improvements in both these measures.

In addition to calculating recommended ICISS and DALY measures, the underlying ICD based injury coding data should also be made available in road safety data systems. This will allow researchers in particular to undertake a wide range of potential analyses with a very specific focus in body region of injury for relevant countermeasures. This includes countermeasures that target specific body regions such as helmets and curtain airbags.

Having a comprehensive road safety data system incorporating the combined recommended measures of serious injury is vital to ensure the new measures accurately and consistently measure serious injury trends in Victoria whilst facilitating the range of policy and research uses the data needs to serve. MUARC research provides a blueprint for what that system should ultimately look like with the linked TAC-RCIS–TIS data system forming a sound basis from which to build. Solutions to the specific problems of the lack of police recording of non-injury crash data and the resulting move away from validating TAC claims against TIS need to be found urgently to guarantee the quality and consistency of the data. Solutions such as the on-line crash reporting system as used in WA and the closer integration of the TIS and TAC data systems might offer potential to solve these problems. The benefits of linking the VAED data directly into the TAC-RCIS-TIS linked data system using personal identifiers for matching also need to be investigated thoroughly.

It is also important that a proper management and data repository system be established for the new enhanced road safety data system. As described, the current system is reliant on administrative data systems which are not collected for the primary purpose of contributing to a base road safety data system. It also relies on the resources within and goodwill between agencies to support the current systems. The many financial and resource pressures within government agencies in the current climate potentially threaten the current system. To ensure the road safety data system is seen as an essential resource to support effective road safety policy and practice, establishment of a dedicated road safety data office is recommended. The office needs to have appropriate resourcing and authority to ensure the establishment, development and management of the road safety data system. Careful consideration needs to be given on where this office should sit to best meet its charter. It needs to have close collaborations with each agency contributing vital data to the system and needs to have the power to mandate requirements for data collection within these agencies.

6 COSTING SERIOUS INJURY

MUARC does not have extensive experience in costing injury outcomes due to road trauma. Rather its expertise is based around the use of injury cost data to evaluate the economic
benefits of road safety programs. Consequently MUARC will not make extensive comment in this submission on the methods for costing any new measure of serious injury that is adopted apart from the following points:

- The issue of costing any new measure of serious injury to be used in Victoria can only be properly addressed when the measure or measures of serious injury that are to be used in Victoria for monitoring road safety performance are established.
- Extensive work has already been carried out by the Commonwealth Government Bureau of Transport and Regional Economics to produce the current widely used costing estimates for road injury in Australia (BITRE, 2010). There is significant advantage to using well validated national estimates of road injury costs if available so it might be prudent for Victoria to work with the Commonwealth to calculate costs associated with whatever measure of serious injury is adopted. This might also encourage other states to follow Victoria’s lead to adopting a new serious injury measure.
- The current BITRE road injury costs are based on the human capital approach. Australia is one of the few Western economies to still be using human capital based estimates of road injury costs with the majority of countries now moving to a willingness to pay methodology. Some other Australian states including New South Wales have also used a willingness to pay based cost. Victoria should also consider whether moving to a willingness to pay based costing system will better reflect the desire of the Victorian community to address the road safety problem and hence encourage and support additional investment in road safety programs.
- The current BITRE road injury costs are formulated on the current coarse scale of injury outcome measured (fatality, hospitalisation, etc.). Moving to a new measure of serious injury could facilitate calculation of injury costs on a much finer scale which could then potentially better reflect economic worth of road safety programs to which they are applied.

7 ADDRESSING THE SERIOUS INJURY PROBLEM IN VICTORIA: REDUCTIONS IN ROAD TRAUMA RESULTING FROM DIFFERENT COUNTERMEASURES

Identifying road safety countermeasures that will best address serious injury from road crashes in Victoria is difficult to do before the measures of serious injury to be used are agreed. Rather than trying to pre-empt a final decision on which measures will be adopted, this submission outlines the broad approach to which packages of road safety countermeasures can be selected for implementation to best address a problem. It is considered that the types of countermeasures that have proved effective at reducing serious injury in the past are also likely to be effective against any newly defined serious injury measure. Assuming this to be the case, the following sections outline a broad range of countermeasures that research evidence has identified as being important for inclusion in any future road safety strategy. The material presented is necessarily general in nature and discusses the broad relationships between injury outcomes and various countermeasure types.

Under the Safe System principles adopted by the road authorities of Australasia, road safety countermeasures are usually categorised under the cornerstones of Safe Road Use, Safe Vehicles, Safe Roads & Roadside and Safe Speeds. This section aims to provide some insight into the key countermeasures with the greatest proven potential to eliminate not only
fatalities, as was the focus of road safety efforts for many years, but also to be effective in reducing numbers of seriously injured persons.

Recommendations are based on the experience of modelling the benefits of a road safety strategy using the METS (Macro Estimates for Target Setting) approach, developed in 2005 to assist with the development of arrive alive 2008-2017 and funded by VicRoads. METS focuses primarily on reductions in serious casualties (fatalities and seriously injured persons). Initially the model used police-reported ‘taken to hospital’ figures that typically exceeded TAC-reported hospitalisations by around 15%. Due to the deficiencies in this current measure of serious injury TAC-reported hospitalisations were used.

Since the first version of METS, more recent iterations have attempted to report fatality and serious injury savings separately rather than as serious casualties in aggregate. This necessitated making assumptions regarding the effectiveness of countermeasures in acting separately upon fatalities and serious injuries. For some initiatives, disaggregated effectiveness values were available or able to be derived, but for most there was little evidence and consensus estimates were required.

In METS, geographical subdivisions are made using the GISCA Accessibility and Remoteness Index of Australia (ARIA+) classifications, as shown in Table 7.1. In contrast to the frequently historical or political boundaries between metropolitan and rural areas, the ARIA+ categorises areas by road distance to service centres and therefore forms a more objective and consistent measure of road usage and type than traditional classifications that may vary between jurisdictions. Figure 7.1 shows the ARIA+ regions of Victoria.

![Figure 7.1: ARIA+ regions of Victoria. Red = Major Cities; Orange = Inner Regional; Light Green = Outer Regional; Light Blue = Remote](image-url)
For reference, Table 7.1 indicates numbers and proportions of serious casualties by Victorian geographical region. In the most recent METS model the serious injury to fatality ratios shown in Table 7.1 were derived using fatality and TAC-derived hospitalisation data. More than 90% of serious casualties occur in the Major Cities and Inner Regional areas that comprise roughly 50% of the geographical area of the state, therefore providing a strong focus for the targeting of initiatives in order to address the bulk of the serious injury problem.

<table>
<thead>
<tr>
<th>Region†</th>
<th>Annual serious casualties, 2007-2009</th>
<th>average</th>
<th>SI:F ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>5969 (100%)</td>
<td></td>
<td>18.7</td>
</tr>
<tr>
<td>Major cities (‘metropolitan’)</td>
<td>3929 (66%)</td>
<td></td>
<td>27.0</td>
</tr>
<tr>
<td>Inner regional</td>
<td>1607 (27%)</td>
<td></td>
<td>12.4</td>
</tr>
<tr>
<td>Outer regional</td>
<td>416 (7%)</td>
<td></td>
<td>9.3</td>
</tr>
<tr>
<td>Inner/outer regional (‘rural’)</td>
<td>2023 (34%)</td>
<td></td>
<td>11.6</td>
</tr>
<tr>
<td>Remote/very remote</td>
<td>17 (0.3%)</td>
<td></td>
<td>4.8</td>
</tr>
</tbody>
</table>

†Geographical regions based on ARIA+ classification [http://goo.gl/XMnEE](http://goo.gl/XMnEE)

7.1 SAFE ROADS AND ROADSIDES

The most significant single crash type contributing to serious injury on Victorian roads is intersection crashes. Between 2007 and 2009 an average of 2646 people were seriously injured at an intersection with this figure remaining practically constant over the previous seven years. Almost 80% of this total occurred in metropolitan areas, with 97% in metropolitan and inner regional areas combined. Of the countermeasures applied as part of the SRIP2 program and evaluated by MUARC (Budd, Newstead & Scully, 2011), the most effective by far was the installation of a roundabout to replace a conventional intersection, with an estimated casualty crash reduction (all injury levels) of 76% (95% C.I. 44-89%). An evaluation conducted in the Netherlands by Churchill, Stipdonk and Bijleveld (2010) of roundabouts installed between 1999 and 2005 yielded reductions in killed and seriously injured of 46%, with 76% of fatalities being eliminated.

Where roundabouts may be impractical for traffic capacity reasons, another solution with the potential to effect similar levels of serious injury reduction in urban areas is to reduce the speeds of vehicles coming into conflict. Modern cars are able to protect occupants from serious injury at impact speeds in a right-angle collision of up to about 50 km/h. The majority of signalised intersections on arterial roads, operating at 60 km/h or higher, are therefore operating outside the limits of the Safe System and are therefore causing avoidable serious injury. Countermeasures to reduce impact speeds to 50 km/h or below will significantly reduce serious injury at intersections. A number of innovative intersection treatments aimed at reducing conflict speeds and optimising impact angles without incurring some of the capacity issues experienced by roundabouts are to be trialled as part of a large intersection design study currently underway between MUARC and VicRoads.
Run-off-road crashes led to an average 1791 seriously injured persons annually between 2007 and 2009, with 39% occurring in Inner Regional areas and 50% in metropolitan areas. On roads carrying significant volumes of traffic, the most effective countermeasure currently is flexible wire rope barrier, which has been shown to reduce serious casualty head-on and off-path crashes by 56% overall (Candappa, D’Elia, Corben and Newstead, 2011) and by more than 80% on high-volume, high speed roads like the Eastern Freeway and Hume Highway.

The issue of run-off-road serious injuries in urban areas is more problematic, since it is frequently impractical to install barrier systems on urban arterials, collector roads and the like due to access requirements. Solutions to the run-off-road issue for these road types should focus on setting appropriate travel speeds (see following section) in the context of the desired road function with the road infrastructure being tailored to match.

### 7.2 SAFE VEHICLES

Vehicle passive safety technology - vehicle crashworthiness - has progressed significantly in the last forty years, with modern vehicles being three times less likely to result in serious injury to their occupants in the event of a crash (Newstead, Watson & Cameron, 2012) than those manufactured in the early 1970s. However, improved vehicle safety generally only occurs through vehicle replacement. In Victoria, the average vehicle age is 10 years (ABS, 2012) and annual replacement rates are around 5%, meaning that a significant proportion of the vehicle fleet is without many advanced vehicle safety features and full turnover of the fleet takes around 20 years.

Perhaps the biggest gains in reducing serious injury in the future lie with active safety, or crash avoidance technology. Anti-lock braking systems (ABS) and electronic stability control (ESC) are two current technologies helping drivers. Continual advances in available computing power and sensor technologies are helping modern vehicles to more accurately perceive and interpret their environment and consequently assist drivers to avoid a crash. Also showing real promise are vehicle to vehicle ("V2V") and vehicle to infrastructure ("V2I") technologies, also known as cooperative crash avoidance. Fundamentally, these comprise location awareness (through GPS and other similar systems) and short range, low latency radio communication to relay their location to surrounding road users. Vehicles can then become aware of impending conflict situations independent of visual detection ability and either provide warnings to the driver or take control of the vehicle to prevent a crash. A conservative estimate of the potential benefits of full take-up of such technologies could reduce serious injuries by 25-35% (Taranto, Young & Logan, 2011), although it is imperative to commence real-world implementation trials in the near future to facilitate long-term integration into the transport system.

### 7.3 SAFE SPEEDS

The work of Nilsson (2004), Elvik (Elvik, Christensen & Amundsen, 2004) and others has demonstrated the strong relationship between speed and serious injury. Reductions in mean travel speed of 5% can result in serious injury savings of 15%. While recent work has questioned the strength of the savings in urban environments, serious crash reductions of 5-10% are still feasible under this more conservative model for urban arterials and perhaps higher for environments with a high proportion of vulnerable road users.

Current Victorian urban speed limits are significantly higher than those of the best-performing European nations. Recent modelling has indicated potential serious casualty
savings over ten years of 280 annually in 60 km/h speed zones and 170 each year in 50 km/h zones on the basis of a 10 km/h reduction in signed speed limit with conservative estimates of only 3-4 km/h reductions in mean speeds in each of these two urban speed zones.

In non-urban areas it is important to support desired speed limits, chosen for mobility and other economic reasons, with the level of road infrastructure necessary to ensure that crashes occur within the biomechanical tolerances of road users. Where levels of infrastructure investment are not feasible to allow high travel speeds, speed limits need to be reduced to a level where road users and the vehicles in which they are travelling are compatible with levels of protection afforded. Modelling for Victoria indicated that a reduction in travel speed of 5 km/h on current 100 km/h two-lane undivided roads would prevent 50 serious casualties each year for the period 2013-2022.

7.4 SAFE ROAD USE

There is less potential to derive significant serious injury savings from road user-focused initiatives than in the other cornerstones. Rather than attempting to continually stretch limited enforcement capacity to what is a highly distributed system, there is scope for the introduction of large-scale technological solutions to address the problems that currently rely on public campaigns, education and enforcement for compliance. Mandatory alcohol interlock fitment to all new vehicles has the potential to prevent between 110 and 450 serious casualties (after Lahausse & Fildes, 2009) annually, depending upon how difficult the devices are to be circumvented. Similarly, seat belt interlocks may have an effect on recidivist non-wearers. Intelligent Speed Assist (ISA) has significant potential to address speeding and low-level unintentional speeding in particular, although systems would need to be supportive rather than advisory for best effect.

All of the above initiatives would require further estimates of effectiveness to be researched prior to implementation as modelling of such initiatives is less well-developed than for the other Safe System cornerstones.

7.6 SUMMARY OF CONSIDERATIONS FOR IDENTIFYING ROAD SAFETY COUNTERMEASURES TO ADDRESS A NEW MEASURE OF ROAD SAFETY

Adopting new measures of serious injury for Victoria will have clear implications for determining the mix of countermeasures to be included in road safety strategies that will best reduce fatalities and serious injury as defined by the new measures. The new measure will have to be adopted across all road safety systems and activities. This will include adopting the new measures as the focus of key target setting in road safety strategies and explicitly evaluating the effects of road safety countermeasures on the measures adopted.

It is recommended that the METS style modelling approach used over the last decade to formulate Australia’s national and state road safety strategies continue to be used in formulating future road safety strategies. This methodology provides a quantitative approach for identifying which of the available road safety countermeasures best addresses the road safety problems within each individual jurisdiction with the resources available. Countermeasure effectiveness estimates and analysis of road safety problems to be used in the METS approach need to be based on the new measures of serious injury defined. In the short term there is likely to be limited countermeasure effectiveness estimates from evaluation studies based on the new measures adopted. This dictates the need to establish a
methodology to translate countermeasure effectiveness based on the old serious injury measure to give likely effects based on the new measures. These could then be used on the METS process in the short term until direct estimates based on the new measures become available progressively in the future.

8.0 REFERENCES


