DOTARS
DEPARTMENT OF TRANSPORT AND REGIONAL SERVICES

SUBMISSION NO. 5

VARIABLE SPEED LIMITS – A CASE STUDY OF THE EFFECTIVENESS OF INTELLIGENT TRANSPORT SYSTEMS

Department of Transport and Regional Services Submission to the House of Representatives Standing Committee on Transport and Regional Services Inquiry

September 2002

The views expressed in this submission are those of the Department and do not necessarily reflect those of the Minister for Transport and Regional Services or the Government.

1 The Department's Interest in the Inquiry

The overriding objective of the Department of Transport and Regional Services (DOTARS) is:

> *A better transport system for Australia and greater recognition and opportunities for local, regional and territory communities.*

A "better" transport system is considered to be one that is safer, more efficient, internationally competitive, sustainable and accessible.

A better transport system can be achieved in many ways including improvements in road infrastructure, driver behaviour and traffic management arrangements. Intelligent Transport Systems (ITS) are one of the tools available to help achieve this goal. ITS is the application of modern computer and communication technologies to transport systems, to increase efficiency, reduce pollution and other environmental effects of transport, and to increase the safety of the travelling public. Variable speed limits (VSL) are one example of an ITS application.

Australia has considerable ITS capability and is a world leader in the development and deployment of several ITS products and services. DOTARS is active in promoting and supporting innovation and development and adoption of new technologies in the transport sector. To further harness the enormous potential of advanced technologies to improve Australia's transport systems, DOTARS participated in the development of *e*-transport, the National Strategy for ITS. DOTARS also contributes financial support to ITS Australia, the body responsible for implementing *e*-transport.

To date, ITS solutions have primarily been implemented on a project-by-project basis, instigated by the relevant roads authority. The Government has recently announced *AusLink*, a rolling 5-10 year transport infrastructure development plan. On the basis of this national plan, the Government will seek project proposals that advance the plan's strategic priorities. One significant aspect of this plan is that new technology and ITS solutions will be eligible for funding. This would ensure that such solutions are implemented in a nationally consistent and strategic manner. DOTARS is committed to pursuing an agenda of facilitating the improved efficiency of the transport sector through the application of technology.

This submission concentrates on the role of speed limits in Australia, the impacts of speed and an overview of VSL and other ITS speed management tools available to decision makers. It also briefly examines the potential application of VSL on the F3 Freeway and Hume Highway between Sydney and Canberra.

2 The Role of Speed Limits

Speed limits are one of the oldest strategies for controlling driving speeds. It has been argued that most drivers can be assumed to be capable of making reasonable judgments about appropriate driving speeds. The primary reason for regulating individual choices, however, is the significant risks drivers can impose on others. Different drivers have different tolerances for risk and individual decisions may not adequately take into consideration the risk a particular driver's choices impose on other road users.

2.1 Speed Limit Overview

The primary reason for setting speed limits is safety. In setting speed limits, decision makers attempt to strike an appropriate societal balance between desirable travel time and risk for given road and traffic conditions. Thus, the posted legal limit informs motorists of maximum driving speeds that decision makers consider reasonable and safe for particular roads or highways under favourable conditions.

In addition, speed limits provide the basis for enforcement. Well-conceived speed limits provide law enforcement officers and courts with an indication of appropriate speeds for favourable conditions and thus help target enforcement and sanctions on those who drive at speeds that are excessive for conditions and likely to endanger others.

Speed limits have also been established for fuel conservation, as they were in the USA following the oil crisis in 1973. Finally, speed limits could be imposed to improve air quality. However, although motor vehicles emit more pollutants at high speeds, speed limits are rarely established solely for environmental goals.

Speed limits can thus be conceptualised as a trade-off between safety, travel times, fuel consumption, vehicle emissions, driving enjoyment and other social or economic impacts. The Australian Transport Safety Bureau (ATSB) acknowledges the fact that striking the right balance between these factors is a difficult task based on imprecise methods.

2.2 Speed Limits in Australia

Posted speed limits are still the backbone of speed management in Australia. But speed management is concerned not only with the setting and enforcing of speed limits (to discourage or prevent *excess speeds*) but also with achieving driver behaviour which results in choices of speed that are appropriate in the prevailing circumstances (to discourage or prevent *inappropriate speeds*).

By international standards Australia has quite permissive legal limits, especially on two-lane undivided rural roads, urban arterials and residential streets. Non-motorway rural speed limits in European and North American countries are generally more restrictive than in Australia, with most countries applying limits of 80 or 90 km/h on normal rural roads (see Attachment 2). It should be noted, however, that in Australia the maximum speed limit on many major, rural, undivided roads is the same as for modern, divided freeways. This situation does not recognise the very different driving conditions and safety performance of these two road types. It is hard to argue that 110km/h is a safe speed on the two-lane Newell Highway, for example, if this is the maximum allowed on the divided sections of the Hume Highway between Sydney and Melbourne.

There have been calls for higher speed limits on Australian roads to suit the large distances often travelled. A common line of argument is that higher speeds would lead to reduced driver fatigue (and fewer crashes) because journey times would be shorter and the driving task would be more stimulating. The ATSB has highlighted a number of problems with these arguments. Firstly, time-savings are likely to be quite small in relation to total trip times, and any reductions in fatigue-related impairment are likely to be far outweighed by increases in speed-related crash risk (see section below on impacts of speed). Secondly, driving at high speeds may be challenging and arousing for short periods, but there is evidence (cited in Donald and Cairney 1997) that such effects are not maintained over long distances or time periods.

It is interesting to note that the current situation in Australia could ironically be working against development of the best road system with more divided roads. This can arise as, under Austroads (the association of Australian and New Zealand road transport and traffic authorities) procedures used by the Commonwealth and State road agencies, road proposals are justified through the economic benefits they provide. Most of these benefits are related to travel time savings to road users. Calculation of travel time benefits under uncongested conditions assumes the maximum permitted speed as the free flow speed for light vehicles. If there was a greater speed differential between freeways and two-lane roads the travel time savings, and hence the overall benefits, of freeways would increase thereby improving their economic warrant over less safe two-lane roads.

3 Impacts of Speed

Research has shown that many of the undesirable effects of road transport are directly linked to traffic speeds. For example, it has been established that casualty crash rates, greenhouse gas emissions and fuel consumption all increase rapidly as traffic speeds increase above 80 km/h.

Road safety outcomes are especially sensitive to changes in traffic speeds. There is a large body of research to show that small increases (or decreases) in vehicle travel speeds result in relatively large increases (or decreases) in road casualties.
The association between speed and safety is linked to several causal mechanisms that are discussed in some detail in Kloeden, Ponte and McLean (2001). These include the effects of travelling speed on: driver reaction time; braking distances; impact speeds; and crash energy. An important issue here is that speed is critically related not just to the number of crashes that occur, but also to the severity and injury outcomes of those crashes.

3.1 Correlational studies

These studies use aggregate crash data to infer a relationship between speed and crash outcomes, by comparing situations with different average traffic speeds: before and after speed limit changes at specific locations; or between sites with different speed limits.

Reviews of these studies have led to the following broad conclusions:

- very small changes in mean speeds (of the order of 1 km/h or less) can be expected to result in measurable and substantial changes in crash outcomes;

- for total crash numbers the relationship is at least linear, but more likely to be quadratic;

- severe crashes (serious injuries and fatalities) are much more sensitive to speed changes than crashes in general.

Nilsson (1984) developed an equation (often cited informally as Nilsson's Power Rule) that summarised the results of extensive research into the effects of speed limit changes on Swedish rural roads.

Subsequent research evidence has supported the usefulness of the Nilsson equation as a rule of thumb for predicting the safety impacts of speed changes. In summary, the equation predicts that a given percentage change in actual travel speeds will result in approximately:

- a two-fold percentage change in minor injury crashes;

- a three-fold percentage change in serious injury crashes;

- a four-fold percentage change in fatal crashes.

Recent Australian case control studies have found a roughly exponential relationship between individual travel speeds and risk of a casualty crash, on both urban (60 km/h speed limit) and rural roads. In the urban study, casualty crash risk approximately doubled for each 5 km/h above 60 km/h (Kloeden et al 1997).

On rural roads, with limits ranging from 80 to 110 km/h, the speed-risk relationship was slightly greater than exponential, with the risk (relative to vehicles travelling at the mean speed) more than doubling for vehicles travelling 10 km/h above the mean, and reaching 5.8 times for vehicles 20 km/h above the mean (Figure 1). Significant risk reductions were found for speeds below the mean (Kloeden, Ponte and McLean, 2001).

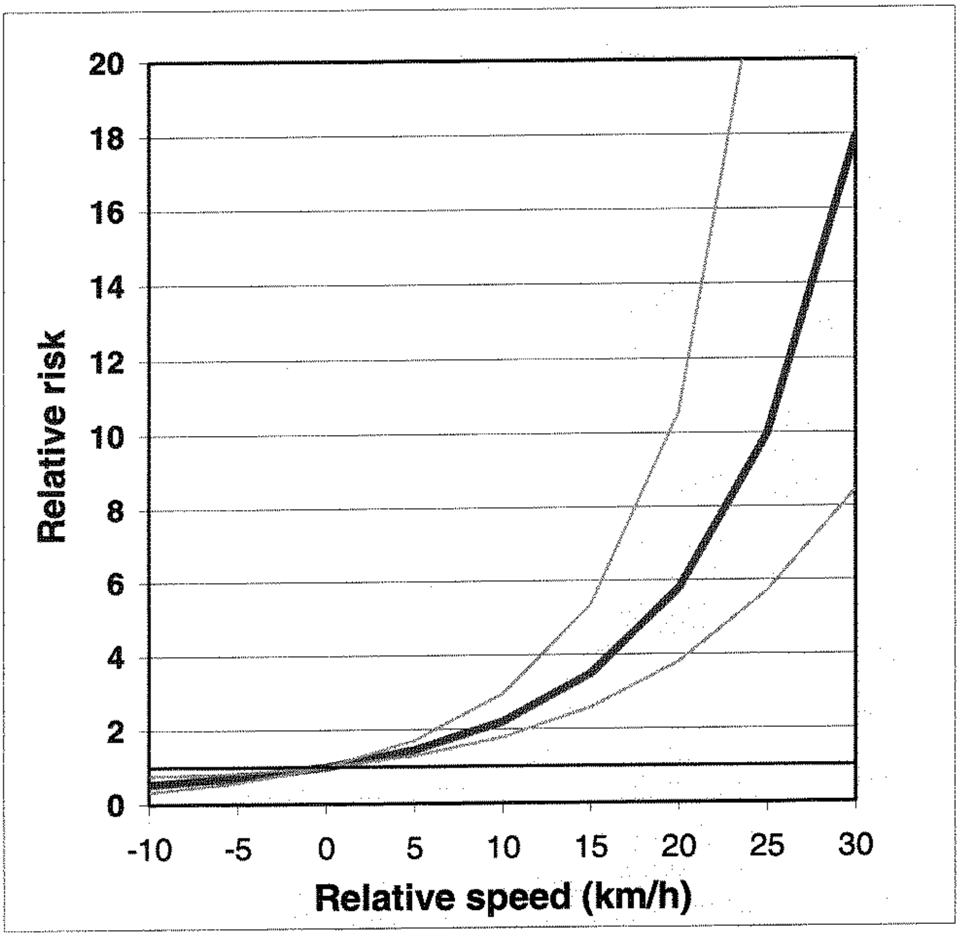

Figure 1. Relative risk as a function of differences between case speeds and average control speed on rural roads (95% confidence intervals shown by thin lines). Based on Kloeden et al (2001).

3.2 Speed Limits

While the effects of speed on crash outcomes have been well established, the relationship between speed *limits* and safety is more complicated. This is because the legal limit is only one of several factors influencing actual traffic speeds.

Nevertheless, there have been numerous evaluation studies linking speed limit changes to significant changes in casualty rates (see Kloeden et al, 1997, for an overview of evidence). Much of this work has focussed on the effects of lowered speed limits and has generally reported substantial casualty reductions.

Some studies have also examined the effects of raising speed limits. For example:

- A considerable amount of evaluation work was undertaken in the United States after most states, in the late 1980s, raised their limits on rural interstate highways from 55 mph to 65 mph. (The lower limit had been introduced nationally in 1974 as a fuel saving measure). Overall, these studies point to an underlying increase of 20 percent or more in fatalities on roads that adopted the raised limit. Godwin (1992, cited in Kloeden et al, 1997) analysed data from 18 states and concluded that fatality numbers had increased 35 percent on affected roads, compared to a 9 percent increase on roads that retained the lower limit.

- In the Australian context, Silogeris (1992, cited in Donald and Cairney, 1997), analysed changes in speed limits on Melbourne's rural and outer urban freeway network. In June 1987, the limit on these roads was raised from 100 km/h to 110 km/h, then lowered back to 100 km/h in September 1989. The study found that the injury accident rate increased by 24.6 percent when the higher limit was in operation, then decreased by 19.3 percent after the lower limit was restored.

It is noteworthy that these studies generally looked at high standard highways and involved speed limit changes that would not have exceeded the original design speeds of the roads.

The evidence indicates that any variation in limits that changes actual traffic speeds will also have an impact on crash outcomes – speed increases as small as 3 km/h are likely to increase casualty crashes by about 10 percent, and fatal crashes by an even larger amount.

3.3 Speed and vehicle emissions

Emissions from road transport consist of a variety of pollutants, which are produced in different quantities at different speeds. The major pollutants are oxides of nitrogen whose emissions increase with speed, hydrocarbons whose emissions generally decrease with speed, and carbon monoxide and particulate matter whose emission levels are lowest at medium speeds. Carbon dioxide emissions are proportional to the amount of fuel consumed. Changes in speed can make a large contribution to emissions and in particular acceleration can cause disproportionate emissions. In addition, at speeds above 40-50 km/h noise from traffic increases linearly with speed.

Changes in speed can also vary costs to users of vehicles in the form of time spent on journeys, amount of fuel used, wear and tear on the vehicle, etc.

4 Variable Speed Limits

Variable speed limits (VSL) are mainly used to manage traffic flows and incidents on motorways. They typically allow the speed limit on a given segment of road to be lowered from the normal statutory or posted limit in response to congested traffic or adverse weather conditions. The main objectives are to improve traffic flows, improve safety and sometimes to reduce pollution.

VSL systems can operate on pre-set schedules (eg reduced limits during known peak traffic periods) or can respond automatically to feedback from traffic or weather sensors. Increasingly, they are being developed as dynamic systems controlled by a centralised computer and operating as part of a fully integrated incident management scheme. More advanced VSL systems typically utilise a combination of a number of different technologies including variable message signs (see section 5.2), loop detectors measuring traffic density and speed, incident management systems, and weather and road surface condition information to determine and display appropriate travel speeds to drivers.

Reduced speed limits are usually used in conditions in which drivers might well reduce speeds anyway, and variable limits thus bring an "extra" reduction. However, there are cases where the speed differential of the traffic stream can paradoxically increase under more dangerous conditions as drivers' perceptions of an appropriate safe speed can vary substantially. For example, if some drivers slow when visibility is low, the risk to faster drivers of running into their vehicle increases. One of the benefits of VSL in adverse conditions, therefore, is in unifying the traffic speed of drivers who want to remain at the normal speed limit and those who wish to moderate their speed to suit prevailing conditions.

VSL applications can also improve the credibility of the speed limit system as speed limits become more flexible and more appropriate for the prevailing conditions. The speed reducing capacity of VSL systems appears to be largest if the reason for the current limit is indicated in the form of a warning or advice. In general it has been reported that road users often welcome VSL and this can result in improved compliance.

What can be considered a safe speed is necessarily a compromise of a number of factors, including road type, traffic conditions, weather, time of day, vehicle type and condition, and driver skill and experience. A speed that may be quite reasonable for a skilled driver in a new vehicle with light traffic conditions on a fine day may be dangerous for a teenager in an old car at peak hour on a wet evening. It may not be possible to remove all these factors from the speed equation, but VSL systems provide an opportunity to make speed limits better reflect two of these factors, traffic and weather conditions.

VSL precedes ITS technology with school zones being an example. For many years motorways in UK had orange lights which mandated a lower speed limit when activated by police, usually for fog or ice conditions. Modern ITS provides increased potential to ensure speed limits are relevant to conditions, that the speed limits are clearly advised to motorists and that the speed limits can be monitored and enforced.

Modern VSL systems, however, involve significant installation and maintenance costs. A speed management report prepared for the European Commission in 1998 (Kallberg et al. 1998) concluded that if VSL applications are mainly used to reduce speeds in bad driving conditions, the overall benefits can exceed the costs. If, on the other hand, VSL applications are used to increase speed limits in ideal driving conditions, the overall accident risk may increase and benefits can remain well below the costs.

A report prepared for the US Federal Highway Administration concluded that, due to its high cost, VSL should be implemented in areas where environmental and/or traffic conditions resulted in significant fluctuations in the desired speed. The report estimated VSL to cost between US$0.4 and US$1 million per kilometre (Coleman et al. 1995).

4.1 Current Experience

In Australia, VSL systems are already operating in NSW. The NSW Roads and Traffic Authority's (RTA) Transport Management Centre (TMC) enables innovative and integrated management of the State's road networks (the TMC was the command centre for managing the transport task of the Olympic Games). The main role of the TMC is to ensure that the road network is available to run to its capacity. This is achieved by managing special events and unplanned incidents, disseminating information and optimising the operation of traffic systems. One of the tools used by the TMC to manage road incidents is the application of VSL. The RTA has advised that VSL are most appropriate for high volume roads with restricted access/egress, and preferably used in conjunction with incident detection systems.

Currently VSL applications are limited to motorways (the M4 and M5) and tunnels, as well as General Holmes Drive in Sydney.

The aim of VSL systems in NSW is to reduce speeds in response to traffic incidents, weather conditions, or at times of high congestion. The M4 system, established in 2000, enables speed limits to be varied from 90km/h (normal limit) to 40km/h. Initial operation was based on pre-set cycles, but the system is being developed to automatically respond to changing traffic densities. There are currently 45 VSL signs in operation on the M4 Motorway. This project, which also encompassed automatic traffic data monitoring, incident detection and variable message signs, cost approximately $12 million to implement.

Evaluation data on the effects of VSL are generally limited, though there is some overseas evidence for their effectiveness in increasing both traffic flows and safety (see Attachment 1). The effectiveness of VSL in reducing traffic speeds depends on the extent to which drivers comply with the lower speed limits. This points to the need for supporting enforcement strategies, such as speed camera operations. Studies have shown that speed enforcement can significantly decrease speeds.

5 Other Intelligent Transport Systems Speed Management Tools

It is important to note that there are a host of innovative speed management tools in addition to VSL systems. Recent technological advances have allowed the application of information technology and modern communications to transport issues, typically termed intelligent transport systems (ITS). ITS offers flexibility and provides broad opportunities to manage speed in varying conditions (eg adverse road and weather conditions) and in place and time related critical conditions (eg in school zones and where road works may be taking place). ITS applications may include equipment in the road environment and/or in the vehicle.

ITS for speed management may broadly be divided into three categories:

1. Informative/warning systems that aim to influence drivers' speed choices, but leave the decision to them. This includes variable speed limit signs at the roadside, speed feedback signs at the roadside, and informative in-vehicle devices.

2. Recording systems that register speed (eg automatic speed surveillance, in-vehicle speed recorders, etc).

3. Intervening tools that set the limit in the vehicle and thereby take away the possibility from the driver to exceed the pre-set limit (eg adaptive cruise control, fixed and variable speed limiters, etc).

5.1 Vehicle-Related Technologies

Technologies are continually being developed that aim to provide more information and feedback to drivers about driving speeds and, in the longer term, to create "intelligent" vehicle control systems.

For example, heads-up display speedometers that provide continuous speed information to drivers in their normal fields of view, rather than requiring drivers to look at the dashboard periodically, are available. Electronic devices mounted on the dashboard that are activated by roadside transmitters at mileposts or speed limit signs have been tested for their potential to warn drivers that they are exceeding legal speed limits. User acceptance of such devices is likely to be better if the device is activated only in highly hazardous locations (Comte et al. 1997).

Emergency warning systems are also being developed. For example, sensors on the front of the vehicle could detect when a vehicle is closing too fast on the vehicle immediately ahead and warn the driver when the distance equals a predefined limit for the travel speed. A curve approach warning system, using roadside communications beacons to provide information about roadway geometry, could alert drivers to sharp curves, warning them if the vehicle is approaching at excessive speed. This type of system could be particularly effective in forestalling speed related, run-off-the-road crashes. However, commercialisation and broad driver acceptance of many of these speed related information systems depend on cost, as well as resolution of human factor issues, such as driver distraction and information overload.

Vehicle control technologies offer another level of sophistication in speed management. Conventional cruise control systems, which are mainly used in highway driving, already enable drivers to establish and maintain a fixed vehicle speed. More advanced adaptive cruise control systems, which are already under development by many car manufacturers and their suppliers, would use forward looking sensors and adjust vehicle speeds automatically to maintain a safe following distance from the vehicle ahead. Key concerns are reliability and the pros (eg crash avoidance) and cons (eg driver inattentiveness) of automating critical driving tasks. Fully developed collision avoidance systems would also involve lane departure avoidance systems as well as frontal collision avoidance systems.

Speed limiters offer a solution for limiting the maximum speed of a vehicle. Speed limiters are already fitted to a large number of heavy vehicles operating in Australia. The primary reasons for using speed limiters on heavy vehicles are fuel efficiency, safety, and equipment wear. In the USA speed limiters are usually set at the speed that provides maximum fuel efficiency, which generally falls below most current maximum speed limits on major highways (TRB 1998). The use of speed limiters on passenger vehicles has been tested in Europe (Comte et al. 1997), but issues of driver control, system cost, and, above all, consumer acceptance, are likely to preclude their widespread use in the foreseeable future.

5.2 Highway-Related Technologies

Road-based technologies use electronic capabilities to provide drivers with information about upcoming road conditions. One of the most commonly available technologies are variable message signs (VMS), which can be used for speed control. VMS have gained more importance over recent years due to the improved flexibility of signs brought about by improved electronics and the widespread availability of communications. A wide range of messages can now be displayed on VMS in the form of text or pictograms. In terms of the provision of speed advice or mandatory speed indication by means of VMS, however, the effects have been small. Typically, there has been a 3 to 4 km/h speed reduction for a 20 km/h reduction in the speed limit, with evidence that effects reduce over time, and in some cases speed reductions have been undetectable (ECMT 1998). Variable speed limits represent a more sophisticated use of VMS to convey information to drivers about appropriate speed limits.

Another road-based approach to managing speed is to provide drivers with direct feedback about their driving speeds through the use of mobile roadside speedometers. The devices usually include a speed limit sign, a radar to measure speeds, and a changeable message sign that displays the speed of the approaching vehicle to the driver. A fog warning and speed advisory system was installed along an 11km stretch of the F6 Tollway south of Sydney where the speed of a vehicle passing through a detector was displayed to the next vehicle as an advisory speed. The system resulted in a 60% reduction in the number of speeders, but the effect was temporary – there was no reduction in speeding 300m downstream (Coleman et al. 1995). The effectiveness of such systems is clearly linked with enforcement.

Fully automated highways, which would combine many of the vehicle and highway related technologies described above, would fully control speed essentially by taking the driving task away from the individual driver. However, even if reliability and liability issues could be resolved, the large investment costs are likely to severely limit deployment in the near-term.

6 Potential for application of VSL on the F3 Freeway and Hume Highway between Sydney and Canberra

As noted above, VSL systems are typically applied in order to improve traffic flow and safety in adverse conditions, in particular during times of congestion and poor weather.

Internationally, VSL systems have been put in place on roads subject to regular congestion and/or extreme weather conditions such as fog, snow and ice. On England's M25 freeway, the installation of VSL combined with message signs, cameras and loop detectors has resulted in a 28 per cent reduction in traffic incidents. Similarly, VSL systems used on German autobahns have reportedly reduced cash rates by between 20 and 30 per cent. Attachment 1 contains details of international VSL examples.

For the purposes of determining any potential for applying VSL on the F3 Freeway and the Hume Highway, the usage patterns, accident history, typical weather conditions and cost of VSL installation would need to be taken into account.

The NSW Government has commenced a project to install a Driver Aid Scheme on the F3 Freeway between Wahroonga and Kariong (near Gosford). The scheme will include variable message signs, closed circuit television cameras, automatic incident detection and VSL signs. The Commonwealth contributed approximately $4 million to the first stage of the project (variable message signs and cameras).[1]

It would seem that VSL systems would be most appropriate for sections of the F3 and Hume Highway which are subject to regular congestion (i.e. between Wahroonga and Gosford on the F3 and Prestons and Narellan Road on the Hume Highway), extreme weather such as fog (possibly along sections of the Hume Highway in the Goulburn-Southern Highlands corridor) or where accidents are recurrent (see box). A thorough analysis of these roads and accident data to identify high accident-risk locations, followed by a cost-benefit analysis, would be necessary before deploying VSL to greatest advantage. The analysis should include consideration of the likely impact of VSL on the incidence of congestion and accidents (eg. are accidents in these locations caused primarily by factors which could be removed or reduced through implementing VSL?), and to whether the cost of installing VSL could be better allocated (eg. on upgrading the road at high accident-risk locations).

Box: Costs of Accidents on Hume Highway and F3 Freeway

There were 10 fatal and 448 injury accidents on the Hume Highway between Sydney and Gunning in 2000 (RTA NSW data). Corresponding figures for the F3 Freeway between Sydney and Newcastle were 5 fatal accidents and 123 injury accidents.

The Bureau of Transport and Regional Economics (2000) estimates the cost of a fatal crash at $1.7 million, a serious injury accident at $408,000 and a minor injury accident at $14,000.

As the RTA data does not classify the seriousness of the injury accidents, for the purposes of this estimation, an average cost of $211,000 per injury accident is assumed.

The cost of accidents on the Hume Highway between Sydney and Gunning in 2000 was therefore estimated as $112 million and $34 million on the F3 Freeway.

Data on the cause of the accidents was unavailable. However, if VSL were able to reduce the incidence of fatal and injury accidents by 20 per cent, the annual costs would be reduced by $22 million on the Hume Highway (Sydney – Gunning) and by $7 million on the F3 Freeway.

6.1 Potential for other Intelligent Transport Systems to be included in the Case Studies

DOTARS would strongly support the consideration of other ITS applications to be incorporated into the case studies in addition to VSL. These could include variable

[1] DOTARS has requested further information from the RTA on the remaining stages of the project; this information is in preparation but had not been received at the time of this submission.

messaging signs (which would indicate to drivers the reason for reduced speed limits, shown to induce higher levels of compliance) and incident detection and alert systems.

7 Conclusion

DOTARS supports a case study of VSL on the F3 and Hume Highway, subject to further investigation and analysis of the costs and potential benefits. A thorough examination of the accident history, usage and weather patterns of the roads would be necessary in order to identify appropriate case study locations. Incorporation of other ITS applications such as incident detection and alert systems would also be preferred.

References

Bureau of Transport and Regional Economics (2000) *Road Crash Costs in Australia*, Report 102, BTRE, Canberra.

Coleman, J.A., et al. (1995). *FHWA Study Tour for Speed Management and Enforcement Technology*, Federal Highway Administration, US Department of Transportation.

Comte, S., Várhelyi, A. and Santos, J. (1997). *The Effects of ATT and Non-ATT Systems and Treatments on Driver Speed Behaviour*, MASTER Working Paper R. 3.1.1., ECMT.

Corben B., Lenné, M., Regan, M. and Triggs, T. (2001). *Technology to Enhance Speed Limit Compliance*, Proceedings of the Road Safety Research, Policing and Education Conference, Melbourne.

Donald, D. and Cairney, P. (1997). *Higher Open Road Speed Limit: An Objective Assessment*, Research Report ARR 298, ARRB Transport Research Ltd, Melbourne.

ECMT (1998). *MASTER – Managing Speeds of Traffic on European Roads*, Final Report of Project MASTER.

Highways Agency (1997). *Highways Agency Annual Report 1996/1997.*

Kallberg, V-P., Allsop, R.E., Ward, H., van der Horst, R. and Várhelyi, A. (1998). *Recommendations for Speed Management Strategies and Policies*, MASTER Deliverable 12 (Report 4.1.1.).

Kloeden C N, McLean A J, Moore VM, & Ponte G (1997). *Travelling speed and the risk of crash involvement.* CR172, Federal Office of Road Safety. Canberra.

Kloeden C N, Ponte G, and McLean A J (2001). *Travelling Speed and the Risk of Crash Involvement on Rural Roads* CR204, Australian Transport Safety Bureau. Canberra.

Lassauce, P. (1998). Variable Speed Limits on Motorways, *Revue Generales des Routes, 768*, 16-19.

Nilsson, G (1984). *Speeds, accident rates and personal injury consequences for different road types.* Rapport 277, Swedish National Road and Transport Research Institute (VTI). Sweden.

Roads and Traffic Authority (NSW) (2001), *Road Traffic Accidents – 2000*, RTA, Sydney.

Robinson, M. (2000). *Examples of Variable Speed Limit Applications*, Document prepared for Speed Management Workshop, Transportation Research Board 79th Annual Meeting.

Transportation Research Board (1998). *Special Report 254: Managing Speed – Review of Current Practice for Setting and Enforcing Speed Limits*, National Academy Press, Washington, D.C.

Overseas Data on the Effects of Variable Speed Limits

England

Speed limits were adjusted in response to the level of congestion on the M25, one of the most congested freeways in England. Using variable message signs, closed circuit television and loop detectors measuring traffic density and speed, speed limits were lowered in increments as congestion increased. The system also monitors stationary traffic to slow vehicles down approaching a queue, and has additional logic to stop speed limit settings fluctuating too often. Speed cameras were used to enforce the speed limits.

It is reported that motorists were more inclined to keep to their lane when a "faster lane" no longer existed. They were also more inclined to keep to the inside lane and to keep proper distances between successive vehicles, resulting in smoother traffic flow which actually increased average travel times of traffic. Results show that the VSL scheme resulted in less pollution and a 28% reduction in traffic incidents (Highways Agency 1997).

France

A trial of VSL on a 12km section of the A4 in Strasbourg set up "advised speeds" of 50, 70, 90 or 110 km/h depending on traffic density. Results showed that traffic flow increased by more than 3,000 vehicles per hour over the life of the trial. At the same time, traffic speeds were reduced in the 90-110 km/h and under 50 km/h ranges, but increased in the 70-90 km/h range, suggesting less congestion – indications were that effective capacity during peak hours increased by 5% (Lassauce 1998, cited by Corben at al. 2001).

Germany

A system of variable speed limits is used on the Autobahn between Salzburg and Munich, between Sieburg and Cologne, and near Karlsruhe, to stabilise traffic flow at times of high congestion and thereby reduce the probability of crashes and environmental impacts. Such limits have been in use since the 1970s and recent data has shown that the use of the speed limit and warning signs has reduced the crash rate by 20% to 30%. It has also been reported that motorists respond better to the electronic signage than fixed signage because the former provides advisory information (Robinson 2000).

Netherlands

A VSL system near Breda was installed to elicit safer driving behaviour during heavy fog. The posted speed limit is 100 km/h, but this is lowered to 80 km/h and 60 km/h when visibility drops below 140m and 70m respectively. After the system was installed, it was found that drivers reduced their mean speeds by 8 to 10 km/h during fog conditions (Robinson 2000).

Speed Limits for Light Vehicles in Europe, North America and Australia

Country	Motorways (km/h)	Outside built-up areas (except motorways) (km/h)	Within built-up areas (km/h)
Europe			
Austria	130	100	50
Belgium	120	90	50
Czech Republic	110	90	60
Denmark	110	80	50
Finland	120	80-100	50
France	130	90	50
Germany	130 [a]	100	50
Greece	80	80	50
Hungary	120	80	50
Ireland	97	97	48
Italy	130	90	50
Latvia	--	90	50
Lithuania	110	90	60
Luxembourg	120	90	50
Morocco	120	100	40-60
Netherlands	100-120	80	50
Norway	90	80	50
Poland	110	90	60
Portugal	120	90-100	50
Romania	90	90	60
Slovak Republic	110	90	50
Slovenia	120	80	50
Spain	120	90-100	50
Sweden	110	70-90	50
Switzerland	120	80	50
Turkey	130	50-90	50
United Kingdom	113	97	48
North America			
Canada	100-110	80	50
USA	105-121	89 [b]	48
Australia	100-110	100-110	50-60 [c]

Main source: Donald and Cairney (1997).

[a] Large sections of Germany's motorway (autobahn) network do not have mandatory speed limits, but typically have a recommended limit of 130 km/h; many parts of the network are subject to legal limits ranging from 100 to 130 km/h.

[b] The majority of US States apply limits of 89 km/h or less to non-motorway standard rural roads, however some have limits up to 113 km/h.

[c] 70-80 km/h on non-motorway arterial roads.