VELOCITY SERIES DISCUSSION
PAPER 4: FACTORS INFLUENCING TRAVEL SPEED

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Abstract:
The Victorian ‘arrive alive’ 2008-2017 road safety strategy aims to reduce road trauma, to deliver further major improvements to our road transport system, and to improve safety for all Victorian road users. The strategy identifies reductions in traffic speed as having an important role in achieving this aim and this requires the introduction and maintenance of effective speed management strategies. A review of the recent and current literature on the factors that influence choice of driving/riding travel speed was undertaken and a number of factors were identified. These include driver/rider characteristics, motivational and attitudinal factors, speed limits, enforcement, available technologies and road design and infrastructure.

A more definitive understanding of these factors can be used to guide recommendations for an improved and enhanced speed management strategy. A suite of recommendations for an enhanced strategy is provided and includes measures addressing the main identified factors influencing speed choice, namely, appropriate speed limit setting, enforcement programs, road design and infrastructure, behavioural and educational programs and uptake of promising technologies. Incorporation of these recommendations will provide more effective speed management in Victoria and thereby further reduce road trauma.

Key Words: Speed, speeding, road safety, countermeasure, behaviour, speed limits, road design, enforcement

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Preface

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Ethics Statement
Ethics approval was not required for this project.
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EXECUTIVE SUMMARY

As part of the effort to achieve greater gains in the reduction of the frequency and severity of road crashes, VicRoads commissioned a series of four papers addressing various aspects of speed management. The overall aims of the project are to review the current speed management approach in use in Victoria, provide the best available evidence on aspects relating to speeding behaviour and provide evidence-based recommendations for the way forward to improve the current approach in Victoria to achieve greater gains in the reduction and severity of road crashes.

This report details the work undertaken addressing the factors that influence speed choice. A review of the recent and current literature was undertaken with the objectives to:

- Provide a summary of available research on the factors that influence the speeds that drivers and riders adopt in different environments,
- Identify issues that need to be considered to improve speed management strategies, and
- Propose ways of achieving more effective speed management in Victoria.

Factors that influence travel speed choice

A number of key factors and predictors that affect driver/rider speed choice and their relative importance to speed and speeding behaviour were identified as a result of this literature review. The main factors are briefly described below.

Driver/Rider characteristics

Driver/rider choice of speed is a continuous series of discrete transitory behaviours, able to be varied and reviewed according to the driver/rider’s perception of the road, other road users, risk of crashing or being caught and fined for speeding, etc. Many drivers exceed speed limits and there are a number of contributing factors that may explain why many drivers continue to drive at high speeds. There are specific groups of drivers/riders who are likely to engage in speeding behaviours and these are generally young males and those who possess specific attitudes, beliefs, and motivations that promote speeding behaviour. Some examples of these motivations and beliefs include: difficulty to not speed and keep to the speed limit especially when others are speeding, lack of moral pressure to not speed, perception that all other drivers speed, and lack of an appreciation of the injury consequences of speeding. More specifically, the following issues were highlighted:

- Drivers and riders, by and large, lack awareness of the true relationship between speed and road trauma, especially with regard to the large increase in serious injury risk that accompanies small increases in impact speed in the event of a crash;
- Drivers and riders under-estimate crash and injury risk and over-estimate what is a safe speed;
- Higher speeds have a “contagious effect” on other drivers and riders, leading to even higher average speeds.

Speed limits

There is a range of road factors that can influence the choice of speed and it is suggested that posted speed limits are the most powerful road feature that determines speed choice and therefore appropriate setting of speed limits plays a pivotal role in determining overall crash and injury risk. The evidence is clear that lowering of speed limits results in reductions in crash and injury risk.
Our challenge is to increase the understanding amongst the general driving/riding population of the credibility of speed limits and the road safety benefits of keeping travel speed under the posted speed limit in all traffic environments.

*Enforcement*

The evidence is also clear that effective enforcement of speed and speeding behaviour is crucial in maintaining safe speeds. The primary focus of Police enforcement is on compliance with the zoned speed limits and this generally takes place in both a general and location-specific form in Victoria. The general approach attempts to have the maximum deterrent effect, across the entire road-transport system, while the location-specific approach aims to minimise speeding at locations of identified high crash or injury risk.

The choice of speed involves assessing the risk involved and deciding on how much risk one wishes to accept. In addition to the perceived risk of being involved in a crash (which is generally low) there is the perceived risk of being caught for speeding. Speeding, except at extreme levels, is not regarded by drivers as a particularly dangerous activity. Furthermore, there is perhaps a perception that being caught for speeding carries with it a relatively low risk.

*Road design and infrastructure*

Road characteristics greatly influence the speed at which drivers and riders operate their vehicles. Road characteristics determine what is physically possible for a vehicle but, more importantly, they also influence what seems to be the appropriate speed to a driver/rider.

It is possible that many roads give incorrect messages to drivers. Many roads look safe to travel at high speeds, therefore many drivers do so. However, in reality, it may not be safe because there may be vulnerable road users present (pedestrians, cyclists, motorcyclists), or the road may have a tight curve at the end of a straight section.

**Recommendations for the way forward:**

There is strong and consistent evidence that the Victorian speed enforcement program has resulted in significant reductions in crash and injury risk over the last few decades. While this is encouraging, we are at a stage where reductions have plateaued somewhat, and there is an urgent need to implement enhanced speed management strategies to further reduce speed-related trauma in Victoria.

A range of recommendations for improvements to speed management strategies in Victoria are provided in this report and fall within the following key categories as follows:

*Recommendations for appropriate and credible speed limits*

It is clear from the literature review that appropriately set speed limits can achieve great gains in reducing crash and injury risk. It is also clear that it is of utmost importance that the public understand, are aware of and believe that speed limits are posted for the purpose of increasing road safety. This is crucial to speed compliance. Therefore, setting speed limits needs to be accompanied with public education and promotion to ensure that the public understands why speed limits are set at their respective level, and the factors considered in the process.

To address the issue of placing the onus on the road-user to determine appropriate travel speeds during altered environmental or situational circumstances, variable speed limit technologies may be useful. This decreases ambiguity associated with determining appropriated speeds, and replaces the onus on developing a Safe-System road infrastructure.
In addition, the research identified that enforcement plays a crucial role in posted speed limit compliance. It is recommended that speed limit setting be consolidated with enforcement strategies to strengthen compliance in the general community.

**Recommendations for enhanced enforcement**

Like speed limits, effective enforcement is an important component of any speed management strategy. The success of law enforcement depends on its ability to create a meaningful deterrent threat to road-users. Enforcement operates based on the notion of fear of consequences. Unfortunately, there is a strong public perception that enforcement of speeding, especially through the use of covert cameras, is a ‘revenue-raising’ activity. Given this, it is recommended that education and advertising campaigns be accompanied with enforcement strategies to educate the public and help to establish an understanding for why enforcement is necessary, that is to enhance road safety.

It is also recommended that minimal tolerance levels be adopted in conjunction with rationalised speed limits based on a Safe System approach.

Enforcement needs to be widespread, highly visible and constant in order to consistently maintain appropriate risk perceptions held by motorists. If enforcement presence is not high, the perceived risk of being held accountable for speeding behaviour remains low, therefore providing minimal motivation for a driver/rider to maintain their travel speed at the posted limit.

An increased amount of visible symbols alerting road-users to potential covert operations may also be helpful in terms of increasing general deterrence.

**Recommendations for improved technology**

There are a number of emerging technologies that can address speeding behaviour and be incorporated in speed management strategies. The most promising technology currently available is the ISA system and some recommendations are made regarding this technology:

- Retrofitting of aggressive ISA technology for recidivist offending excessive speeders.
- Encourage government at all levels and commercial enterprises to purchase fleet vehicles with ISA technology as a minimum (support, promotion of ANCAP and inclusion of safety features in purchasing policies), and,
- Work towards developing the inclusion of enhanced ISA systems as a high-value component of ANCAP, through the award of extra points.

In addition, ISA should be implemented in conjunction with other complementary initiatives and programs, such as behaviour change campaigns that promote longer-term changes in behaviour.

**Recommendations for behaviour change campaigns and education programs:**

Educational and mass media campaigns are important activities, especially when they support legislation and enforcement. These programs are likely to prompt increased compliance with speed limits amongst unintentional speeders and those travelling at inappropriate speeds, and include:

- Creation of a suite of public education programs with more innovative messages to promote the benefits of reduced overall speed, particularly targeting unintentional speeders and those travelling at inappropriate speeds (as well as non-users in general).
- Enhanced design of mass media campaigns through exposure to several campaigns. Given the evidence that programs and campaigns separately may only have the ability to target a particular demographic of the population, consideration of simultaneous running of
campaigns is recommended. Further, to ensuring consistent messages are delivered throughout the population, it would be beneficial to offer different advertisements with similar messages.

- It may be beneficial for the advertising campaigns to be accompanied by education to help viewers identify the reasons behind the messages. Providing viewers with the background knowledge may help to increase the motivation of road-users that in turn, will inform an intention to alter any pre-existing maladaptive speeding behaviour.

In addition, the review identified a distinct lack of evaluation studies of behavioural and educational programs. For the continued development and effectiveness of these initiatives, evaluation studies are recommended to achieve a better understanding of the effects of advertising campaigns on speeding behaviour.

**Recommendations for improved road design and infrastructure**

Road design and infrastructure provides a useful tool for helping to manage speeding behaviour but is most effective when used in combination with other strategies. It is recommended that the design of road infrastructure be carefully considered to complement the existing posted speed limits. The main aim should be to develop road infrastructure that has the ability to match and encourage safe travel speeds throughout the road network system. Moreover, these measures should be designed to support drivers and riders to determine an appropriate speed for respective environmental and road circumstances.

It is recommended that various road design technologies be used to assist in maintaining appropriate speeds. These include a broad range of traffic calming measures and perceptual countermeasures, and these can be incorporated with in-vehicle information systems such as GPS, ADAS, etc., and out-of-vehicle information systems such as variable speed limits, activated warning signs, etc.

**Conclusions**

Speeding remains a major contributor to trauma on our roads, held to be a major factor in around one-third of fatal crashes and over 10 percent of all crashes. While many efforts have been undertaken to reduce the road toll such as reducing drink driving, managing the speed at which people travel on the road, we still have a substantial number of deaths and serious injuries on our roads, and a high proportion of these crashes involve speeding drivers.

Excessive or inappropriate speeding compromises safety and is one of the key areas where effective management, enforcement and education measures are required to minimise crash frequency and severity, thereby further reducing the road toll. Victoria’s Road Safety Strategy ‘**arrive alive!**’ recognises the problem of speeding drivers and emphasises the need to provide a road environment that allows safe travel at speeds which are consistent with general standards and public expectations. While this is encouraging, the evidence suggests that there are a number of strategies and initiatives that may be considered to result in effective speed reduction (and therefore fatal and serious injury reductions). This review has highlighted some measures that may be considered to enhance trauma reduction efforts.

The Strategy aims to reduce deaths and injuries on Victoria’s roads by 20 percent within five years. It adds that initiatives will be undertaken to achieve community recognition and acceptance that travelling at inappropriate speeds and speeds above the posted speed limit is inappropriate behaviour and is socially unacceptable. Set against both a rising road toll and the modest outcomes of the previous Road Safety Strategy (Safety First – 1995-2000’), the challenge is formidable. In order to meet the 2007 target, then focused, well-resourced, more radical actions must be implemented.
1.0 INTRODUCTION

1.1 BACKGROUND

Speed management is at the centre of the Safe System philosophy that is guiding road safety strategies in Victoria and throughout other parts of Australia. Before developing a specific strategic approach to speed management in Victoria, it is important to consider and critically evaluate the extensive range of perspectives and issues associated with the topic. In response to this, VicRoads has commissioned a series of discussion papers to identify issues associated with effective speed management within Victoria. These discussion papers will in turn provide the basis for developing a speed management strategy for Victoria. There will be four discussion papers that review the following topics:

1. Speed management, travel times, the environment and the economy;
2. Speed management and safety;
3. Community and stakeholder attitudes to speed management; and
4. Factors influencing travel speed.

The present report will address Topic 4, hence factors influencing travel speed. Given speeding behaviour has remained a significant problem within Victoria, it is crucial that an understanding is established relating to how different factors either directly, or indirectly, influence travel speeds across different road-user types; mainly drivers and motorcycle riders. In fact, previous research has established a range of different factors, which contribute or motivate road-users to partake in speeding. Developing an in-depth understanding surrounding the processes and mechanisms associated with these factors and speeding behaviour, will provide useful information in the development of an effective speed management strategy aimed to reduce such behaviour. Hence, identifying the factors and how they function to influence speeding behaviour will in turn inform which countermeasures will be most effective in addressing this problem that causes significant road trauma each year, in Victoria.

1.2 AIMS

The main aim of the literature review is to explore how, and to what extent, different factors influence travel speed, through a critical review of existing research in the area, combined with key stakeholder consultations. A series of recommendations will be identified and developed following the review, aiming to inform potential countermeasures that may be effective in the development of a new speed management strategy in Victoria.

1.3 SCOPE

The report will explore and evaluate a series of factors that have been found to influence the choice of travel speed by different road-users. These factors include:

- Human characteristics;
- Speed limits;
- Enforcement;
- Technologies (both vehicle and road infrastructure technologies that have been designed to assist with the control of speeding behaviour);
- Behavioural change campaigns and education; and
• Road infrastructure development.

Evidence for the mechanisms of their effect, as well as their overall effectiveness across a range of different road-user types (namely, motor vehicle drivers and motorcycle riders) will be discussed. It is important to recognise that each factor has the potential to impact speeding behaviour of varied road-users differently based on the motivating factors that underlie their travel speed choice.

1.4 STRUCTURE

The report begins with an introduction about the aims and scope of the literature review and stakeholder consultation meeting. This will be followed by a discussion surrounding speed and how it fits within the Safe System framework that has been adopted throughout Australasia. A brief section will then follow, outlining the main concepts related to speed management and how understanding factors that influence travel speed will inform speed management countermeasures. The next section is dedicated to evaluating how each of the six factors; namely human characteristics, speed limits, enforcement, technology, behaviour change campaigns and education, as well as road infrastructure, all impact on speeding behaviour. Motor vehicle drivers and riders will both be considered in this section, given each factor or combination of factors has the potential to impact varied road-users in different ways. The final section of the report presents a synthesis of the main findings and some recommendations for managing speed and speeding in Victoria, while also including potential future research opportunities.
2.0 SPEED AND SPEEDING

The traffic environment can be conceptualised as a complex social system, where road-user behaviours are highly influenced by a range of different external or situational factors, as well as individual road-user characteristics (Palamara & Stevenson, 2003). A particular adverse road-user behaviour that has received considerable attention in the field of road safety is speeding behaviour. For a long time, speeding behaviour has been identified as having a strong correlation with serious road trauma, yet the prevalence of this behaviour still remains at unacceptable levels. This section will:

- Define speed and speeding behaviour;
- Review how speeding behaviour fits within the context of a Safe System framework; and
- Evaluate the current significance of the problem (with a particular focus on Victoria).

2.1 DEFINITION

It is well established in road safety literature that “driving too fast” contributes to both the number of, and outcomes associated with road accidents (Warner, 2006). This can be understood in terms of “speed” and “speeding behaviour”. In order to investigate the phenomenon of “speeding” within society, it is important to first have well-established, operational definitions that describe and distinguish between the two.

Speed or travel speed can be defined or considered in terms of (Oxley & Corben, 2002):

- **Speed of the individual driver:** In this situation, speed relates to both the risk of a crash occurring and the risk of injury once a crash occurs. The probability of crashing increases with increasing speed because higher speed reduces the ability to control a vehicle, which increases unpredictability, while reducing the time available to avoid a collision. The probability of severe injury increases sharply with increases in the impact speed of a vehicle in a collision. The risk is even greater when a vehicle travelling at a speed above 30-40km/h strikes a vulnerable road-user (such as a pedestrian, bicyclist, motorcyclist or older road-user).

- **Aggregate speed:** In this situation, speed distributions and variance are considered in crash involvement. Early work investigating the relationship between speed and crash risk used several measures of speed, and suggested that it is speed variance, not mean travel speed, that is important in crash involvement (e.g. Solomon, 1964; West & Dunn, 1971). More recent work has challenged this view, finding no clear relationship between slower speeds and increased crash involvement (Fildes, Rumbold & Leening, 1991; Bowie & Walz, 1994) and no distinction between individual and aggregate measures of risk (Davis, 2002).

Most road safety experts agree that the single most important contributor to road fatalities around the world is poor speed selection, in the form of “inappropriate vehicle speeds”, otherwise known as “speeding behaviour” (Global Road Safety Partnership, 2008). The important distinction used to define speeding behaviour is the difference between “inappropriate” and “illegal” speeding behaviour. The definitions can be understood as follows (Oxley & Corben, 2002):

- **Inappropriate speeding:** Driving or riding too fast for the circumstantial road conditions, despite being within speed limits (for e.g., in high pedestrian activity areas). Driving at inappropriate speed can increase the potential for crashing and sustaining serious injury.
• **Illegal speeding:** Driving or riding faster than the posted speed limit. There are three levels of illegal speeds categorised as:
  
  - **Level 1:** speeding in excess of the posted speed limit, but within 10 km/h;
  - **Level 2:** speeding in excess of 10-25 km/h over the posted speed limit; and
  - **Level 3:** speeding in excess of 25 km/h or more over the posted limit.

Understanding how speed and speeding behaviour can be categorised is essential to establishing countermeasures that aim to address the problem. Speed management initiatives need to be able to target all speeding behaviours, and this can only be achieved through identifying the varied motivations behind different levels of speeding across road-users. Before discussing the current situation and impact of speeding behaviour on society, speed will be discussed in the context of a Safe System framework. The Safe System philosophy helps to set the scene for how countermeasures for the development of a speed management strategy can be achieved.

### 2.2 SAFE SYSTEM FRAMEWORK

#### 2.1.1 The Safe System Philosophy

The Australasian Safe System philosophy has been generated from the best elements of the Swedish Vision Zero and the Dutch Sustainable Safety visions to create a best-practice framework for developing road safety in this country. This philosophy and overall approach recognises the limitations of humans using the road-transport system (Corben, Logan, Fanciulli, Farley & Cameron, 2010) and aims to provide a forgiving system that acknowledges and supports such conditions. Underpinning the Safe System framework are four key principles, which include:

- **The limits of human performance:** recognition of the limited intrinsic capabilities of humans in contrast to traditional approaches, which strongly focused on preventing human failures within the road-transport system;

- **The limits of human tolerance to violent forces:** recognition of the biomechanical limits of humans and seeking to create a road-transport system that is tolerant of this;

- **Safe road use:** recognition and implementation of a shared responsibility for road safety by both the system design and compliance to safe road use; and

- **Creating a forgiving road-transport system:** recognition of the limitations of humans and developing a road-transport system that considers the interactive effects of objects, both vehicles and humans.

Based on consideration of the principles described above, the Safe System framework has strategically identified four categories of initiatives that are important in achieving a safe road network. These categories address safe travel speeds, safe roads and roadsides, safe vehicles, as well as safe road use (Corben et al, 2010). Given the scope of the current report, a more in depth discussion will be completed on safe travel speeds within the context of a Safe System framework.

#### 2.1.2 Safe Speeds within the Safe-System Approach

The Safe System approach acknowledges the vital role of speed in determining overall system safety. This approach represents a shift in previous policy, placing a higher priority on safety. More importantly, the Safe System approach acknowledges that crashes will continue to occur, but aims to ensure that such crashes will only entail impact speeds that will not be life threatening or lead to serious impairment. In summary, if a “safe system” is to be achieved in the absence of appropriate infrastructure protection, effective speed management strategies are essential to ensure that
threshold impact speed values are maintained with the road network system (Oxley, Langford & Fildes, 2007).

It is well established in the literature that higher travel speed increases the likelihood of crashes due to an increased likelihood of the driver losing control of the vehicle, reduced ability to observe important hazard cues, increased distance the vehicle will travel once the brakes are applied and overall increased unpredictability. In addition to this, the severity of injuries resulting from crashes is also directly related to the pre-crash speed of the vehicle. Higher travel speeds invariably mean higher impact speeds and consequently, more severe injuries for those involved (see Oxley et al., 2007).

The central factor in the relationship between speed and both crash frequency and crash severity is stopping distance. There are two components to stopping distances including, the distance travelled by the vehicle during the reaction time of the driver, and the distance travelled once the brakes are applied. For example, (assuming normal reaction times, as well as, typical road and vehicle braking capabilities) a vehicle travelling at a speed of 30 km/h could come to a halt in 15 metres, whereas a vehicle travelling at a speed of 40 km/h would come to a halt in approximately 22 metres. At 15 metres, this vehicle would still be travelling at approximately 37 km/h (Oxley et al., 2007). This highlights the non-linear relationship between speed and stopping distance that needs to be considered when determining appropriate speed limits for roads.

Within a Safe System approach, the level of safety required should determine speed. This conflicts with traditional mobility philosophies where safety is traded off against rapid transport functioning. The Safe System approach stems from an ethical stance with the notion that it is unethical to consider trading lives for the benefit of travelling quickly (Oxley et al., 2007). It is important to recognise that this approach also posits that higher speeds can be justified if optimum levels of road and road infrastructure are provided and maintained simultaneously.

In summary, the Safe System approach to traffic management requires that all forms of speeding be comprehensively addressed. Illegal or excessive speeding needs to be targeted through the setting of appropriate speed limits, enforcement of high speeds, as well as education, publicity and promotion of the critical nature associated with speed, in terms of understanding crash and injury risk (Oxley, et al., 2007). A change in the current “speed culture”, hence societies’ acceptance of high speeds, may arguably be vital to not only recognising the significance of the problem, but to offer a change in future speeding behaviour observed on Victorian roads.

2.3 SIGNIFICANCE OF THE PROBLEM

Existing research has identified speed as being a key risk factor in road traffic injuries throughout the world, with higher speeds leading to a greater risk of a crash, in addition to a greater probability of serious injury, if one occurs (Global Road Safety Partnership, 2008). According to the Global Health Observatory (2011), each year, approximately 1.2 million people are killed in road traffic accidents throughout the world, with between 20 to 50 million suffering from non-fatal injuries. In developed countries however, the number of deaths in road traffic accidents are decreasing over time due to the introduction of speed limits, together with other safety measures such as seat belt laws, daylight running lights, improved road networks and better cars (Warner, 2006). With this being said, road traffic injuries still remain at problematic levels within Australia, despite a reducing trend.

In 2005, there were over 1,600 people killed in road crashes in Australia, and around 10 times this number were seriously injured (ATSB, 2006). More recent statistics indicate that the statistic has dropped to approximately 1,400 people killed in road crashes in Australia each year (Department of Infrastructure, Transport, Regional Development and Local Government, 2009). Despite this reduction, speed and speeding continues to be a major contributor to road trauma throughout Australia. More specifically in Victoria, speeding and inappropriate travel speeds directly contribute to at least 30 percent of deaths on Victoria’s roads each year (arrive alive!, 2008).
Despite universal recognition that traffic speeds are closely related to crash risk, speeding still remains a common occurrence on roads throughout the world. This phenomenon has been a key issue examined by a series of traffic and road safety researchers. Speeding behaviour presents as a complex concept given the large array of factors that influence this behaviour including, both external or situational factors (such as road infrastructure, traffic volume and speed, vehicle characteristics, time of day, levels and types of enforcement, trip purpose), as well as, driver factors (including human characteristics, age, gender, personal motivations, behavioural traits, beliefs and attitudes towards speeding) (Palamara & Stevenson, 2003). Furthermore, it is important to also recognise the “speeding culture” that underlies these factors, where despite road-users being aware of the increased crash and injury risk associated with speed, speeding behaviour is still not considered dangerous. Hence, there appears to be an inconsistency between road-user beliefs and attitudes with that of their behaviour (European Commission Road Safety, 2007).

2.4 THEORY AND RESEARCH

Traffic psychology places a particular focus on developing theories that explain behavioural factors that cause or contribute to traffic accidents (Warner, 2006). It is based on the assumption that people’s behaviour in traffic reflects their behaviour in other situations. One particular model that has been well researched is the theory of planned behaviour, which is often used by road safety experts to predict and explain why road-users choose to exceed the posted speed limits.

2.4.1 The Theory of Planned Behaviour

The theory of planned behaviour (Ajzen, 1991) was developed from an earlier theory known as the theory of reasoned actions. The theory of reasoned actions attempted to explain human behaviour as predicted by both the attitude towards the behaviour, as well as subjective norms (Ajzen & Fishbein, 1980; Fishbein & Ajzen, 1975). This theory was limited because it did not consider the influence of involuntary behaviours. In an attempt to address this limitation, the theory of planned behaviour extended on the theory of reasoned actions to incorporate control as a predictive factor. This is particularly important in driving and riding research, given autonomous decision-making contributes significantly to both behaviours (Åberg, year).

In a review of 46 studies Wicker (1969) found low correlations between attitude and outcome behaviours, with results indicating correlation values rarely exceeded .30, and more often being closer to zero. This suggests that the attitude-behaviour relationship often does not explain the outcome behaviour. Building on this, Fishbein and Ajzen (1975) proposed that people consider the outcomes of their behaviours in quite a rational and systematic way, before deciding what to do. This led to the inclusion of “intention”, rather than merely “attitude” to predict behaviour (Warner, 2006). Figure 2.1 presents a schematic representation of the theory of planned behaviour and how intention fits within the model.
In summary, according to the theory of planned behaviour, people’s attitude towards the behaviour, their subjective norms and their perceived behavioural control determines their behaviour (a defined action) indirectly via their intention (willingness to try to perform the behaviour) (Ajzen, 2006). More specifically, each component can be broken down to:

- Behavioural beliefs, hence beliefs about the likely consequences of the behaviour (known as behavioural belief strength) are weighted by the evaluation of how good or bad the outcome would be (known as the outcome evaluation), to determine one’s *attitude towards the behaviour*.

- Normative beliefs, hence beliefs about what important others think about the behaviour (known as normative belief strength) are weighted by the motivation to comply with these important others (motivation to comply), to determine one’s *subjective norms*.

- Control beliefs, hence beliefs about factors that may facilitate or impede performance of the behaviour (known as control belief strength) are weighted by the perceived power of these factors (control belief power), to determine one’s *perceived behavioural control*.

These beliefs interact in a way that is consistent with the expectancy-value theory, which proposes that people’s attitude towards an object, action or event is based on the sum of the expected attributes of this object, action or event, weighted by the values ascribed to those expected attributes (Warner, 2006). According to Ajzen (2006), a combination of positive attitude and subjective norms, in conjunction with large perceived behavioural control, results in a strong intention to perform the behaviour. It is important to note that some behaviours exist where the individual does not have complete volitional control, and therefore perceived behavioural control becomes a co-determinant (together with intention) of the behaviour. This is particularly relevant to speeding behaviour. Another cautionary aspect to note when utilising this model is that the relationship between perceived behavioural control and behaviour is dependent upon the accuracy of people’s perception of their own control over the behaviour (Warner, 2006).

In conclusion, the theory of planned behaviour provides a good structural and reliable conceptual framework for understanding the motivations for speeding behaviour, as well as how various factors can influence choice of travel speed for both drivers and riders.
2.4.2 Data Collection

In understanding and drawing conclusions from existing speeding behaviour research, it is important to recognise the existing limitations with data collection that may have important implications associated with interpreting the findings. Data collection and analysis has historically relied heavily upon speed enforcement records and self reports, which poses limitations in understanding the magnitude and prevalence of the problem (Ellison & Greaves, 2010). More recent research on speeding behaviour has implemented instrumentation of the vehicle using Global Positioning System (GPS) technology (Ogle, 2005). This data collection methodology has the advantage where motorists are monitored while driving around during their normal daily routines, providing the opportunity to study the factors impacting speeding in greater depth. Simultaneously however, disadvantages associated with this data collection method involve relatively small sample sizes, as well as the potential impact of monitoring on vehicle user behaviour (Ellison & Greaves, 2010).
3.0  SPEED MANAGEMENT

In reviewing the factors that influence travel speed, it is important to include a discussion regarding speed management because this has the potential to impact speeding behaviour significantly. Speeding behaviour and speed management share a reciprocal relationship where speeding behaviour can be influenced by speed management strategies, and vice versa. This section will:

- Define speed management; and
- Discuss the benefits of having an effective speed management strategy.

3.1  DEFINITION

Speed management can be described as the range of measures or strategies implemented to balance safety and efficiency of vehicle speeds on a road network (OECD/ECMT Transport Research Centre, 2006). The overall goal of speed management is to reduce the incidence of driving too fast for prevailing conditions, and to maximise compliance with speed limits (Global Road Safety Partnership, 2008). Therefore, the underlying aim of any speed management strategy is to reduce crash and injury risk through the control of vehicle speeds (Oxley & Corben, 2002). Currently, within Victoria, speed management strategies are developed within the Safe System framework, which puts forth safety as the main priority, in the context of mobility and a range of other prevailing conditions such as roadside development, range or road-users, frequency of access to the road, volume and mix of traffic, environmental concerns and the overall quality of life for residents living on that road (Global Road Safety Partnership, 2008).

3.2  BENEFITS OF EFFECTIVE SPEED MANAGEMENT

There are a range of benefits that result from successful promotion and implementation of a successful speed management program based on a Safe System approach. This includes the primary and most obvious outcome being a reduction in the number of deaths and injuries that result from crashes (Global Road Safety Partnership, 2008).

Other secondary benefits associated with lowered travel speed, may include (Global Road Safety Partnerships, 2008):

- Longer time to recognise hazards;
- Reduced distance travelled while reacting to hazards;
- Reduced stopping distance of the vehicle after braking;
- Increased ability of other road-users to judge vehicle speed and time before collision;
- Greater opportunity for other road-users to avoid a collision; and
- Reduced likelihood that a driver will lose vehicle control.

To support the benefits described above, Table 3.1 illustrates the significant difference small changes in average speed can deliver. More specifically, Table 3.1 illustrates the estimated safety effect of a reduction of speed by 1 km/h and 2 km/h, from different reference levels, in terms of percentage savings across different severities of crashes. Overall, it identifies that speed reductions have a greater effect for more severe crashes.
Table 3.1 Application of the Power Model for Different Reference Speeds when Average Speed is Reduced by 1 km/h and 2 km/h.

<table>
<thead>
<tr>
<th>Reference speed in km/h</th>
<th>50</th>
<th>60</th>
<th>70</th>
<th>80</th>
<th>90</th>
<th>100</th>
<th>110</th>
<th>120</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Percentage (%) in reduction in crashes for 1 km/h reduction in average speeds</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All injury crashes</td>
<td>4.0</td>
<td>3.3</td>
<td>2.8</td>
<td>2.5</td>
<td>2.2</td>
<td>2.0</td>
<td>1.8</td>
<td>1.7</td>
</tr>
<tr>
<td>Fatal and serious crashes</td>
<td>5.9</td>
<td>4.9</td>
<td>4.2</td>
<td>3.7</td>
<td>3.3</td>
<td>3.0</td>
<td>2.7</td>
<td>2.5</td>
</tr>
<tr>
<td>Fatal crashes</td>
<td>7.8</td>
<td>6.5</td>
<td>5.6</td>
<td>4.9</td>
<td>4.4</td>
<td>3.9</td>
<td>3.6</td>
<td>3.3</td>
</tr>
<tr>
<td><strong>Percentage (%) in reduction in crashes for 2 km/h reductions in average speeds</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All injury crashes</td>
<td>7.8</td>
<td>6.6</td>
<td>5.6</td>
<td>4.9</td>
<td>4.4</td>
<td>4.0</td>
<td>3.6</td>
<td>3.0</td>
</tr>
<tr>
<td>Fatal and serious crashes</td>
<td>11.5</td>
<td>9.7</td>
<td>8.3</td>
<td>7.3</td>
<td>6.5</td>
<td>5.9</td>
<td>5.4</td>
<td>4.9</td>
</tr>
<tr>
<td>Fatal crashes</td>
<td>15.1</td>
<td>12.7</td>
<td>10.9</td>
<td>9.6</td>
<td>8.6</td>
<td>7.8</td>
<td>7.1</td>
<td>6.5</td>
</tr>
</tbody>
</table>

Source: Aarts & van Schagen (2006).

3.3 ACHIEVING EFFECTIVE SPEED MANAGEMENT

Speed management plays a vital role in achieving compliance to reduced speeds, and is therefore a significant area of interest to traffic and road safety researchers. There are a series of tools that have been designed to assist in establishing effective speed management throughout the world, and often a range of these are selected as different countermeasures. These tools include but are not exclusive to (Global Road Safety Partnership, 2008):

- **Speed zoning and speed limits:** Speed limits are set at levels that account for the road and environmental circumstances, providing the most overt indicator of appropriate travel speeds, and hence a fundamental tool for speed management. It is particularly important to consider the variation in traffic within both urban and rural settings, and developing speed limits that are appropriate for each setting.

- **Enforcement and regulation of speed:** Legislative and regulatory settings exist with the aim of ensuring that travel speeds remain within posted speed limits. Enforcement strategies may include the use of fixed and mobile speed cameras, as well as penalties such as fines, demerit points, licence suspensions and vehicle confiscations. It is also important to consider tolerance levels for police enforcement when exploring the impact of enforcement on speeding behaviour.

- **Technologies:** Speed-limiting technologies, as well as intelligent speed adaptation tools may be utilised to control for vehicle travel speeds.

- **Behaviour change campaigns and education:** Behaviour change offers the greatest potential for long-term speed compliance. It is important to explore effective methods of educating the public regarding the risks associated with speed, and therefore the importance of changing this problematic behaviour.
- **Road infrastructure**: The road infrastructure can affect the choice of travel speed and therefore, engineering designs have the potential to assist with speed compliance using a range of appropriate treatments such as speed humps, raised pavement sections and road narrowing to help reduce travel speeds in pedestrian prone areas.

In addition to the tools described above, road-user characteristics, as well as human factors also play a crucial role in determining how effective a speed management strategy will be. It is important to understand the vehicle user’s characteristics (such as age, gender, personal motivations, behavioural traits, beliefs and attitudes towards speeding), given certain trends have been established between characteristics and the likelihood of speeding behaviour (Palamara & Stevenson, 2003). Simultaneously, human factors such as risk perception, as well as the ability to judge safe and appropriate speeds, also needs to be considered (Oxley & Corben, 2002).

Whether the factors are characteristic of the vehicle operator or external and situational, they all contribute to informing an effective speed management strategy. The remainder of the report will review factors that influence travel speed, and outline recommendations for how to effectively implement targeted countermeasures to assist with the development of a successful speed management strategy in Victoria.
4.0 FACTORS INFLUENCING TRAVEL SPEED

Before attempting to address the issue of speed management, it is essential to establish and understand the underlying factors that result in road-user speeding behaviour, as this informs the countermeasures required for a speed management program. The selection of travel speed can be conceptualised as a “feedback-controlled behaviour”, influenced by a combination of both environmental and intrapersonal factors (Harrison, Fitzgerald, Pronk & Fildes, 1998). This model conceptualises drivers (and can be generalised to riders) as behaving in response to a range of factors that in turn bias them towards either increasing or reducing their speed at any given point in time. It is important to note that speed travel choice imposes risks that affect both the probability and severity of crashes and therefore, understanding which factors and how they impact on speeding behaviour is of great value.

There are many reasons why individual drivers speed and understanding the motivations behind this behaviour can be a complex task. Speeding behaviour is formed from a complex interaction between environmental or situational circumstances, as well as aspects relevant to the vehicle user (including personal motivations, underlying beliefs surrounding risk and perceived competency). This section will:

- Review human factors that influence travel speed choice. These factors will include:
  - Road-user characteristics
  - Beliefs, attitudes and motivations

- Review a series of environmental or situational factors that influence travel speed choice. These factors will include:
  - Speed limits
  - Enforcement
  - Technology
  - Behaviour change campaigns and education
  - Road infrastructure

In an attempt to put these factors into context, Oxley and Corben (2002) provided a model that aims to summarise all the different factors that have potential to influence driver or rider travel speed. This is illustrated in Figure 4.1. The remainder of this section will be used to discuss each of these factors in detail.
4.1 HUMAN FACTORS

4.1.1 Road-user characteristics

There has been a strong body of research conducted to describe the demographic population who participate in speeding behaviour. Studies have repeatedly found that males, who are between the ages of 18 to 24 years, are the group who are most likely to speed (Palamara & Stevenson, 2003). Interestingly however, a study conducted by Fildes et al. (1991) identified conflicting results, where it was found that male drivers were not significantly more likely than female drivers to be observed travelling at higher speeds on either rural or metropolitan roads. This was also consistent with a later study conducted by Harrison, Fitzgerald, Pronk and Fildes (1998) however, both studies have been criticised for not having considered driver age within the relationship between gender and speeding. Interestingly though, there is some recent (anecdotal) evidence that driving behaviour, and therefore crash risk, of young female drivers is changing and becoming more like that of their male counterparts (e.g., Lonczak, Neighbors & Donovan, 2007), although, this is yet to be examined fully.

In Palamara and Stevenson’s (2003) review, it was found that males, particularly young males are most likely to be fined for speeding and subsequently, to be repeat speeding offenders. Furthermore, male drivers of all ages were more likely to be involved in speed related crashes, as well as being killed in a crash involving speed. Based on this review, it was concluded that gender and age are both risk factors involved with speeding behaviour and subsequently speed related crashes. It is important to note however, that although the history of road safety research has identified the male demographic to be at increased risk, more recent research as indicated above, suggests that there may be a potential shift. Despite further research needed to explore this notion, it offers valuable information that may help in the continued investigation of common characteristics (such as their beliefs, attitudes and motivations) that extend both demographic groups, which may contribute to an increased observation of speeding behaviour. In line with this, it is important to consider the current understanding surrounding underlying beliefs, attitudes and motivations of individuals who voluntarily choose to speed.
4.1.2 Beliefs, attitudes and motivations

When considering the beliefs and attitudes that underlie speeding behaviour, it is important to refer back to the model discussed earlier, the theory of planned behaviour. Research has found that there is a low correlation between expressed attitudes and observed behaviour, suggesting that the attitude-behaviour relationship does not entirely represent the outcome behaviour (Forward, 1997). This is otherwise known as the “speed paradox”. Evidence to support this notion can be found in a study conducted by Fleiter and Watson (2005), which investigated preferred driving speeds and frequency of speeding in Queensland drivers. It was found that two thirds of participants agreed that exceeding the limit was not worth the risk; nor was it acceptable to exceed the posted limit. Inconsistent with this belief however, results identified that more than half of the participants reported a preference to exceed the 100 km/h speed limit (with a third doing so by 10 to 20 km/h) and the mean preferred driving speeds on both urban and open roads were at and above the 10% tolerance level (Fleiter & Watson, 2005). This demonstrates that, despite holding certain negative beliefs or attitudes about speeding, road-users may still not comply within speed limits if the intention is not present.

Motivation often underlies intention where motivation refers to the reason that compels a particular behaviour. There are several motivating factors that may influence speeding behaviour, which include risk-taking or sensation seeking, purpose of the trip, as well as reinforcement from previous speeding behaviour occasions where one was not held accountable. Most drivers drive without experiencing a crash, which reinforces the attitude that speeding is not risky. This belief results in an underestimation of the association between speeding and the probability of serious injury or death in a crash (Elliott, 2001). Furthermore, drivers have a tendency to over-estimate what is considered to be an appropriate or safe speed, subsequently driving at speeds within a perceived tolerance margin where enforcement will not occur (Corbett & Simon, 1999). Other factors that may also influence a driver’s motivation to speed include level of intoxication (i.e., blood alcohol or drug impairment), the presence of other passengers in the vehicle, as well as vehicle ownership.

Another interesting motivating factor for speeding behaviour stems from the perceived speed of other surrounding road-users. Connolly and Åberg (1993) suggested that drivers’ adjust their own speed by comparing their speed with other surrounding drivers, almost producing an effect where speeding becomes “contagious”. Åberg, Larsen, Glad and Beilinsson (1997) concluded that perceived behaviour of other drivers affect not only speed choice but also, attitudes towards speeding, regardless of how accurate this perception is. A study conducted in New Zealand exploring such perceptions found that, in general, drivers accurately reported driving speed however, they often overestimated the average driver speed, claimed to drive slower than the average driver, while also claiming to be safer than the average driver (Walton & Bathurst, 1998). This suggests that drivers may often inaccurately estimate the speed of others, as well as their own ability and hence, risk associated with speeding.

Risk perception is a vital component that interacts with individual motivations for speeding behaviour. Speed choice always involves an assessment of the risk associated and determining how much of that risk one is willing to accept (Oxley & Corben, 2002). It has been established that risk perception in relation to crash involvement is a complex process, where risk estimation assumes that risk-taking is a conscious decision process based on:

- Identification of possible courses of action;
- Identification of consequences;
- Evaluation of chances of the consequences; and
- Choice of action.

During this process, two factors are considered, which include the perceived risk of being involved in a crash, in addition to the perceived risk of being caught for speeding (Oxley & Corben, 2002).
When considering the assessment of risk, it is important to recognise that, for many drivers or riders, speeding (with the exception of extreme levels) is generally not considered as a particularly dangerous activity (Oxley & Corben, 2002). From the perspective of the vehicle road-user, speeding behaviour is often reinforced by positive consequences (such as perceived savings in time and no enforcement encountered) as opposed to negative consequences (such as being held accountable for speeding). As a result, road-users often do not perceive an increased crash risk associated with travelling at speeds slightly above the posted speed limit.

Closely intertwined with risk perception is the notion of optimism bias, where the vehicle user perceives themselves to be safer and more skilled than the average vehicle user (Svenson, 1981; McKenna, Stanier & Lewis, 1991; Walton & McKeown, 2001). This psychological effect of disparity between perceived ability of self and others is essentially an unrealistic, inflated appraisal of one’s own ability (Oxley & Corben, 2002).

As reviewed, there is a range of attitudes, beliefs, and motivations surrounding why speeding behaviour occurs. A Western Australia study conducted by Elliott (2001) summarised these reasons well, with findings indicating that widespread speeding occurs because most drivers who speed:

- believe that it is hard not to speed and they find it difficult to keep at the speed limit especially when the traffic flow is also speeding or they are late for an appointment;
- feel little or no moral pressure to not speed and have only slight (if any) feelings of regret for speeding;
- perceive that everyone/most drivers are speeding;
- see themselves as frequently and safely exceeding the posted speed limit, and that while they could easily not speed, they do not believe that positive outcomes of not speeding are likely (e.g. relaxed, hassle free driving, lower risk of crashing).

### 4.2 SPEED LIMITS

#### 4.2.1 Definition

The posted speed limit is considered to be the most powerful road feature that determines speed choice and therefore plays a pivotal role in determining overall crash and injury risk (Nilsson, 1993). The primary reason for setting speed limits is to provide safety and mobility, with the aim of identifying an appropriate balance between both travel time and crash risk for specific roadway sections. Posted speed limits are designed to inform drivers of maximum driving speeds that authorities consider reasonable and safe (Oxley & Corben, 2002). There is controversy however surrounding political influences that are believed to impact on the selection of these posted speeds (Mannering, 2009). It is important to note that the posted speeds determined do not take into account altered environmental and situational factors. Hence, they provide a maximum advisory travel speed that may need to be reconsidered during altered circumstances.

Research has identified that crash incidence and injury severity decline with reduced speed limits (e.g. Nilsson, 1990; Frith & Toomath, 1982; Sliogeris, 1992; Finch, Kompfner, Lockwood & Maycock, 1994; Newstead & Mullan, 1996; Haworth, Unger, Vulcan & Corben, 2001; Oxley, Corben & Diamantopoulou, 2001). Conversely, studies have also identified that the number of crashes and injury severity have a tendency to increase when speed limits are raised, particularly on freeways (e.g. Transportation Research Board, 1998; Sliogeris, 1992; Parker Jr, 1997; Newstead & Mullan, 1996; Patterson, Frith, Povey & Keall, 2002; Newstead & Narayan, 2001; Johnston, 2004; Cameron, 2004; Richter, Barach, Friedman, Krikler & Israeli, 2004). This suggests that lowered speed limits offer greater safety for all road-users, and that higher speed limits contribute to a predisposition for greater crash risk and serious trauma.
Speed limits are generally set by relying heavily on the 85th percentile speed of traffic, based on the perception that speed limits need to be ‘credible’ to the road-users for them to adhere to the posted limit. Setting speed limits with this process also ensures that enforcement remains manageable and affordable. Issues associated with establishing speed limits using this procedure include the inability to adequately account for some factors that influence road-user speed choice, as well as the limitations of human factors. The debate surrounding this process revolves around the notion that allowing drivers to set what they believe to be acceptable travel speeds is arguably unsafe. There is research that suggests that drivers who have poor judgement when choosing a safe speed and often have limited appreciation for what is safe and unsafe on the road. As a consequence, allowing drivers to determine speed means that speed limits will often be in excess of what is inherently safe for the road conditions.

It is important to explore the relationship between speed limits, and speeding behaviour. Despite posted speed limits being set, it appears that road-users still have the tendency to both inappropriately and illegally speed. Understanding how speed limits impact on this behaviour is central to countermeasures with the aim of achieving speed management.

4.2.2 Relationship between speed limits and speeding behaviour

Public perceptions and respect for speed limits has continued to be a problematic issue for road safety worldwide. A key motivating factor underlying road-users’ tendency to exceed posted speed limits resides in their belief that excess speed does not threaten safety (Mannering, 2009). This belief may develop from a range of different reasons including political influences that result in public disrespect for the limits set, over-confidence in one’s own ability, as well as inadequate understanding surrounding the risk associated with speeding behaviour. A study conducted by Kanellaidis, Golias and Zarifopoulos (1995) found that Greek drivers who believed that speed limits could reduce accidents were more likely to comply with speed limits in general. Their findings also indicated that speed limit compliance increased with increased education level. These results support the notion that road-users may need to be able to recognise and believe in the impact of reduced speeds, or the relationship between posted speed limits and safety for road-users, in order to comply with the limits set.

Road-users understand or have the expectation that posted speed limits are appropriate speeds to travel at. As a result, most drivers or riders have a tendency to travel at the specified posted limit without realising that the specified limit refers to a maximum travel speed under normal road conditions, and that the speed posted may not be appropriate for varied conditions (e.g. bad weather, night time driving) or for drivers who are less experienced (e.g. learners or newly licensed learners). For road-users who are unaware of how posted speed limits are set, this may result in their travel speeds exceeding what is considered safe outside of normal conditions. Another issue with this method of speed limit setting is the assumption that road-users can safety estimate appropriate speeds for altered environmental and situational circumstances. This puts the onus on the road-user and may not necessarily be effectively taken from a Safe System perspective.

According to a study conducted by the NHTSA (2011) looking at countermeasures that are effective, speed limits were demonstrated to have a 5-star effectiveness rate, indicating that speed limits were found to be "effective in addressing speeding behaviour in several high-quality evaluations with consistent results." In line with this research, rational speed limits, is an issue to also be considered. A strategy that has been implemented to enhance safety through compliance toward speed limits is to develop credible speed limits for homogenous road segments. This needs to be complemented with respective enforcement, in order to influence drivers' perceptions of safe speeds (NHTSA (2011)). Therefore, aside from the occasional "high-risk driver", appropriate and credible speed limit settings will encourage voluntary compliance with the speed limits set. Given this, there is an argument to suggest speed limits should in fact not be set based on the 85th percentile speed, but rather as a consideration of other factors (e.g. environmental surrounding including road works and school settings; presence of pedestrians), which is consistent with safe system thinking, hence self-explaining roads. Based on this, it is recommended that the criteria for
setting speed limits should be revised in order to address the issue of developing credible speed limits.

Driver speed choice is also influenced by “tolerance levels” for compliance with speed limits. Tolerance levels were originally adopted because of measurement error known to exist in both speedometer readings and speed measurement equipment used by Police for enforcement. It also focused enforcement on deterring excessive and potentially more dangerous offenders (Oxley & Corben, 2002). In Victoria, prior to 2002, it was commonly understood that enforcement only occurred when a driver/rider exceeded the posted speed limit by 9 percent plus 3km/h. In road safety terms, this tolerance level represented a substantial increase in crash and injury risk. As a result, road-users have developed a tendency to add tolerance levels to their travel speeds, with the belief that such speeds are acceptable. Hence, tolerance levels not only perpetuate higher speeds but simultaneously fuel the culture for speeding. The danger associated with this acceptance is it further masks the true risk and dangers associated with travelling at speeds above the posted limit, while also invalidating posted speed limits set. In 2002, Victoria Police publicly announced that this tolerance no longer applied without giving details of the new level. The media interpreted the change as a 3km/h tolerance (Bobevski, Hosking, Oxley & Cameron, 2007). While this announcement led to a public outcry and subsequently a political issue, it also resulted in substantial reductions in death and serious injury (Delaney, Diamantopoulou & Cameron, 2003; Johnson, 2007; Corben, 2007).

Fatigue and driver distraction has become an emerging issue in road safety. There has been some suggestion that reducing speed limits may in turn create added travel time to long journeys that subsequently, may contribute to fatigue-related crashes (NRMA, 2009). It is important to note that research has found support for minimal increases in travel time with lowered speed limits (for e.g. Dyson, Taylor, Woolley and Zito, 2001; Archer, Fotheringham, Symmons & Corben, 2008), in addition to the benefit of smoother traffic flow. Research more directly addressing the issue of fatigue-related crashes conducted by RTA (2011) has found no support for an increased rate of fatigue-related crashes associated with lower speed limits. Contrary to such suggestions, the research further proposes that high speeds require greater concentration, which in turn induce fatigue.

It is important to highlight that understanding how speed limits impact on drivers and riders can depend on whether speeding behaviour occurs as a result of intention. In a study conducted by Warner (2006), it was found that drivers who intended to exceed the speed limit reported observing fewer speed signs and/or more easily disregarded the signs they did observe, compared to drivers who reported unintentional speeding. It is important to distinguish between drivers who are willing participants in speeding behaviour, and those who are unaware, because clear signage of speed limits would have a greater impact on the latter group. For those with the intention of speeding, posted speed signs produce little effect on changing their behaviour.

Research has established that changing posted speed limits alone, without additional countermeasures, produces minor effects on road-user speeding behaviour (Parker Jr, 1997). For speed limits to be effective, speed limits should be set at a level that is consistent with the respective road infrastructure, to establish road-user credibility, which will in turn, foster compliance. This is in line with a Safe System approach. The following section will outline a series of recommendations that take into account possible targets for countermeasures in a speed management strategy that addresses speed limit setting and implementation.

**4.2.3 Recommendations and conclusions**

It is clear from the research reviewed that public understanding and belief that set posted speed limits will contribute to increased road safety is crucial to speed compliance. Therefore, setting speed limits needs to be accompanied with public education and promotion to ensure that the public understands why speed limits are set at their respective level, and the factors considered in the process. In education and promotion campaigns, it should be communicated to the public that:
• Posted speed limits are set at a maximum, and that different situational or environmental circumstances may require the individual road-user to alter their speed; and

• The public should also be educated about the impact of speed and how small reductions have the potential to contribute to rates of serious trauma each year.

The research has identified that enforcement plays a crucial role in posted speed limit compliance. It is recommended that speed limit setting be consolidated with enforcement strategies to strengthen compliance in the general community.

Speed limits appear to affect unintentional and intentional speeding road-users differently. Based on this understanding, providing complementary in-vehicle technologies to assist with maintaining appropriately safe speeds may be beneficial. At present Intelligent Speed Adaptation (ISA) systems that can be categorised into advisory and intervening may benefit unintentional and intentional speeding behaviour, respectively. (Note: This will be discussed in greater detail in Section 4.3).

To address the issue of placing the onus on the road-user to determine appropriate travel speeds during altered environmental or situational circumstances, variable speed limit technologies may be useful. This decreases ambiguity associated with determining appropriated speeds, and replaces the onus on developing a Safe System road infrastructure. It is important however, that speeds are set at a credible level in order to assist with road user compliance. Therefore, it is recommended that the criteria for setting speed limits should be revised in order to address the issue of developing credible speed limits.

In conclusion, when considering setting speed limits, it is important to recognise the strong relationship between the quality of roads and speed limits. Vehicle speeds should be limited to a level that ensures the inherent safety of the road system, and determined by the standards of safety so as not to exceed the level of violence that is tolerable to the human body. Therefore, if high quality roads with desirable treatments can be provided, then speed limits can be maintained however, if high quality roads cannot be ensured, reduced speed limits need to be considered, along with the recommendations discussed above to ensure countermeasures addressing speed limits are incorporated.

4.3 ENFORCEMENT

4.3.1 Definition

An extensive body of research clearly shows that speed enforcement has a positive effect on driving/riding behaviour. More specifically, past evaluations of speed management programs conducted in Victoria have identified significant reductions in crash frequency (Harrison, et al., 1999; Newstead, Cameron, Gantzè & Vulcan, 1995). Speed enforcement, also generally known as traffic enforcement, functions to reduce road trauma and enhance road safety through two key mechanisms (Delaney et al., 2003):

- **General deterrence**: This refers to a process of influencing a potential traffic law offender to avoid offending, through fear of detection and the consequences of being detected. The key element in general deterrence is the threat of detection as perceived by the driver and the perceived risk of detection may be higher than the actual risk.

- **Specific deterrence**: This refers to a process of encouraging an apprehended offender, through his actual experience of detection and the consequences, to avoid re-offending. The key element in specific deterrence is the magnitude of the penalty, especially that applying if subsequent offences are committed. These individuals have experienced the threat of detection, and are therefore aware that the risk is real.
The type of technology available influences the type of enforcement program that can be implemented. In general, speed enforcement technology can be either fixed or mobile. They include mobile speed cameras, hand-held laser speed detection devices, mobile radar speed detectors and fixed speed cameras (Delaney et al., 2003).

4.3.2 Relationship between enforcement and speeding behaviour

Speed enforcement plays a vital role in any speed management strategy, both alone and in conjunction with other initiatives. Research however, indicates that despite intensive enforcement campaigns having the ability to reduce speeding behaviours for a period of time, the effects are limited. In two studies conducted by Holland & Conner (1996) and Vaa (1997), in the United Kingdom and Norway respectively, effects were found to only last up to eight or nine weeks after the intervention was removed.

In a study conducted in the U.S.A that examined the effectiveness of speeding tickets, it was found that drivers who received speeding tickets were at an increased risk of receiving subsequent speeding tickets, hence recidivist offenders (Lawpoolsri, Li & Braver, 2007). This suggests that issuing speeding tickets has a limited effect on deterrence in the context of the enforcement system.

The effect of conspicuous traffic enforcement has also been researched. In a study conducted by Dowling and Holloman (2008), it was found that the element of surprise accompanied with conspicuous traffic enforcement produces a greater reduction in speed, and across a greater period of time compared with other methods of enforcement. Interestingly, this result was found even for motorists who were not initially speeding. Furthermore, the findings also established that motorists confronted with this element of surprise had a tendency to continue at a decreased speed as they travelled further away from the location of the enforcement unit. This suggests that it takes time for motorists to process the information, and as a consequence of this element of surprise, the level of risk perception may increase.

Enforcement carries with it the notion of punishment and therefore, in terms of speeding behaviour, drivers and riders are punished through fines, demerit points, as well as loss of driving rights. Research surrounding punishment however, indicates that its efficacy is variable. In fact, research indicates that there is potential for punishment to induce masochistic behaviour where some offenders become more aversive, as it can produce unwanted responses towards the punishing agent, which in the case of speeding behaviour, target the police. Furthermore, punishment can be effective in the short-term but fail to ultimately change the behaviour over time.

Public perceptions surrounding the underlying reasons for enforcement are important to consider. In a 2002 survey conducted in Victoria, which investigated public perceptions of the State’s enforcement initiatives, it was found that (Smith & Senserrick, 2004):

- 71 percent of the sample population believed that speeding fines were issued mostly for revenue raising purposes; and
- 24 percent felt that speed cameras improved road safety.

Similarly, a study conducted by Soole, Lennon and Watson (2008) that aimed to explore driver perceptions of police speed enforcement, also found that participants perceived police enforcement to be a revenue raising tool. Paradoxically however, they also acknowledged that police enforcement served a road-safety benefit. In the study, findings also indicated that non-camera based methods, (e.g. on-road patrols) received stronger support and were associated with greater self-reported compliance to speed limits than camera-based methods. Support for camera-based methods (e.g. mobile speed camera vans and fixed cameras) were dependent upon transparency regarding camera locations. Furthermore research has been conducted into the visibility of enforcement (Soole, Watson & Lennon, 2009). This study found that visible enforcement was associated with significantly greater self-reported compliance, in contrast to covert operations, irrespective of the mobility approach.
In summary, it appears that enforcement is a well-established strategy that has demonstrated effectiveness throughout a range of different implementation techniques. It enforces consequences following the undesirable behaviour, hence speeding. At present however, there is a well-documented stigma attached to enforcement strategies, where there is a general public perception that believes the underlying motivation for enforcement is to raise revenue. This belief needs to be addressed in the planning of a future speed management strategy to ensure that negative outcomes do not result from such a stance. A transparent and communicable approach to speed enforcement is required.

4.3.3 Recommendations and conclusions

The success of law enforcement depends on its ability to create a meaningful deterrent threat to road-users (Lawpoolsri, et al., 2007). Enforcement operates based on the notion of fear of consequences, which can sometimes produce undesirable beliefs and feelings throughout the public. Given this, it is recommended that education and advertising campaigns be accompanied with enforcement strategies to educate the public and help to establish an understanding for why enforcement is necessary. More importantly, it is important to shift the existing belief that enforcement is primarily a “money-making” scheme. A shift in this belief may increase accurate risk perception; as well provide motivation for a change in speeding behaviour, and its acceptance.

It is also recommended that minimal tolerance levels be adopted in conjunction with rationalised speed limits based on a Safe System approach. Tolerance levels, as discussed in Section 4.1.2 do not provide the motorist with a definitive maximum speed, and as a result, may promote increased travel speeds.

Enforcement needs to be widespread, highly visible and constant in order to consistently maintain appropriate risk perceptions held by motorists. If enforcement presence is not high, the risk of being held accountable for speeding behaviour remains low, providing minimal motivation for a motorist to maintain their travel speed at the posted limit. To ensure that there is public awareness of widespread enforcement, it may be useful to ensure that it is accompanied by mass media publicity.

An increased amount of visible symbols alerting road-users to potential covert operations may also be helpful in terms of increasing general deterrence.

4.4 TECHNOLOGY

4.4.1 Definition

Over time, the development of Intelligent Transport Systems (ITS) with their accompanied safety enhancing effects has assisted with enhancing mobility, efficiency and safety in the transport system. In a review of 138 systems, Bayly, Fildes, Regan and Young (2007) concluded that, despite some inconsistencies among the literature regarding the expected degree of effectiveness of such systems, considerable evidence exists to suggest that ITS contributes positive effects on road-user safety. This has been accompanied by a large degree of interest surrounding the further development of ITS.

ITS is an umbrella term that has been used to define a number of electronic, information processing, communication, and control technologies that may be combined and applied to the transport domain (Bayly et al., 2007). These systems function in a number of ways that may include interaction with a single user or vehicle, or alternatively, an entire road network. The aims of ITS include improving traffic safety, traffic flow and capacity, public transport and commercial vehicle efficiency and productivity, while reducing vehicle emissions and resource consumption (Bayly, et al., 2007).

There are several ways that ITS can be categorised, based on either the physical location of the system, the timing of the effects of the system, and the means by which the system enhances safety
of the transport domain which it is applied to (Bayly, et al., 2007). This is summarised in Table 4.1. Given the magnitude of scope in the area of ITS, for the purpose of this report, the focus will target speed-related ITS. (Note: For a comprehensive review on a range of ITS, see Bayly et al. (2007).)

Table 4.1 ITS Classifications

<table>
<thead>
<tr>
<th>Physical location of the system</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>In-vehicle</td>
<td>Technologies are based within the vehicle and provide additional information to the user, automate or intervene with some part of the driving task, or provide warnings to the user about potential hazards.</td>
</tr>
<tr>
<td>Infrastructure-based</td>
<td>Technologies are placed in the road environment and aims to serve one of two general functions: to provide drivers with additional information via roadside messages, or to better manage and control traffic flow.</td>
</tr>
<tr>
<td>Cooperative</td>
<td>Cooperative systems involve communication between vehicles and the infrastructure or between vehicles. This communication may be one-way or two-way.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>When the system takes effect</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active</td>
<td>These systems serve to prevent a crash from occurring. Active systems continuously monitor an aspect of performance of the user, vehicle, road environment or transport network, and either alert the user/s to potential danger, intervene with the driving task to avoid danger, or automate part of the driving task.</td>
</tr>
<tr>
<td>Passive</td>
<td>These systems may be considered crash mitigation or minimisation technologies that serve to enhance the safety of the driver or other road-users by minimising the severity of a crash once it has already occurred.</td>
</tr>
<tr>
<td>Combined passive and active systems (CAPS)</td>
<td>These systems monitor the road environment, vehicle and/or driver for potential danger (the active components), and then applies passive safety measures when a crash has been deemed to be unavoidable.</td>
</tr>
</tbody>
</table>

Source: Developed from Bayly et al. (2007)

One of the more recent and promising technologies that has been designed to assist with speed management (i.e., reducing excessive and inappropriate speeds) is intelligent speed adaptation (ISA). ISA is a generic term for a class of Advanced Driver Assistance Systems (ADAS) where the driver is warned and/or where the vehicle speed is automatically limited when the driver is either intentionally, or inadvertently, travelling over the posted speed limit or another pre-defined threshold (Young & Lenne, 2010). The system utilises Global Positioning System (GPS) technology to establish vehicle positioning to compare the vehicle travel speed with the local posted speed limit, and responds if this limit is exceeded. It is important to note that there are also different classes of ISA systems, which range from supportive systems that allow the occupant of the vehicle to control the speed, to fixed systems. The type of ISA system and mode of operation are two key factors that are likely to influence community acceptance and appropriate use of such technology, and hence subsequent associated crash reductions.

4.4.2 ISA and speeding behaviour

The established benefits of ISA include reductions in travel speed, speed variability and speed violations, and an associated reduction in injury and fatal crashes (Young & Lenne, 2010). It appears that the more controlling or supportive the system, the more effective it is in reducing speeds.

In a field study conducted by Hjalmdahl (2004), it was identified that a supportive system was only effective in reducing the speed of those drivers who held positive attitudes toward the system and
previously drove at speed limits that were close to the posted limits. This suggests that the speed reduction effect of advisory or supportive systems may have minimal influence on motorists who have little or no intention of complying with the speed limit. This finding is consistent with the theory of planned behaviour, where intention is a necessary factor for the desired behaviour. This is also confounded by the fact that ISA changes speeding behaviours by means of tactile and operational speed support, rather than long-term behavioural or attitudinal change, which suggests that ISA systems need to remain active to maintain reduced speeds or that it needs to be implemented in conjunction with other behaviour change strategies to reinforce longer term changes.

A study that looked at factors influencing drivers’ decision to install an electronic speed checker in their car found that of 10,300 participants recruited, 40% of the respondents accepted the offer to have an electronic speed checker installed (Garvill, Marell & Westin, 2003). More specifically, factors that affected the acceptance of this technology included age, perceived risk, morale and perceived difficulty in keeping to speed limits.

Another factor that has the potential to influence ISA effectiveness is speed limit credibility. In a study conducted by van Nes and van Schagen (2008), findings indicated that both ISA and credibility of speed limits are effective measures to reduce speeding. Interestingly, non-ISA users appear to display greater sensitivity to speed limits compared to ISA users and there was a general positive experience reported regarding the use of the ISA system.

Moreover, some research has addressed the potential for road-user behaviour to change with the installation of ISA. Behavioural adaptation has been defined by the OECD (1990) as ‘those behaviours which may occur following the introduction of changes to the road-vehicle-user system and which were not intended by the initiators of the change’. Behavioural adaptation can include the adoption of risky driving behaviours, system over-reliance and delegation of responsibility, and increased workload and distraction.

Automating driving task functions can affect drivers’ perceptions and motivations towards driving. As well as recognising the positive effects on reducing speeding behaviour with the use of ISA systems, it is also important to identify and recognise the negative outcomes. Research suggests that there is evidence that the use of ISA in some instances results in drivers attempting to compensate for slower speeds previously travelled by driving faster in segments where ISA is not activated (Comte, 2000) or in situations where lower speeds are more appropriate, such as turning (Almqvist, Hyden & Risser, 1991; Hjalmadhal and Varhelyi, 2004).

Risky driving behaviours can also be associated with the use of ISA. These behaviours may include accepting smaller gaps, later/harder braking, running red lights, as well as unsafe overtaking behaviour (Comte, 2000; Jamson, Chorlton, Jamson, Horrobin & Carsten, 2007). This behaviour may be the result of over-dependency on the system technology, which in effect breeds over-confidence in the vehicle user. In addition, ISA may also increase the speeds for drivers who would otherwise drive below the posted speed limit (Hjalmadhal, Almqvist & Varhelyi, 2002; Vlassenroot, Broekx, Mol, Panis, Brijs &Wets, 2007). In both cases, crash risk may be increased for road-users.

In summary, there is good evidence that ISA is effective in reducing travel speed and is associated with reductions in fatal and serious injury crashes. Speed-warning devices do have the potential to reduce the amount of time the drivers spend above the speed limit, and to some extent, also reduce their main speeds. This effect however, decreases over time due to habituation (the decline in the tendency to respond to stimuli that have become familiar through repeated exposure). Despite this, the utility of ISA systems in the management of speed remains promising, provided that there is awareness surrounding the current limitations and potential negative outcomes also associated with the use of this system.
4.4.3 Recommendations and conclusions

There is good evidence that ISA is an effective road safety initiative. The introduction of ISA has a number of expected safety, mobility and environmental benefits, including reductions in speed, speed variability and speed violations; reductions in injury and fatal crashes; and reduced fuel consumption and emission volumes. It is recommended that ISA systems be implemented in conjunction with other strategies, such as behaviour change campaigns that promote longer-term changes in behaviour.

Research suggests that there is an effectiveness-acceptability trade-off between more controlling ISA variants, where the more effective speed controlling ISA devices are accompanied with less public acceptance. It may be most effective to utilise supportive systems that allow voluntary control of speed in non-offending road-users, whereas for recidivist speed offenders, a more fixed controlled ISA system may be warranted.

Incentives (such as decreases in insurance premiums) can also be provided to promote the installing and use of ISA technologies amongst road-users.

4.5 BEHAVIOUR CHANGE CAMPAIGNS AND EDUCATION

4.5.1 Defined

It is important to look at possible initiatives and strategies that target behaviour change in any speed management program because when effective, it can eradicate the problematic behaviour, which in this instance is speeding behaviour. Positive behaviour change can be achieved by the introduction of education, publicity and promotional programs. These behaviour change strategies have traditionally played an important role in road safety initiatives and have been shown to be effective when introduced in combination with other initiatives that include engineering and enforcement measures. Unfortunately, the effectiveness of behaviour change initiatives and strategies is rarely assessed. Further, there is a clear lack of well-defined, measurable evaluation studies.

Road safety advertising is one of the most common forms of behaviour change strategies used to influence a change in the speeding behaviour and culture observed in Australia. There are two main factors that are considered when developing an advertisement for road safety, which include: 1) determining the message content to motivate appropriate action; and 2) executing the message in a way that the target audience understands and accepts while retaining its motivational potential (Donovan, Jalleh & Henley, 1999). The effectiveness of these messages is dependent upon both message-related and individual-based characteristics, summarised in Table 4.2.
Table 4.2 Message-related and individual-based characteristics of advertising material

<table>
<thead>
<tr>
<th>Message-related characteristics</th>
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<tbody>
<tr>
<td><strong>Response efficacy</strong></td>
<td>Providing strategies to prevent or minimise the threat of a crash appears crucial to enhancing a message’s persuasiveness.</td>
</tr>
<tr>
<td><strong>Threat relevance</strong></td>
<td>The extent to which the threat is relevant to the audience, and their vulnerability to it, has an important influence on message effectiveness. The differences in negative consequences portrayed (i.e. differences in message content reflect what the message creators perceive to be appropriate motivators for the different target audiences.</td>
</tr>
<tr>
<td><strong>Type of emotional appeal</strong></td>
<td>Advertising campaigns have been traditionally directed towards negative threat or fear-inducing emotion, whereas more recently, humour has been implemented.</td>
</tr>
<tr>
<td><strong>Ordering the message</strong></td>
<td>The content of how the message is generated to the audience is important. For example, it is beneficial for strategies to be provided following the threat proposed.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Individual based characteristics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender</strong></td>
<td>Directing the message towards a particular gender group.</td>
</tr>
<tr>
<td><strong>Pre-existing beliefs</strong></td>
<td>Pre-existing attitudes represent one of the strongest predictors of intention.</td>
</tr>
</tbody>
</table>

Source: Adapted from CARRS (2010)

4.5.2 Relationship between behaviour change campaigns/education and speeding behaviour

Fear (threat appeal) has been the traditional method used in advertising campaigns to promote improved driving safety. Lewis, Watson, Tay and White (2007) argued that, although fear arousal is important in attracting the attention of the viewer, the overall contribution to behaviour change is limited. In fact, they suggested that fear arousal was less critical to behaviour change, compared with messages addressing perceptions of vulnerability and providing effective coping strategies. This research also looked particularly at such an approach with the younger male population, where physical harm was utilised in the advertising as the threat. The effectiveness of this was shown to be limited, emphasising the importance of matching appropriate threat-based messages with the target demographic.

The effectiveness of alternative emotion-based approaches has also been investigated with a focus on the use of positive emotional appeals, which incorporate humour or pride. Lewis, Watson and White (2008) found that self-report message acceptance reported by males after exposure to positive emotional appeals was a more important predictor of subsequent speeding behaviour than their past speeding behaviour. Interestingly, those exposed to negative emotional appeals indicated that such appeals have limited impact on males’ speeding behaviour, with past speeding behaviour emerging as the only significant predictor. These results suggest that positive emotion-based approaches may be more effective.

Understanding why such emotion-based approaches are accepted or rejected by the public is important for developing future effective advertising design. A study exploring this issue found that emotional and cognitive components of persuasive health messages were of great importance, and that response efficacy is a key cognitive construct that influences the effectiveness of not only fear-based messages but also positive emotion-based messages (Lewis, Watson & White, 2009). The effectiveness however may differ for the two forms of emotion-based messages.
Wundersitz, Hutchinson and Woolley (2010) completed a review of Australian and international advertising literature published from 2001 until 2009. Evaluations of mass media advertising for road safety have found that:

- There is a need for realistic expectations from campaigns. Campaigns have demonstrated success at conveying information and altering attitudes rather than changing behaviour. Behaviour change may be an outcome that requires longer exposure however, this is difficult to measure;

- Fear appeal can only have an impact when specific conditions are satisfied including: it must describe a threat and suggest a specific plan for reducing or avoiding the threat that is possible to carry out, perceived as effective, and allows the target audience to believe that they are capable of performing the safe behaviour;

- Gender may influence the effectiveness of different emotional appeals. There is some evidence suggesting that positive emotional appeals (e.g. humour) may be more persuasive for males than fear appeals, and vice versa for females; and

- Industry standards suggest three exposures are needed to achieve minimum effective frequency although there are suggestions that a single exposure might be enough in some situations.

4.5.3 Recommendations and conclusions

Based on existing literature, it is apparent that more effective evaluation methods are necessary to achieve a better understanding of the effects of advertising campaigns on speeding behaviour. It is therefore recommended that such evaluations be developed based on the literature surrounding how to construct an effective evaluative study. Longitudinal studies would also be beneficial in order to provide an indication of the lasting effects of behaviour change promotion.

In terms of designing advertising campaigns to address speeding behaviour, it is recommended that exposure to several campaigns be offered simultaneously because it is clear from the literature that each campaign advertisement may only have the ability to target a particular demographic of people. To ensure the message is delivered throughout, the population, it would be beneficial to offer different advertisements with similar messages.

It may be beneficial for the advertising campaigns to be accompanied by education to help viewers identify the reasons behind the messages. Providing viewers with the background knowledge may help to increase the motivation of road-users that in turn, will inform an intention to alter any pre-existing maladaptive speeding behaviour.

4.6 ROAD INFRASTRUCTURE

4.6.1 Defined

The level of road infrastructure determines speed limits. Only when roads of high standard and with appropriate infrastructure treatments are provided, can higher speed limits be set. If, however, roads are not of high quality, higher speed limits cannot be maintained and reduced speed limits must be considered. Consistent with the Safe System approach, road infrastructure plays a vital role in determining which speed limit provides adequate safety for all relevant road-users. High quality roads are those that have: high design characteristics, good surfaces, wide sealed shoulders, traffic separation, and appropriate intersection control (Oxley et al., 2007). Given economic constraints and policy limitations, it is difficult to maintain high quality roads throughout the system. Therefore, within the Safe System framework, other measures need to be adjusted and that means adjusting speed limits.
Environmental factors, not exclusively, but including road infrastructure, has the potential to influence a road-user’s speed choice through influencing their perception of their current speed, as well as the speed to which they believe is appropriate for the road (Edquist, Rudin-Brown & Lenné, 2009). A driver’s perception of his or her own speed (in the absence of explicit information such as speedometers or vehicle-activated indicators) is primarily determined by the optical rate in their peripheral visual field (Gibson, 1958). The remainder of this section will explore various road infrastructure adjustments that have varied effects on a road-user’s choice of travel speed.

### 4.6.2 Relationship between road infrastructure and speeding behaviour

The evidence suggests that road geometry contributes to the choice of travel speed. For example, drivers have a tendency to select lower speeds when they are travelling on roads that have rough surfaces, are narrow, winding, hilly, and where the direction of the road and boundaries are not well delineated (Edquist, et al., 2009). By reducing their speed, drivers in these situations are more able to navigate through their external environment safely.

Approximately 100,000 Australians have been killed at intersections within the last decade (Corben, Van Nes, Candappa, Logan, & Archer, 2010), making intersection safety and design a significant issue. The proportion of serious casualties occurring at intersections remains at high proportions, with the majority occurring at intersections with a speed limit of 60 km/h (Corben et al., 2010). This highlights the need to not only improve intersection design but also examine speed limits at intersections. In a study conducted by (Corben, Candappa, Van Nes, Logan., & Peiris, 2010) various intersection design variations are considered, accompanying reduced speeds. This can be achieved either via suggesting a speed reduction at the intersection or achieving speed reduction through the design (e.g. including a roundabout, part time signals at roundabouts, see report for full discussion). Despite the infrastructure design, it is clear from the research that a reduction in speed at intersections will reduce the risk of serious casualties.

The road-side environment can also influence the travel speed selected by the vehicle user. Having objects or multiple objects that are next to the road has the potential to increase peripheral visual flow, which in turn produces an effect of perceived increased speed. Consequently, this results in the motorist reducing their speed to adjust for this perceived increased speed. In general visually complex environments have the tendency to induce a reduction in speed because not only is the road-user’s perceived speed at a higher level, but such environments also demand processing of higher levels of visual information (Edquist, et al., 2009).

Road signs and road markings are designed with the aim of providing road-users with explicit information about what speeds are appropriate. A review conducted by Edquist, et al. (2009) on their effectiveness has found minimal effect in their ability to reduce speeds.

Temporary factors such as lighting conditions and other road-users also have implications for road infrastructure design in reducing speeding behaviour. Whether road-users then increase or decrease their speed is largely dependent upon how safe they feel. In the instance where roads are unlit, a driver may travel faster if other visual information is not present to provide perceptual cues to speed, or slower, if the lack of visual information induces a feeling that higher speeds will be less safe due to limited visibility. This is often the case when bad weather presents, where road surfaces not only become slippery but visibility is also very limited causing reduced travel speeds. Congestion on the roads also has the potential to promote a reduction in speeds (Edquist, et al., 2009).

In summary, the most effective way to incorporate road infrastructure into a speed management strategy is through careful consideration of the underlying design aspects of the system that aligns both the road-users expectations formed from the road environment, and speeds that are appropriate from a Safe System approach. If road infrastructure is implemented effectively, the ability to manipulate aspects of the road environment helps to provide credibility for speed limits, and also helps to reduce overall speeds on the roads.
4.6.3 Recommendations and conclusions

Road infrastructure provides a useful tool for helping to manage speeding behaviour but is most effective when used in combination with other strategies. It is recommended that the design of road infrastructure be carefully considered with existing vehicle abilities. The main aim should be to develop road infrastructure that has the ability to match safe travel speeds throughout the road network system.

It is recommended that various technologies be used to assist in maintaining appropriate speeds, especially when environmental circumstances are altered (for e.g. visibility due to weather or lighting conditions). It may also be useful to incorporate some of this information within in-vehicle technologies to assist with the support in helping the driver or rider, determine an appropriate speed for respective environmental and road circumstances.

Enforcement of posted speed limits in different conditions may be necessary initially, in order to help develop compliance. Again, enforcement needs to be accompanied by various educational behaviour change campaigns to ensure there is transparency regarding reasons for enforcement. This will provide the most effective outcome, and may reduce aversive feelings towards enforcement.
5.0 CONCLUSIONS AND RECOMMENDATIONS

The Victorian ‘arrive alive’ 2008-2017 road safety strategy aims to reduce road trauma, to deliver further major improvements to our road transport system, and to improve safety for all Victorian road users. The strategy identifies reductions in traffic speed as having an important role in achieving this aim and this requires the introduction and maintenance of effective speed management strategies.

This discussion paper is one of a series of four papers with the overall aim to identify issues associated with speed management. The specific focus of this paper was to provide a better understanding of the factors that influence choice of travel speed and to provide recommendations for the development of an enhanced speed management strategy for Victoria.

This concluding chapter brings together the findings and insights of the review. Overall, the report has highlighted a number of factors that influence the choice of travel speed by drivers and riders and these include: driver/rider characteristics, posted speed limits, level of enforcement, road design and infrastructure, and behavioural educational programs. The report has also identified effective countermeasures aimed at managing speed and speeding behaviour at many levels including policies and practices in setting appropriate speed limits, provision of high quality road infrastructure, education and promotional activities at the community level to mass media campaigns, enforcement strategies, and promising in-vehicle technologies to assist drivers/riders choose appropriate travel speeds.

Victoria and Australia, like several other Western societies, is in an anomalous situation with regard to speed management. On the one hand, overall travel speeds are encouragingly low, with the majority of drivers and riders complying with the posted speed limit and choosing appropriate travel speeds for the environment. This situation has been brought about over the past three or so decades and principally through government legislation, enforcement and publicity campaigns.

On the other hand, it is noted that speed and speeding behaviour contributes significantly to crash and injury risk, and there is a substantial proportion of the driving/riding population who speed (either at inappropriate or excessive levels). The literature identifies two groups of speeding behaviour, including those who choose to travel close to the speed limit, and those who choose to travel at excessive speeds above the speed limit. It is clear that we need to understand the motivations for engaging in these behaviours in order to develop effective speed management strategies. It is also clear that there are strategies that may be considered to make further improvements to reduce travel speeds on our roads and these strategies may be different for each identified group.

Road safety practitioners can bring about a reduction in travel speed to ones that are appropriate for the traffic environment through a combination of legislation and enforcement, provision of high quality road infrastructure with appropriate posted speed limits for the environment, education and public awareness campaigns, and introduction of effective technologies. The recommendations emerging from this review of the literature are provided below.

5.1 Recommendations for appropriate and credible speed limits

It is clear from the literature review that appropriately set speed limits can achieve great gains in reducing crash and injury risk. It is also clear that it is of utmost importance that the public understand, are aware of and believe that speed limits are posted for the purpose of increasing road safety. This is crucial to speed compliance. Therefore, setting speed limits needs to be accompanied with public education and promotion to ensure that the public understands why speed limits are set at their respective level, and the factors considered in the process. In the education and promotion campaigns, it should be communicated to the public that:
posted speed limits are set at a maximum, and that different situational or environmental circumstances may require the individual road-user to alter their speed; and

speed impact is a major determinant of injury risk and that small reductions in travel speed and therefore impact speed have the potential to contribute to significant reductions in the rate of serious trauma each year.

Speed limits appear to affect unintentional and intentional speeding road-users and those engaging in inappropriate and excessive speeding differently. Based on this understanding, strategies to target each group should be considered. As an example, provision of in-vehicle technologies to assist with maintaining appropriately safe speeds may be beneficial. At present intelligence speed adaptation systems that can be categorised into advisory and intervening may benefit the speeding behaviour of each group, respectively.

To address the issue of placing the onus on the road-user to determine appropriate travel speeds during altered environmental or situational circumstances, variable speed limit technologies may be useful. This decreases ambiguity associated with determining appropriated speeds, and replaces the onus on developing a Safe-System road infrastructure.

The research identified that enforcement plays a crucial role in posted speed limit compliance. It is recommended that speed limit setting be consolidated with enforcement strategies to strengthen compliance in the general community.

5.2 Recommendations for enhanced enforcement

Like speed limits, effective enforcement is an important component of any speed management strategy. The success of law enforcement depends on its ability to create a meaningful deterrent threat to road-users (Lawpooolsri, et al., 2007). Enforcement operates based on the notion of fear of consequences, which can sometimes produce undesirable beliefs and feelings amongst the public. Indeed, there is a strong public perception that enforcement of speeding, especially through the use of covert cameras, is a ‘revenue-raising’ activity. Given this, it is recommended that education and advertising campaigns be accompanied with enforcement strategies to educate the public and help to establish an understanding for why enforcement is necessary, that is to enhance road safety. More importantly, it is important to shift the existing belief that enforcement is primarily a money-making scheme. A shift in this belief may increase accurate risk perception; as well provide motivation for a change in speeding behaviour, and its acceptance.

It is also recommended that minimal tolerance levels be adopted in conjunction with rationalised speed limits based on a Safe System approach. Tolerance levels, as discussed in Section 4.1.2 do not provide the motorist with a definitive maximum speed, and as a result, may promote increased travel speeds.

Enforcement needs to be widespread, highly visible and constant in order to consistently maintain appropriate risk perceptions held by motorists. If enforcement presence is not high, the perceived risk of being held accountable for speeding behaviour remains low, therefore providing minimal motivation for a driver/rider to maintain their travel speed at the posted limit. To ensure that there is public awareness of widespread enforcement, it may be useful to ensure that it is accompanied by mass media publicity.

An increased amount of visible symbols alerting road-users to potential covert operations may also be helpful in terms of increasing general deterrence.

5.3 Recommendations for improved technology

There are a number of emerging technologies that can address speeding behaviour and be incorporated in speed management strategies. The most promising technology currently available is the ISA system. This technology has a number of expected safety, mobility and environmental
benefits, including reductions in speed, speed variability and speed violations; reductions in injury
and fatal crashes; and reduced fuel consumption and emission volumes. It is recommended that
ISA systems be promoted for inclusion in the current vehicle fleet as well as new vehicles. Some
specific recommendations are:

- Retrofitting of aggressive ISA technology for recidivist offending excessive speeders. Evidence suggests that recidivist offenders are the most difficult group to address. There is,
  unfortunately, little known about what motivates these groups to continue risky speeding
  behaviours. Moreover, little is known about the feasibility of ISA for this group. Nevertheless, traditional measures have not addressed this group adequately, and clearly
  strong interventions need to be applied. Drivers/riders who continue to show resistance to
  speed reduction measures require stronger measures. The imposition of a post-sale
  enhanced ISA system as a condition for continued licensing is a logical next step for this
  sub-group.

- Encourage government at all levels and commercial enterprises to purchase fleet vehicles
  with ISA technology as a minimum. The support and promotion of such technologies by
government and commercial enterprises (through promotion of ANCAP and inclusion of
  safety features in purchasing policies) is an important step to introduce technologies
  addressing speeding behaviour quickly into the vehicle fleet.

- Work towards developing the inclusion of enhanced ISA systems as a high-value
  component of ANCAP, through the award of extra points.

In addition, ISA should be implemented in conjunction with other complementary initiatives and
programs, such as behaviour change campaigns that promote longer-term changes in behaviour.

Research identified suggests that there is an effectiveness-acceptability trade-off between more
controlling ISA variants, where the more effective speed controlling ISA devices are accompanied
with less public acceptance. It may be most effective to utilise supportive systems that allow
voluntary control of speed in non-offending road-users, whereas for recidivist speed offenders, a
more fixed controlled ISA system may be warranted.

Incentives (such as decreases in insurance premiums) can also be provided to promote the installing
and use of ISA technologies amongst road-users.

5.4 Recommendations for behaviour change campaigns and education programs:

Based on existing literature, it is apparent that educational and mass media campaigns are
important activities, especially when they support legislation and enforcement. These programs are
likely to prompt increased compliance with speed limits amongst unintentional speeders and those
travelling at inappropriate speeds. Some specific recommendations follow:

- Creation of a suite of public education programs with more innovative messages to
  promote the benefits of reduced overall speed, particularly targeting unintentional speeders
  and those travelling at inappropriate speeds (as well as non-users in general).

- Enhanced design of mass media campaigns through exposure to several campaigns. Given
  the evidence that programs and campaigns separately may only have the ability to target a
  particular demographic of the population, consideration of simultaneous running of
  campaigns is recommended. Further, to ensuring consistent messages are delivered
  throughout the population, it would be beneficial to offer different advertisements with
  similar messages.

- It may be beneficial for the advertising campaigns to be accompanied by education to help
  viewers identify the reasons behind the messages. Providing viewers with the background
knowledge may help to increase the motivation of road-users that in turn, will inform an intention to alter any pre-existing maladaptive speeding behaviour.

In addition, the review identified a distinct lack of evaluation studies of behavioural and educational programs. For the continued development and effectiveness of these initiatives, evaluation studies are recommended to achieve a better understanding of the effects of advertising campaigns on speeding behaviour. It is therefore recommended that such evaluations be developed based on the literature surrounding how to construct an effective evaluative study. Longitudinal studies would also be beneficial in order to provide an indication of the lasting effects of behaviour change promotion.

5.5 **Recommendations for improved road design and infrastructure**

Road design and infrastructure provides a useful tool for helping to manage speeding behaviour but is most effective when used in combination with other strategies. It is recommended that the design of road infrastructure be carefully considered to complement the existing posted speed limits. The main aim should be to develop road infrastructure that has the ability to match and encourage safe travel speeds throughout the road network system. Moreover, these measures should be designed to support drivers and riders to determine an appropriate speed for respective environmental and road circumstances.

It is recommended that various road design technologies be used to assist in maintaining appropriate speeds. These include a broad range of traffic calming measures and perceptual countermeasures, and these can be incorporated with in-vehicle information systems such as GPS, ADAS, etc., and out-of-vehicle information systems such as variable speed limits, activated warning signs, etc.

Some examples of traffic calming are: road narrowing, road re-alignment, gateways, roundabouts, kerb extensions, speed humps. Some examples of perceptual countermeasures are: painted lines, chicanes, roadside posts and furniture, etc.

Enforcement of posted speed limits in different conditions may be necessary initially, in order to help develop compliance. Again, enforcement needs to be accompanied by various educational behaviour change campaigns to ensure there is transparency regarding reasons for enforcement. This will provide the most effective outcome, and may reduce aversive feelings towards enforcement.

5.2 **Conclusions**

To summarise, addressing the factors that impact on travel speed is a complex issue. Drivers and riders use a range of cues, both internal and external to choose a speed to travel at. This review provided a general outline of how each of six main factors, including human characteristics, speed limits, enforcement, technology, behaviour change campaigns and education, as well as road infrastructure impacts on travel speed selection. Even more importantly, it is essential that one reviews each of the factors while considering how they fit in line with the theory of planned behaviour. The effectiveness of implementing countermeasures that address each factor or combination of factors is dependent upon whether the countermeasure or combination of measures can induce an 'intention' to change. This intention that promotes behaviour change must also be sustained over time to achieve long-term behaviour change, and hence a reduction in speeding behaviours on Victorian roads.

A number of recommendations have been made for speed management strategies, taking into account the factors that influence choice of travel speed and include improvements/enhancement to speed limits, enforcement, behavioural programs and road design and infrastructure.
6.0 REFERENCES


Åberg, L. (XXXX). Reasons for speeding and need for technical support.


