Roads and Traffic Authority

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Speed Control Devices for Cars

by Michael Paine

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PREFACE

This report was commissioned by the Vehicle and Equipment Safety Section, Road Safety and Traffic Management Directorate, Roads and Traffic Authority of New South Wales, Australia.

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ABSTRACT

A range of on-vehicle devices for controlling vehicle speeds or influencing the speed behaviour of drivers are examined. These include top speed limiters, automatic speed limiters which adjust to posted speed limits, changes to speedometer design, on-board monitoring devices and crash recorders. The potential effects of Intelligent Transportation Systems (ITS) are also examined.

Research on the speeding problem is reviewed. Effects of speed control devices on crashes, the environment and traffic efficiency are estimated and the results of a benefit cost analysis are presented.

With modern engine management technology there is an opportunity to introduce top speed limiting of many new cars at a very low cost. This approach would mainly affect crashes in rural areas. Automatic speed limiters, which have the potential to reduce speed-related crashes in rural and urban areas, would require expenditure on the road infrastructure, to provide a speed limit signal to the on-vehicle device. Coded magnetic strips which are bonded to the roadway could provide this signal at relatively low cost. Widespread implementation of such a signalling system could result in voluntary fitting of automatic speed limiters to existing vehicles.

REPRINTS

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Executive Summary

New South Wales has developed a "Speed Management Program and Action Plan" to address the serious problem of speeding related crashes. Vehicle design requirements and standards form part of the plan. This report describes the results of an investigation of speed limiters for cars, together with other devices which offer an opportunity for controlling vehicle speeds.

There is relatively little research being conducted into the potential for speed control using vehicle technology. This technology is reaching the level of sophistication where speed control features are already built in or can be readily incorporated in the engine management systems typical of modern vehicles. Currently these systems are set at unrealistically high speeds (around 200 km/h). There is an opportunity to reduce the number and severity of speeding related crashes through the application of this technology, both by preventing vehicles from travelling at excessive speeds and by modifying the behaviour of drivers.

The key findings of the investigations are:

Technology

It is recommended that the 10% tolerance for speedometers provided under ADR 18 be reviewed. A 2% tolerance on underestimating speed would be appropriate based on the available technology and industry practices and this should not involve extra manufacturing costs.

Speed limiter technology which has been developed for heavy vehicles can be readily applied to cars and other light vehicles. Many new cars have electronic engine management systems and it is understood that these can be modified, at a very low cost per vehicle, to provide an effective top speed limiter.

None of the cruise control systems surveyed had a top speed limiter function but the cost of such a feature should be minimal.

Reference to statutory speed limits is noticeably absent from Intelligent Transportation System (ITS) strategies. There are now available several relatively cheap methods of transmitting speed limit information to vehicles - estimated statewide installation cost $10 million. Vehicles could then be fitted with *automatic speed limiters* which prevent the vehicle from being driven in excess of the posted speed limit or *speed alarms* which sound a warning if the posted speed limit is exceeded.

Vehicle monitoring devices (VMD), such as tachographs are an alternative to speed limiters for recividist drivers and they are less vulnerable to tampering. In-vehicle crash recorders might also help to modify speed behaviour.

If a new safety feature is introduced by way of new vehicles (e.g. through ADRs) then it can take six years after implementation for the feature to account for 50% of annual vehicle kilometres travelled. In addition to this time, it can take several years for an ADR to be implemented. In assessing speed control strategies, consideration should therefore be given to measures which also affect existing vehicles.

Strong objections to speed limiters can be expected from some motorists and manufacturers, irrespective of the potential road safety and environmental benefits of such devices.

Speed and crashes

NSW police-reported crash data indicates that, during 1994, speed was involved in 21% of fatal crashes, 12% of serious injury crashes and 7% of other crashes. More detailed studies suggest that speed is involved in approximately double those indicated by the police-reported crash data and therefore an analysis based on that data should be conservative.

Overseas research indicates that substantial crash savings can be achieved through small reductions in mean traffic speeds. It is estimated that a 3% reduction in mean traffic speeds would save 71 fatal, 342 serious injury, 1191 other injury and 2335 non-casualty crashes per year in NSW.

Speed limits and safe speeds

The driving task of judging a vehicle's speed is becoming more difficult with the trend to quieter, smoother vehicles. Some roadways are known to be over-designed and can induce unsafe traffic speeds. Motorists often do not appreciate the distance they travel between the point when a hazard first became visible (but not necessarily seen) and the point where their foot hits the brake pedal. In summary, motorists cannot be expected to make correct judgements about appropriate travel speeds for the conditions. Objectively set speed limits fulfil the purpose of setting an upper limit but there needs to be an improvement in the credibility of speed limits. Automatic speed limiters in vehicles would enhance the credibility of speeds limits.

It is likely that exceeding a 60km/h speed limit by 15 km/h would carry with it a far greater risk of serious injury (particularly to vulnerable road users) than exceeding a 100 km/h speed limit by 15 km/h. Automatic speed limiters would be an effective countermeasure in lower speed limit zones.

The trend to a variety of speed limits along a transport route places a greater burden on drivers to pay attention to changing speed zones. An automatic speed limiter would assist motorists to drive within the speed limit at all times and widespread use of automatic speed limiters would allow greater flexibility in setting speed limits.

Effects of speed limiters

The introduction of speed limiters for heavy vehicles in Australia has been generally successful. Anecdotal reports of tampering suggest a need for improved enforcement and higher penalties. *It is recommended that repeat offenders be required to fit vehicle monitoring devices and that the ADR be reviewed to determine if a simple means of checking speed limiters can be incorporated in the design.*

In regard to overtaking, the main effect of a speed limiter is that "the driver of a high performance vehicle would no longer perform certain manoeuvres which he now regards as safe". The time taken to overtake a vehicle can be substantially reduced by travelling at excessive speeds but only at a much greater risk of a severe crash.

To overcome the tenuous argument that speed limiters make overtaking less safe, alternative approaches could be considered such as making the vehicle less comfortable to drive at excessive speeds for long periods (e.g. a device which increases the force required to depress the accelerator pedal).

Small savings in fuel consumption, tyres and brake maintenance should result from the use of speed limiters. The estimated overall saving is $42 per vehicle per year for measures which reduce mean traffic speeds by 3%. Small reductions in emissions and noise should also occur.

Overall travel times and network efficiency should not be adversely affected by speed limiting and other measures which result in a 3% reduction in mean traffic speeds. There might be advantages due to a reduction in accidents.

It is estimated that 10% of rural speed-related crashes could be prevented by speed limiting all cars to 120km/h. In 1994 there were at least 86 fatal, 440 serious injury and 813 other injury crashes in rural areas which were speed related.

It is estimated that 50% of all speed-related crashes could be prevented by use of automatic speed limiters in all cars, so that the posted speed limit cannot be exceeded. In 1994 there were at least 135 fatal, 718 serious injury and 1439 other injury crashes which were speed related. The savings would be due to the effects on mean traffic speeds as well as elimination of crashes involving excessive speeding.

Recommended scenarios

Based on the assumptions set out in this report, the scenarios showing the most promise are, in order of merit (benefit cost ratio in brackets):

- All new vehicles fitted with a top speed limiter set at 120km/h at a cost of 50 cents per vehicle (90:1)
- All new vehicles require a speedometer scale no more than 120km/h at a cost of $1 per vehicle (23:1)
- Deviant motorists (worse 3%) required to only drive speed limited or, preferably, VMD equipped vehicles (1.5:1 if the $1000 cost of retro-fitting fitting device is included, although this is more of a penalty for the driver than a cost to the community)
- Roadways are fitted with simple speed limit transmitters (eg coded magnetic strips or nails) at a statewide cost of about $10 million and about 20% of vehicles are voluntarily equipped with sensors and speed control devices or alarms at a cost of $300 per vehicle (0.9:1 - the incentive in this case is avoiding speeding penalties. If only the roadway components are costed the ratio is 13:1)
- Roadways are fitted with speed limit transmitters and new vehicles plus 20% of existing vehicles are fitted with automatic speed limiters (0.6:1)

It is recommended that consideration be given to an ADR which requires cars to be speed limited to 120km/h.

It is recommended that ADR 18 be revised to require a maximum speedometer reading of 120km/h and, in the case of analogue displays, that the pointer be vertical at 60km/h.

It is recommended that further research be undertaken into the feasibility of roadway speed limit transmitters and in-vehicle devices to receive these signals and into driver attitudes to automatic speed limiters.

Contents

14 January 1998

In memory of John Norrish, whose work within the Roads and Traffic Authority contributed greatly to tackling the problem of excessive speeds on our roads.

In his usual efficient, helpful manner, John provided the data and advice about the speeding behaviour of NSW motorists. This enabled estimates to be made of the effectiveness of varous speed control devices assessed in this report.

1 Introduction

1.1 Background

The New South Wales (NSW) "Speed Management Program and Action Plan (1995-96)" contains a range of tasks designed to reduce the incidence and consequences of speeding related vehicle crashes. Part of the vision of the Plan is to achieve the situation where "vehicle design requirements and standards are conducive to compliance with appropriate speeds". One proposed task is to investigate the potential of speed limiters for cars and other light vehicles.

The Speed Management Program and Action Plan defines *speeding* as "travelling at speeds which are excessive, or which are inappropriate for conditions such that the level of safety is unacceptable". *Excessive speed* is "travelling in excess of the speed limit". *Inappropriate speed* is "travelling at a speed that might be below the legal limit, yet greater than suitable for the prevailing conditions".

Several press reports on this subject are included in Appendix A.

1.2 Scope of project

This report describes the results of an investigation of speed limiters for cars, together with other vehicle equipment which offer an opportunity for controlling vehicle speeds or changing driver speed behaviour. The brief for the project covered the following tasks:

- A review of the perceived behavioural/attitudinal benefits - the message that speed limiting of vehicles sends to road users
- An international literature review of previous work on speed control devices for light vehicles
- An analysis of NSW crash data to determine accidents which might have been influenced by speed control devices.
- A review of the types of speed control devices available or under development
- An estimate of the costs and benefits of implementing promising systems.

1.3 Overview of speed control devices

There is a range of vehicle equipment which can directly and indirectly affect speed-related road crashes. A top speed limiter, which physically prevents the vehicle from exceeding a pre-set maximum speed will mainly affect excessive speeding in rural areas. An automatic speed limiter, which adjusts to the local speed limit could affect all types of excessive speeding but requires some type of communication system with the roadway in order to determine the posted speed limit. These devices and other equipment, such as speedometers, cruise controls, crash recorders or vehicle monitoring devices, can also affect excessive and inappropriate speeding by influencing driver behaviour or improving the information available to drivers.

Issues such as engine power, vehicle handling and braking performance are related to speeding. These issues are, however, less likely to have a positive affect on driver speeding behaviour and they were outside the scope of the project.

2 Literature and Research Review

Several road safety literature databases were searched for articles on speed limiting for cars. Very few articles on this specific subject were found. The most advanced research is that being undertaken by the University of Lund in Sweden (Almqvist et al 1991 & Hyden 1993). The author has sought a status report on this project from Christer Hyden but no response had been received at the time of preparation of this report. Numerous articles were found on other issues related to speeds of vehicles. These are referred to in appropriate sections of this report.

The author attended the recent ESV Conference in Melbourne and took the opportunity to seek information about the status of speed control research overseas:

Europe

Claes Tingvall from the Swedish National Road Administration confirmed that the University of Lund is still conducting research on this issue. The Swedes consider that substantial road safety benefits can be obtained by reducing urban traffic speeds.

Jean Breen from the European Transport Safety Council is monitoring the work in Sweden. ETSC has identified the role of vehicle factors in speed moderation as an important road safety issue.

USA

Ken Digges from NHTSA was not aware of any current research in the USA. He recalled that the issue of speed limiters in cars had been considered more than a decade ago and it got no further than preliminary investigations.

Japan

The paper by the Japanese Ministry of Transport (Shimodaira 1996) indicates that "maximum speed and power output" are included in the list of items currently being considered in Japan. For many years vehicles in Japan have been required to be fitted with an alarm which activates if the vehicle exceeds 100km/h.

Australia

Several investigations by Monash University Accident Research Unit have identified speed limiters as a possible countermeasure to excessive speeds (Fildes & Lee 1993, Fildes et al 1991, Howie 1989). The Australian Road Research Board conducted an early investigation of the effects of speed limiters on heavy vehicles (Tan 1993).

Related research concerns moves to reduce residential speed limits to 50km. In general Australia has much higher residential speed limits than other developed nations. As discussed later, the local speed limit is only one of many factors considered by motorists in judging an appropriate travel speed. Vehicle-based speed control devices might form part of the strategy if lower residential speed limits are introduced.

During the conference, several overseas visitors commented that typical urban traffic speeds in Australia appeared to be too high. The literature review tended to confirm this observation.

3 Current Technology

3.1 Speedometer

The speedometer is an essential item of equipment to enable the driver to control the speed of the vehicle. Speedometers have, of course, been fitted to cars as standard equipment for many decades although the Australian Design Rule 18 only required speedometers to be fitted to vehicles manufactured from the mid-1970s. The ADR requires the speedometer to display speed in km/h to an accuracy of +/-10% (i.e when the vehicle is travelling at 110km/h the speedometer must display not less than 99 km/h). This relatively high tolerance could affect the ability of Police to enforce speed limits and, with modern technology, it might be appropriate review the tolerance on underestimating speed. For example, in industry, a 2% tolerance is more usual for this type of instrumentation. Speedometer accuracy is also affected by changing wheels and tyres but these are not relevant considerations for a tolerance on newly manufactured vehicles.

The ADR does not restrict the maximum scale value on the speedometer. Most cars have a speedometer which reads to 180km/h plus. Many popular high powered cars have a maximum speed potential in excess of 200km/h. When travelling at the maximum legal speed limit in Australia (110km/h) the speedometer on most cars is barely half-way around the scale. This practice adversely affects discrimination of readings in the range of interest (0 to 110km/h). It also gives a false impression about the *safe* speed capabilities of the vehicle and it must have an adverse effect on drivers' attitudes to speeding (indeed, it is conceivable that a motorist involved in a very high speed crash could commence litigation against a vehicle manufacturer for "false labelling").

A limit on the maximum scale reading on speedometers would require redesign of these devices (digital and/or analogue displays). Once these initial costs have been defrayed there would be no major extra cost involved in the manufacture of vehicles built for the Australian market. This approach has the advantage that it produces a level playing field for all manufacturers - it would reduce competition over the speed capabilities of vehicles (which is probably one of the main reasons for unrealistically high speedometer scales in the first place).

If a maximum scale reading is introduced then consideration should also be given to standardising the display so that, in the case of analogue displays, the angle of the display for a given speed is the same for each vehicle model. For example, the needle could be vertical at 60km/h (rather than the defacto industry practice of 100km/h).

Head-up displays, which project speed and other information onto the windscreen, have been successfully used on aircraft and some racing vehicles for decades. They reduce the extent of eye-movement needed to read this information. Although they provide a safety benefit it is considered that this benefit is not sufficient to justify mandatory fitment to normal vehicles. There might, however, be a case for standardising displays where head-up displays are provided on a voluntary basis.

3.2 Speed Limiters

ADR65/00 "Maximum road speed limiting for heavy goods vehicles and heavy omnibuses", applies to heavy trucks and buses manufactured from 1991. Speed limiting is usually achieved through either engine management systems or add-on devices which control throttle operation or fuel injector operation. Our investigations indicate that either technology can be applied to cars and other light vehicles. Details of a brief survey of manufacturers are contained in Appendix B and a summary is set out below.

3.2.1 Engine Management Systems

Many new cars are fitted with electronic engine management systems as standard equipment. Most of these already have a pre-programmed top vehicle speed or could be readily adapted with such a feature (a few are based only on engine RPM). At present the pre-programmed top speeds are well in excess of statutory speed limits. Although no estimates of costs of such a change were sought during the survey it is expected that the cost of providing a realistic top speed limit (say 120km/h) into these systems would be very low - less than a dollar per vehicle for popular models in Australia.

This recent wide spread move to electronic engine management systems therefore provides an exceptional opportunity to introduce very low cost speed limiting of new vehicles in Australia.

3.2.2 Add-on Speed Limiters

At least one (and probably most) add-on speed limiting systems designed for trucks can be readily used on cars. For example an Australian instrument supplier markets a system which it has fitted to dozens of Toyota Landcruiser vehicles that operate exclusively within mines in Western Australia. Apparently the mining companies had experienced an unacceptably high number of crashes and decided to limit their vehicles to 80km/h. This system operates on the throttle cable and can be fitted to any vehicle (petrol, diesel, fuel injected or carburettor). The cost of fitment to trucks is around $1,500 including sales tax and installation. The cost for cars should be marginally lower due to better access to vehicle components.

The question of tampering with speed limiters is dealt with in Section 6.1 "Observations about speed limiters on heavy vehicles". Alternatives to physical speed limiting are discussed in Section 6.3 "Overtaking".

3.3 Cruise Control

Cruise control systems are becoming increasingly popular on cars. The basic operation is that the driver attains the desired speed and operates a control to engage the cruise control system. The system then adjusts the throttle settings to maintain the desired speed and it is dis-engaged by operation of the throttle or brake. None of the cruise controls surveyed has a speed-limiter function built-in. Instead they rely on the driver selecting an appropriate speed.

As an optional extra, cruise controls typically cost around $700. Aftermarket devices cost about $300 installed.

The cost of adding a speed-limiting feature to a cruise control system was not sought in the survey but the production costs should be minimal once the system has been developed. Note that this is a similar function to automatic speed control, as discussed in the next section.

3.4 Automatic Speed Control

Most work on automatic cruise control systems is based on 'headway' - detecting the speed and distance to the preceding vehicle and adjusting the vehicle speed to suit the circumstances. Despite an extensive literature search no references were found to the concept of a roadway system which informs the vehicle's cruise control system of the statutory (or advisory) speed limit for a given section on roadway. *Reference to statutory speed limits is noticeably absent from the major ITS strategies.*

An automatic speed limiting system which is based on statutory speed limits can be implemented in the short term and the technology can be readily applied to current vehicles. Almqvist et al (1991) and Hyden (1993) describe the trial of a system in Sweden. Pending the introduction of roadside transmitters at locations where speed limits change, an evaluation was conducted using observers in the vehicle and these observers manually adjusted the speed limiter according the speed zone. The tests were confined to urban areas. The initial findings were that average speeds decreased by 4.5% (which the authors suggest could lead to very high safety benefits), travel time for an 18km trip increased by 33 seconds (2% increase), NOx emissions reduced by 5%, CO emissions reduced by 1.4% and fuel consumption was unchanged. Behavioural changes (mostly favourable) were also noted.

For this type of system to be widely introduced the roadways would need to be fitted with transmitting devices and vehicles would need to be fitted with receiving devices. Almqvist points out that it is preferable if all vehicles are limited to the same speed.

There is a wide range of current technologies that could be used to provide speed limit information to the vehicle, as set out in Table 1.

Table 1. Possible Systems for Informing Vehicles or Drivers About Statutory Speed Limits

Roadway Transmitter	Comment	Vehicle Receiver	Comment
Active radio transmitter (also microwave, infrared or optical beams) (Chang 1995, Toyota 1995, Komoda 1995)	Linked to ITS. Speed & other information can be varied to suit circumstances. Probably expensive to install & maintain. Might be impractical for rural roads.	Receiver in vehicle	A standard needs to be set for frequency usage and content of signal. The system needs to detect which direction the vehicle is going when passing through a speed limit change.
Passive radio transmitter (similar technology to radio dog tags)	Activated by passing vehicle. Information not readily varied. Suitable for country areas.	Receiver and a device to activate the roadway transmitter.	

Roadway Transmitter	Comment	Vehicle Receiver	Comment
Lane markings spaced at intervals which correspond to the speed limit	Each speed zone would have a prescribed spacing for a repeating feature such as lane marking or guide posts. Requires a change to road authority lane-marking practices (AS1742) although it could be confined to areas where speed limits change. Not readily changed. (note possible problem with epilepsy effects at some visual observation frequencies)	Technology which is being developed for lane following could be adapted for this purpose.	Technology for optically detecting lane markings is at the prototype stage. The "speed information" (actually the length of the repeating feature) could be passed on to the vehicle's cruise control system.
		A mechanical system, using a timed shutter system on the line of sight between the roadway feature and the driver could be used.	Capable of informing drivers whether they are travelling at the posted speed limit (when a constant image is visible through the shutter). Could be implemented very cheaply on any vehicle.
"Bar code" on roadway. (Howie 1989)	Equivalent of bar code is painted on the roadway. Possible durability problems.	"Bar code reader" underneath vehicle.	Possible problems with dirt build up.
Magnetic "nails" in roadway, spaced at intervals which correspond to the speed limit.	Trials of lane-following systems have used magnetic nails. If these were spaced according to the speed limit then this information could be passed on to the vehicle (apparently this opportunity has not been used in ITS trials - HIDC 1995). Simple and maintenance free. Not readily changed.	Magnetic sensor underneath vehicle.	Technology for lane following is at the prototype stage. The "speed information" (actually the spacing of the magnets) could be passed on to the vehicle's cruise control system. Could be relatively cheap.
Magnetic Tape applied to roadway (Jacobs et al 1995)	Trials have been conducted using magnetic strips which are equivalent to the tape in tape recorders. Speed limit and other information can be coded into the strip. Not readily changed. Claimed to be durable.	Magnetic pickup underneath vehicle (equivalent to the head of a tape recorder).	Trials conducted. Apparently durable and unaffected by dirt. Could be relatively cheap.
Existing speed limit signs	-	Camera & optical recognition system to detect and decode speed limit signs	Technology at prototype stage. Likely to be problems with visual clutter and false readings (such as the "100 speed limited" signs on the back of trucks in NSW)

It is considered that the apparent lack of attention to statutory speed limits in ITS systems is a major oversight which should be addressed promptly. Several of the above technologies could be implemented quickly and cheaply into the roadway. Trials of possible systems should be undertaken and, taking into account potential ITS developments and vehicle technology issues, a standard system for use on Australian roads should be implemented. Once a roadway system is widely installed market pressures could be expected to push vehicle manufacturers to incorporate the feature in their optional cruise control systems.

A further possibility with an automatic speed control is that the system could adapt to road conditions. For example, the top speed could be reduced by, say, 5km/h if the wipers were operating or the headlights were on. A possible disbenefit is that such a function might discourage use of these safety-related devices. An alternative would be for the roadside transmitters to adjust the transmitted speed limit according to the circumstances.

3.5 Vehicle Monitoring Devices

Vehicle Monitoring Devices (VMD), such as tachographs, are widely used on heavy vehicles in Europe. Heavy vehicles operating in NSW are generally required to be fitted with a VMD. The advantage of these devices is that they provide continuous monitoring of driving behaviour (Howie 1989). Speeding and excessive hours at the wheel can be readily detected. Also it is much more difficult to cheat with a VMD. For example, if a device indicates that a trip from Sydney to Melbourne was a distance of only 700km (instead of 870km) then either the equipment was well out of calibration or had been disconnected for some of the journey. A basic truck VMD costs about $1000 installed.

Simplified systems are under development for use in cars. One instrument supplier recently released a "Fleet Logger" intended for cars. This consists of a vehicle module and a smart card for each driver. The driver inserts the card in the device and it commences to record speed and driving time (three modes of driving are available for Fringe Benefit tax calculations). The data in the smart card are later downloaded into a PC. The system automatically records pre and post crash information. The installed cost will probably be about $900.

Cameron (1993) and Lehmann (1996) describe crash recorder devices which automatically store the previous 30 seconds of vehicle speed, deceleration and other information relevant to crash reconstruction. Howie (1989) notes that a video recorder could be used.

All of these systems have the potential to improve the speed behaviour of drivers through knowledge that their speed is being monitored. The installation costs of VMD devices are similar to those of speed limiters but the ongoing costs are likely to be higher due to the need to periodically download and analyse data.

3.6 New vehicle safety features - fleet penetration

Most new safety features are introduced on vehicles at the time of manufacture. There are inherent delays in the implementation of Australian Design Rules (typically three or more years) and then it takes considerable time for the feature to penetrate the fleet. The average age of cars in NSW is about 9 years (Caldwell 1992). Younger vehicles tend to travel further each year therefore the fleet penetration based on exposure (annual vehicle kilometres travelled) is less prolonged. Table 2 shows an estimate of fleet penetration in years since a safety feature was first introduced, taking into account annual vehicle kilometres travelled.

Table 2. Fleet Penetration of Safety Features

Years since introduced	% of Total Annual VKT	Years since introduced	% of Total Annual VKT
1	13%	11	76%
2	23%	12	80%
3	32%	13	84%
4	38%	14	86%
5	44%	15	89%
6	51%	16	91%
7	57%	17	93%
8	62%	19	94%
9	67%	19	96%
10	72%	20	97%

Source: Paine (1996), based on Australian Bureau of Statistics Usage Surveys and data from DRIVES.

As indicated in the table, it takes about six years for half the annual vehicle kilometres travelled to involve vehicles which have a particular safety feature. This analysis suggests that measures which are intended to produce noticeable benefits in the short term should endeavour to cover existing vehicles.

3.7 Acceptance of the technology

It is anticipated that some motorists, many vehicle manufacturers and most motoring journalists will object to any moves to fit speed limiters to cars or to reduce speedometer scales to realistic values. There is an element of prestige or potency about having a vehicle which is capable of "autobahn" or "Mt Panorama" speeds. Most drivers who would object to such measures would probably never intend to drive at grossly excessive speeds but they like to know there is the potential to do it. There are parallels here with arguments about gun control in Australia. It is therefore important that any proposals to introduce speed limiters on cars are well researched and address all of the issues.

Attempts at tampering will be inevitable (see Section 6.1). One manufacturer's representative said he had heard that after-market technicians charge about $500 to re-program the EMS to override the factory set maximum speed (180 or 220 km/h!).

4 Future Technology

4.1 Electronics

Most of the systems described under Section 3 are being improved from year to year through the use of more advanced electronics. It is anticipated that this will result in a drop in the price of the devices (or an increase in sophistication for the same price). For example, micro-mechanical chip-based accelerometers recently became readily available in the USA for $US20 - about one tenth of the price of a few years ago.

4.2 Intelligent Transportation Systems

Research on fully and partially automated roadway systems is being conducted in most developed countries. The major technologies are unlikely to be introduced before the end of the century and some are unlikely to be implemented within two decades (Komoda 1995). These systems offer excellent opportunities to control vehicle speeds and movements in order to avoid accidents but they rely, of course, on sophisticated features built into the roadway and vehicle. Progress with these systems should be monitored but they are unlikely to offer any significant short term solutions for Australia. The cost of automating the extensive road infrastructure in Australia is likely to be prohibitive and, as mentioned previously, the turn-over in vehicles is relatively low in Australia.

As raised in section 3.6, an important aspect is to ensure that the new technologies can, where possible, be applied to existing vehicles. The potential for an automatic cruise control system is a good example: roadside transmitters developed for ITS should include speed limit information and the format should be standardised as soon as possible so that manufacturers can build suitable in-vehicle devices.

5 Speed and Crashes

5.1 Crash Studies

Police descriptions of the causes of crashes are not reliable indicators of the contribution of excessive or inappropriate speed to crashes. The RTA has therefore developed criteria for identifying speed-involved crashes - a crash in which: the vehicle controller was charged with speeding; the vehicle was described by police as travelling at excessive speed; the stated speed of the vehicle was in excess of the speed limit or the vehicle lost control, skidded or jack-knifed on a curve and no other related factors were evident (RTA 1995b).

Table 3 shows the annual statistics for "crashes involving speed" in 1994.

Table 3 NSW Police-Reported Crash Statistics for 1994

Crashes involving at least one car or light truck which was speeding

Speeding a factor	Fatal	Serious Injury	Other Injury	Non Injury	All
Metropolitan Crashes (Sydney, Newcastle & Wollongong)					
Speed involvement	49	278	626	2001	2954
All	275	3527	14474	40280	58556
% Speed related	18%	8%	4%	5%	5%
Country Areas					
Speed involvement	86	440	813	1731	3070
All	357	2442	6276	12574	21649
% Speed related	24%	18%	13%	14%	14%
All Crashes					
Speed involvement	135	718	1439	3732	6024
All	632	5969	20750	52854	80205
% Speed related	21%	12%	7%	7%	7%

Fildes & Lee (1993) provide a detailed review of research on this subject. Subject to concerns about the reliability and appropriateness of the research they conclude that "evidence from clinical studies seems to suggest that excessive speed is probably involved in between 12 and 16 percent of (all) crashes..." and "excessive speed to be at least a contributing factor in up to 30% of fatal crashes in Australia in 1991-92".

Croft (1993) states there is evidence that excessive speed for the conditions is implicated in around 40% of rural fatal crashes and 30% of metropolitan fatal crashes in NSW.

Note that Fildes' and Croft's data included heavy vehicles and motorcycles which might have a higher proportion of speed-involved crashes, but not to the extent that would account for the difference between their estimates and the NSW data. Recent data from Europe (ECMT 1995) supports Croft's estimates: for example speed was found to be a contributory factor in 50% of all fatal crashes in France. Thus the NSW statistics, which are based on Police reports, are likely to underestimate the involvement of speeding in crashes.

In the absence of better estimates, data from Table 3 will be used as a basis for analysis of countermeasures. This should result in a very conservative estimate of crash savings.

5.2 Relationship between speed and crash involvement

Fildes et al (1991) reports on a comprehensive study of speed behaviour on rural and urban roads. Vehicle speeds were unobtrusively measured and drivers were subsequently stopped and interviewed. A total of 325 drivers were interviewed at the two rural sites and 382 were interviewed at the two urban sites. One of the questions was "Have you been involved as a driver in any road accident (serious or minor) in the last 5 years?". If they answered "yes" they were asked to provide details about the degree of the accident(s) (hospitalised, medical treatment or property damage only). Fildes cautions about the reliability of this self-reported data and small samples sizes. Subject to this reservation, the data for urban cases suggest that drivers observed travelling at 15km/h higher than the mean traffic speed had about twice the involvement rate of those observed travelling at the mean traffic speed (which at one site was already well above the posted speed limit). The data for rural cases were less conclusive but indicated a higher involvement rate for those travelling at excessive speeds. These drivers were also more likely to have been previously involved in serious injury crashes.

It is of concern that driver's who reported they had been involved in crashes resulting in hospitalisation subsequently were observed to drive at excessive speeds. One would expect personal involvement in such traumatic crashes to influence behaviour. Fildes notes that "It is unlikely that education and enforcement measures will be totally sufficient in eliminating excessive speeding ... other possible countermeasures need to be examined". He then discusses speed limiters as a possible "recidivist device". Such an approach is currently being considered under national proposals for heavy vehicle drivers (NRTC 1996). However, if applied to cars, this approach would effectively impose a stigma on speed limiters and it would need to be carefully weighed against the advantages of promoting speed limiters as a safety device for other groups of motorists - particularly since there is scope for recidivist car drivers to circumvent the system. A VMD may be more appropriate in these cases.

5.3 Relationship between speed and crash severity

The empirical relationship between speed of impact and injury severity is well documented (Car frontals:Jones 1982, Gimotty & Chirachavala 1982, Hutchinson 1986, Joksch 1975, ETSC 1993, Evans 1993, O'Neill et al 1996, Pedestrians: Isenberg et al 1996, McLean et al 1996, Fisher & Hall 1972). The probability of severe injury or fatality versus impact speed tends to follow an S-curve (for convenience the term "impact speed" is used here to mean the change in velocity or delta-V rather than the speed at which the vehicle was travelling at the instant of the collision).

In the case of restrained front seat occupants, the mean impact speed for a severe injury is between 37km/h (Evans 1993 - drivers only) and 45km/h (Jones 1982). The mean impact speed for a fatal injury is about 52km/h (Evans 1993 - restrained drivers only). Note that these speeds are well below the usual statutory speed limits in urban and rural areas. New Car Assessment Program (NCAP) testing of the crashworthiness of new vehicle models is conducted with a barrier impact speed of 56km/h and the results generally confirm the risk of severe injury in many popular Australian vehicle models at this impact speed.

For a given mean *traffic* speed there will be a wide range of *impact* consequent crash severities. In many cases a motorist will have an opportunity to substantially reduce the vehicle's speed prior to an impact. In other cases, the vehicle might be travelling at well above the mean traffic speed and be unable to reduce speed before an impact or the object impacted might be an on-coming vehicle of much higher mass so that the lighter vehicle tends to rebound and its overall change in velocity is increased. The distribution of impact speeds for a given mean traffic speed is likely to be close to a normal (probit) distribution - Appendix C examines this in more detail. This *tentative* analysis offers a possible statistical explanation for the empirical observation by Nilsson (1993) that, all other factors being equal, the number of *fatal* crashes increases according to the fourth power of the increase in the mean traffic speed. This is higher than the square relationship conventionally used to explain crash severity on the basis of kinetic energy considerations. Nilsson recommends the use of a square relationship for evaluation of the effects of mean traffic speeds changes on *injury* accidents.

- Change in fatal crashes proportional to $(\text{change in mean traffic speed})^4$
- Change in injury crashes proportional to $(\text{change in mean traffic speed})^2$
- Change in non-casualty crashes proportional to (change in mean traffic speed)

Applying these calculations to crashes set out in table 3, we can estimate the savings resulting in a reduction in mean traffic speeds in urban and country areas. The results are set out in table 4. The 3% reduction represents a 2km/h reduction in urban areas and a 3km/h reduction in rural areas. This assumes all other factors are unchanged.

Table 4. Estimated Crash Savings Resulting from

a Reduction in Mean Traffic Speeds of 3%

	Fatal	Serious Injury	Other Injury	Non-Casualty
Urban	31	202	831	1705
% of all urban	13%	6%	6%	3%
% of speeding urban	63%	72%	130%	58%
Rural	40	140	360	630
% of all rural	13%	6%	6%	3%
% of speeding rural	46%	32%	44%	20%
All	71	342	1191	2335

This analysis suggests that there are substantial road safety benefits to be gained from relatively modest (3%) reductions in mean traffic speeds. Larger reductions could provide even larger benefits (e.g. 5% speed reduction results in a 21% reduction in fatalities and a 10% reduction in injuries) but the measures needed to achieve such reductions are likely to be more extreme.

5.4 Speed Surveys

The NSW RTA regularly conducts unobtrusive surveys of traffic speeds (Norrish 1991 & personal communications). Recent data for NSW roads is presented in Table 5. 100km/h & 110km/h zones were in country areas. The 60km/h zones were on urban arterials.

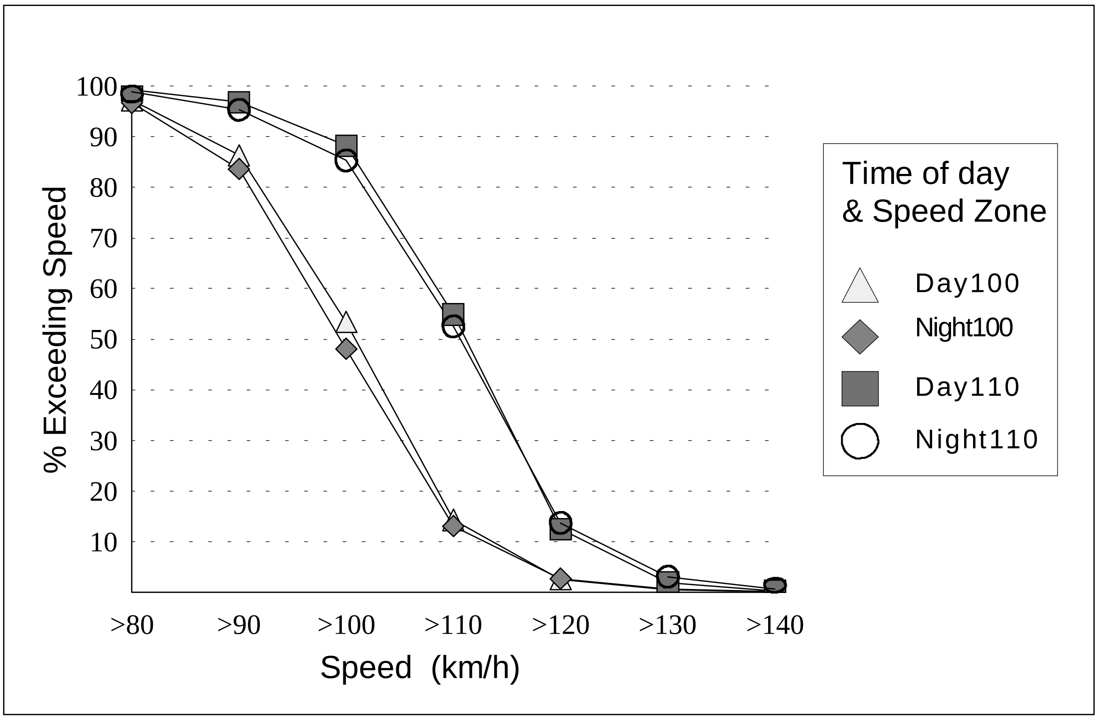
Table 5. NSW Speed Survey Results

November 1995 - Wheelbase up to 3m

	100 km/h Zones		110 km/h Zones		60km/h Zones	
	Day	Night	Day	Night	Day	Night
Mean Traffic Speed	100.9	100	110.9	110.5	66	66
Std Dev.	10.32	10.67	9.91	11.13	9.2	9
Sample size	128456	28652	56186	10532	251065	154504
Maximum Speed	203	206	182	185	180	154
Speed	**Percentage Exceeding**					
>60	-	-	-	-	76.2	74.2
>80	97.2	96.7	99.2	98.9	5.4	5
>90	86.3	83.6	96.8	95.3	-	-
>100	53.4	48.1	88.2	85.3	-	-
>110	14.3	13.1	54.9	52.5	-	-
>120	2.6	2.7	12.5	13.7	-	-
>130	0.5	0.7	1.9	3.1	-	-
>140	0.1	0.2	0.3	0.7	-	-

Figure 1 illustrates the speed distribution for 100km/h & 110km/h zones.

Figure 1 - Speed Surveys of Rural Roads in NSW



For comparison, Fildes et al (1991) surveyed speeds at two rural (100km/h limit) and two urban (60km/h) limit sites in Victoria

Table 6 Speed Surveys in Victoria:

	100 km/h Zones		60 km/h Zones	
	Euroa	Woodend (at bend in road)	Beech Rd	Belmore Rd (poor sight dist.)
Mean Traffic Speed	105.9	92.4	72.3	62.3
Std Dev.	10.8	9.9	10.2	6.8
Sample size	>281	>281	>584	>665
85th Percentile	117	103	-	-
Maximum Speed	-	-	-	-
Speed	**Percentage Exceeding**			
>130	1.5	-	-	-

5.5 Safety effects of changes to speed limits

The safety effects of changes to mean traffic speeds described above were based on several analyses of changes to speed limits in Europe and the USA (Nilsson 1993).

It is important to note that changes to speed limits do not, in general, lead to an equivalent change in mean traffic speeds (on which the crash savings are calculated according to Nilsson's formulae). For example the change from a 55mph to 65mph speed limit in the USA led to mean traffic speeds increasing from 60.6 mph to 64mph (Vulcan 1993). This a 5.6% increase compared with an 18% increase in speed limit.

The observed increase in fatalities of about 20% agrees well with that predicted by Nilsson's formula, based on the increase in mean traffic speed.

Similarly, Sliogeris (1992) reports that mean traffic speeds increased by between 2 and 4 km/h when the speed limit on some Victorian roads was raised from 100 to 110 km/h. He reports a 24% increase in casualty accidents per kilometre when the 100km/h zones were introduced and a 19% reduction when the roads returned to 100km/h zoning. He also notes that the proportion of motorists exceeding 120 km/h doubled (from 7% to 16%) when 110 km/h speed limits were in force.

5.6 Perception of speed and judgements of safety

Drivers frequently need to make instantaneous estimates of their absolute speed and they are often not afforded the luxury of glancing at the speedometer. The road environment, movements of other road users, tyre and engine noise and vibrations and other factors combine to give an indication of vehicle speed. This task is probably becoming more difficult as cars become quieter and smoother.

Drivers also need to make judgements about what is a safe and appropriate speed for the conditions. The effects of the road environment on this judgement are well documented: road characteristics (width, number of lanes etc) has the strongest influence while the roadside environment is also influential but to a lesser degree. Some sections of road are known to be "over-designed" and speed inducing. On the other hand, perceptual countermeasures such as transverse markings can be applied in hazardous areas to draw the driver's attention to excess speed (Fildes & Jarvis 1994 & Fildes & Lee 1993).

Another factor which should be taken into account by motorists is the chance of encountering vulnerable roads users such as children, pedestrians and bicycle riders. Drivers must make a judgement on how much warning they might receive about such a hazard and how long it would take them to stop to avoid a collision. It is apparent from accident statistics that drivers are not very good at making this judgement (McLean 1996, Isenberg 1996). In discussing his paper at the recent ESV Conference, McLean estimated that reducing speed limits in residential streets from 60 km/h to 50 km/h would save approximately 100 pedestrian fatalities each year in Australia.

In assessing the motorist/pedestrian conflict near school buses, Paine & Fisher (1996) point out that drivers often do not appreciate the distance they travel between the point where a hazard first became visible (but not necessarily *seen*) and the point where their foot hits the brake pedal to commence braking. For a vehicle travelling at 100km/h this distance is typically 70m. During this time they must detect, recognise and respond to the hazard (Lay 1991). Motorists tend to think of stopping distance as the distance to stop from the point when the brakes were first applied and this can give a false impression of appropriate travel speeds.

In summary, motorists cannot be expected to make a correct judgement about appropriate travel speeds based on the instantaneous information they have available. There needs to be an unambiguous upper limit to traffic speeds - this is the purpose of the statutory speed limit.

Traditionally, in Australia, speed limits have been set on the basis of the "85% percentile method" - that is the speed limit is set at or near the 85th percentile value of the traffic. There are concerns about the validity of this approach, including drivers' judgements about safe travel speeds. Jarvis & Hoban (1988) describe a computer-based system for determining appropriate speed limits based on numerous objective factors. This is a much more appropriate approach than basing speed limits on the 85th percentile method and it gives an opportunity to improve the credibility of speed-limits.

5.7 Speed enforcement

Enforcement issues have been covered in detail by Fildes (1993 and 1994). Issues relevant to speed limiting of vehicles are:

a) enforcement tolerances, which appear to take account of the tendency for the mean traffic speed to be in excess of the statutory speed limit (there appears to be a Catch 22 situation here because one reason for the traffic travelling faster than the speed limit is general knowledge of large enforcement tolerances)

b) penalties based on absolute speeds rather than proportional to the actual speed limit (e.g. currently larger fines apply at 15km/h and 30km/h over the speed limit, representing 25% and 50% respectively at 60km/h but only 14% and 27% at 110km/h)

c) difficulties enforcing specialised speed limits, such as lower speed limits adjacent to schools during school travel hours (apparently speed enforcement policy provides for a 200m slowing down zone, which in some cases is longer than the section of special speed zoning in question).

The difficulties of speed enforcement are compounded by the recent trend to a variety speed limits along a transport route. For example, many arterial roads in Sydney, including the Harbour Bridge, now have a 70km/h or 80km/h speed limit. These roads change to 60km/h in some hazardous sections, such as when passing through shopping centres. The limits are based on objective criteria and are likely to be appropriate for the sections of road in question. The practice does, however, place a greater burden on the driver to pay attention to changing speed limit zones. Also, speed adaptation is a problem in these circumstances (Fildes & Lee 1993): drivers misjudge their speed when they move from prolonged exposure at one speed to a lower speed zone (most noticeable when slowing down for country towns but also evident in urban areas when moving from arterial to residential streets).

Automatic speed limiters (or warning devices) which detect changes to speed limits would simplify enforcement and would be useful for motorists in these circumstances. There is a possibility of a major reduction in the issue of traffic infringements under an effective automatic speed limiter program. It is assumed that such a revenue loss is not a valid "cost" in the evaluation of a road safety program.

5.8 Driver attitudes to speed limits

For the purpose of assessing countermeasures, it is convenient to group speeding drivers into several categories, as shown in Table 7. The percentages of drivers and crash involvement are speculative and are based on the percentages shown in Table 5. In the case of crash involvement it is assumed that the "deviant" group has three times the crash risk of the other groups and that the "intentional" group has a slightly higher crash risk than the "inadvertent" and "reluctant" groups.

Table 7. Categories of Speeding Drivers
(for the purpose of assessing in-vehicle countermeasures)

Category	Characteristics.	% of Speeders	% of Speed Crashes	Possible Countermeasures
Deviant	Grossly excessive speeds. Risk taker. May be alcohol affected.	3%	10%	Increased, targeted enforcement. Increased penalties. Promote as socially unacceptable. Only permitted to drive speed limited vehicles (this might place a stigma on speed limiting - an alternative is VMDs) Reduce speedometer scale
Intentional	Feels "safe" at 10-15km/h over the speed limit. Knows enforcement tolerances will make a booking unlikely.	30%	35%	Decrease enforcement tolerances. Educate about the safety hazards. Improve credibility of speed limit setting pratice. Mandatory speed limiters (e.g. all new vehicles). Automatic speed limiter for urban areas. Reduce speedometer scale.
Inadvertent	Drives a powerful car which is too easy to drive at over the speed limit OR misses speed sign or forgets current speed zoning (eg changes from 60 to 70 and back on urban arterials)	35%	30%	Existing cruise control for rural areas. Voluntary automatic speed-limiter/alarm for urban areas (part of optional cruise control). More "reminder" speed limit signs in areas where confusion occurs. Educate about safety hazards Improve speedometer discrimination at urban speeds.
Reluctant	Drives at the speed of the traffic stream, which is exceeding speed limit, but under pressure. Does not want to impede traffic. Intimidated by tailgators.	30%	25%	Voluntary automatic speed limiter/alarm to take the pressure away (a machine makes the decision). Enforce anti-tailgating laws. Educate about safety hazards.

As noted in the table, different in-vehicle speed control strategies should apply to these categories of motorists. These strategies are examined later under Section 7.1 "Effects on crashes". It is expected, however, that a measure which targets one category of drivers will have an effect on the other categories. For example, a program which required deviant drivers to only drive vehicles fitted with a speed limiter or VMD would be likely to attract wide publicity. Other motorists could be expected to modify their speed behaviour - both through concern about the new, unpleasant penalty for speeding and the realisation that the government is taking the speeding issue seriously.

5.9 Excessive speed warning signs (Sydney-Wollongong Freeway)

Brisbane (1994) describes a trial system introduced on the F6 freeway between Sydney and Wollongong. Speed sensors are built into the roadway and an overhead sign displays the words "Legal speed limit is 110km/h" if a preset speed (around 115 to 120 km/h) is exceeded. This is an advisory system only. No penalties are associated with the operation of the system, which serves other functions such as displaying fog or accident warnings.

In personal communications Mr Brisbane elaborated on the results presented in his paper, which describes some of the changes to speed behaviour with the trial system. Initially the system displayed actual speed but it soon became evident that some drivers were "testing" their vehicles by driving at grossly excessive speeds (a similar problem to unrealistically high speedometer scales). There were even complaints that the system was not accurate at speeds well in excess of the statutory speed limit. The message was therefore changed to that described above, although some drivers apparently increased their speed slightly in order to trigger the signs (a novelty effect). The long term changes to speed behaviour have been a decrease in the mean traffic speed (a reduction of about 5km/h) but a marginal increase in grossly excessive speeds (the reason for the latter is not clear).

Any vehicle-based speed control measures should be designed to avoid the undesirable behavioural effects found during these trials.

6 Effects of Speed Control Devices on Driving Behaviour

6.1 Observations about speed limiters on heavy vehicles

Generally the introduction of speed limiters on Australian heavy vehicles has been successful. Initial concerns about speed limiters were that drivers would fail to slow down and adjust to changing conditions and that they would accelerate harder and brake later in an attempt to compensate for the slower travel times. An early study by ARRB (Tan 1993) was inconclusive about the effects of speed limiters on truck speeds. There was an indication that speed-limited trucks were travelling at slightly higher speeds through rural towns but the difference was not significant. Also there were indications of increased queue lengths and bunching on the major truck routes. There were, however, relatively few speed limited truck at the time the study was undertaken. As the proportion of speed limited trucks in the fleet gradually increases the incentives for such negative behaviour will diminish and drivers should adopt a less aggressive and less stressful driving style, as reported in Section 7.2.

There are anecdotal reports of truck drivers tampering with speed limiters (ATN 1995). ADR65/00 "Maximum road speed limiting for heavy goods vehicles and heavy omnibuses", which applies to heavy trucks and buses manufactured from 1991, prescribes measures to make the speed limiter resistant to tampering. The description of the tampering in the magazine article indicates that the tampering in question could have been detected by a simple check of the integrity of components. The case suggests a need for more vigilant enforcement and much higher penalties for tampering, rather than a technical deficiency with the ADR.

It is unlikely that speed limiters can be made fully tamperproof, although a recent interesting development is a speed limiter with built-in diagnostics which can indicate whether some types of tampering have occurred.

One enforcement option is to require truck drivers suspected of persistently tampering with speed limiters to fit a VMD because the extra information provided by VMD can be used to verify driving practices. The author was shown a tachograph chart (Appendix D) which clearly shows a speed limiter being rendered inoperative during parts of a journey - presumably when the risk of detection was low. This chart also demonstrates that there was very little difference in average speeds between the two modes and much more wear and tear on the driver and vehicle during times when the speed limiter was inoperative.

6.2 Platoons of heavy vehicles

At times speed-limited heavy vehicles form platoons (bunching) on the national highways. This occurs on both single lane and multiple lane roads. Speed-limited heavy vehicles occasionally attempt to overtake another heavy vehicle which is travelling at a slightly lower speed (due to a different speed limiter setting or lower power for a hill climb). The relative speed difference might be a few km/h and the manoeuvre might take more than a minute. This practice is disruptive to faster moving traffic on multi-lane roads and overtaking lanes and likely to be unsafe on single lane roads. It suggests that more courtesy is required from slower moving vehicles, rather than higher speed capability of the overtaking vehicles, as discussed in the following section.

6.3 Overtaking

Plowden & Hillman (1984) point out that the main effect of a speed limiter is that "the driver of a high-performance vehicle would no longer perform certain manoeuvres which he now regards as safe". In planning an overtaking manoeuvre the driver must take a range of factors into consideration and the potential speed of overtaking is one of these factors.

Methods for calculating overtaking distances are contained in Staysafe (1987). In the simplest case, without taking into account the need to accelerate, the time taken to overtake depends on the relative speed between the two vehicles and the clearances the overtaking driver allows before moving across the centre line to start the manoeuvre and returning to the correct side of the road to complete the manoeuvre. The time taken to overtake is given by:

Time to overtake T = (Total clearance)/(Speed Difference)

and the distance travelled is:

Distance travelled = T x Speed of overtaking vehicle

Analysis of data provided by Lay (1991) and Troutbeck (1984) suggests that currently on rural roads the overtaking vehicle typically travels about 13 km/h faster than the vehicle being overtaken, resulting in a typical overtaking time of 12.5s. Table 8 shows the results for several scenarios of speed limiting.

Table 8. Effect of Speed Limiting on Overtaking Times and Distances

Based on total clearance of 45m

Case	Vehicle 1 (km/h)	Vehicle 2 (km/h)	Speed Diff. m/s	Time to overtake (s)	Distance to overtake (m)
Limited to 120 km/h	90	120	8.3	5.4	180
Limited to 110 km/h	90	110	5.6	8.1	248
Limited to 100 km/h	90	100	2.8	16.2	450
Limited to 120 km/h	95	120	6.9	6.5	216
Limited to 110 km/h*	95	110	4.2	10.8	330
Limited to 100 km/h	95	100	1.4	32.4	900
Limited to 120 km/h	100	120	5.6	8.1	270
Limited to 110 km/h*	100	110	2.8	16.2	495
Limited to 120 km/h	105	120	4.17	10.8	360
Limited to 110 km/h	105	110	1.4	32.4	990

* Same as typical overtaking speed without a speed limiter.

It is evident that the time for completing an overtaking manoeuvre can be substantially reduced by travelling at excessive speeds. This practice brings with it, however, greatly increased risk of loss of control during the manoeuvre and, of course, a more severe crash. On balance the savings in travel time due to the execution of such a questionable overtaking manoeuvre are probably a small fraction of the resulting reduction in life expectancy of the risk taker, not to mention other road users (this travel-time/life-expectancy effect is discussed in more detail in Section 7.3).

Subject to these reservations, a speed limiter could be provided with a delayed action which allows a higher speed to be achieved for a short period. Filde s tentatively suggests 5 to 10 seconds but the above analysis indicates that 20 seconds would be more appropriate. On the other hand, this type of feature may encourage unsafe overtaking practices and it could cause serious difficulties if the manoeuvre was not completed in the allotted time.

An alternative to preventing the vehicle travelling faster is to use a feature which discourages prolonged speeding. In a paper concerning seat belt interlocks Turnbell et al (1996) proposed several methods which could also be considered for speed control:

- external visual signals such as an illuminated light (it is understood that this method is already used on commercial vehicles in Japan)
- internal visual/audible signals
- disabling the radio and/or air conditioner
- throttle feedback (force required to depress accelerator pedal increases substantially once the preset speed is exceeded)

Each of these approaches overcomes the (tenuous) argument that speed limiters make overtaking less safe. To facilitate enforcement there would need to be a method of testing the operation of the feature without the need to drive the vehicle in excess of the speed limit (something missing from ADR 65). For example, the throttle feedback device could also be activated when the ignition was on but the engine not running.

6.4 Urban roads and automatic speed limiters

Table 2 shows that about half of all speed-related crashes occur in metropolitan areas. Although these are generally less severe than rural crashes there is still potential for a major reduction in casualties through the introduction of speed control measures in urban areas. A reduction of only 2km/h in urban mean traffic speeds is estimated to save 31 fatal, 202 serious injury, 831 other injury and 1705 non-casualty crashes each year (Table 4).

As pointed out by Almqvist et al (1991) it is preferable that all vehicles are speed limited so that all of the potential benefits of automatic speed limiters can be realised. With a mixed fleet there would probably be some initial frustration experienced by both the drivers of speed-limited vehicles (other vehicles passing them) and non-speed-limited vehicles (speed limited vehicles impeding them). Once the proportion of speed limited vehicles reached a sizeable proportion (say one third) then the effects would start to become noticeable and other motorists should get the message about speed moderation. This implementation "hurdle" should be judged against the potential long term benefits of automatic speed limiters.

7 Benefits and Costs of Speed Limiters and Cruise Controls

7.1 Effects on crashes

Table 4 sets out the potential savings it is estimated would result from a 3% reduction in mean traffic speeds: 71 fatal crashes, 343 serious injury crashes, 1191 other injury crashes and 2335 non-casualty crashes per year. This is considered to be a realistic target for an overall speed management program. In-vehicle speed control devices are likely to be an important element of such a program, although the individual contribution of these devices is difficult to estimate. The following assumptions have been made for the purpose of the benefit cost analysis:

- Top speed limiters set at 120 km/h will only affect speed-related crashes in rural areas. On the basis of speed surveys and accident involvement histories, it is estimated that 10% of these rural speed-related crashes could be prevented by a top speed limiter set at 120 km/h. A lower setting would influence more crashes but would be less likely to be implemented due to resistance from motorists and manufacturers. A higher setting, such as 130 km/h would probably not directly influence many crashes due to the low proportion of vehicles travelling in excess of this speed (see Table 5) but an estimate of the effects of higher settings has been included in the sensitivity analysis (see Section 8.3).
- Speedometer scales up to a maximum of 120 km/h would influence the same crashes as top speed limiters but would be half as effective.
- Automatic speed limiters, which sense and adjust to local speed limits will prevent 50 % of all speed-related crashes.
- About two-thirds of "inadvertent" speeders (i.e. 20% of all motorists) will elect to retro-fit automatic speed limiters or speed alarms (to save fines and loss of licence).

- Automatic speed alarms, which sense the local speed limit and activate an alarm if that speed is exceeded, will prevent 30% of all speed related crashes (i.e less effective than physical speed limiters).
- A vehicle monitoring device will prevent the same number of crashes as an automatic speed limiter (but operating costs are higher).

The above estimates of effectiveness might be considered optimistic for individual cases but, as indicated in Section 5.6, the measures should have an influence on the speed behaviour of all drivers (a halo effect). Nilsson's analysis indicates that even a small change in mean traffic speeds could have major road safety benefits. Also the NSW estimates of speed related crashes (Table 3) are likely to be under-estimates. Overall these assumptions are considered to be conservative.

7.2 Effects on environment and quality of life

7.2.1 Fuel Consumption

Altshuler et al (1984) reports significant reductions in nationwide fuel consumption when the 55 mph limit was introduced in the USA. This can be explained, in part, by the lower fuel consumption at reduced speeds. Due to effects of aerodynamic drag, fuel consumption is proportional to the square of the speed, when travelling at a constant speed above about 40km/h. In reality, speeds vary considerably and the effects of a top speed limiter will not always influence fuel consumption. In the trials of a speed limiter reported by Hyden (1993) there were no measurable changes to fuel consumption. However, the test vehicles were driven amongst non-speed-limited vehicles and therefore the advantages of smoother traffic flow were not realised.

Watson (1995) draws negative conclusions about the effects, on fuel consumption and emissions, of 40km/h or 50km/h speed limits in residential areas. There are concerns about the assumptions and methodology of Watson's work but, in any case , the negative effects only occur at very low speeds. The speed limiting proposals under consideration in the present project are in the range where a reduction in vehicle speed results in emissions and fuel consumption savings according to Watson's data.

On balance, a conservative approach will be taken in which a small reduction in mean traffic speed is assumed to result in a directly proportional improvement in fuel consumption.

Paine (1996) analysed data for emissions and fuel consumption tests of about 600 in-service Australian cars. The average fuel consumption for the mixed urban/rural driving cycle was 11.35 litres/100km. Australian Bureau of Statistics data for this group of vehicles indicates a typical annual kilometres travelled of 14,900 resulting in the consumption 1,639 litres of petrol per vehicle per year. It is therefore estimated that a 3% reduction in mean traffic speed would save at least 49 litre of petrol per year or about $34 per year in petrol purchases.

In personal communications a Melbourne based coach operator estimates at least 20% savings in tyre and brake maintenance due to the use of top speed limiters on the company's fleet of long-distance coaches. Savings for typical car operations could be expected to less. Again, a conservative estimate should be that the savings are proportional to the change in mean traffic speed. The NRMA (1992) estimates the costs of tyres on a Holden Commodore travelling 15,000km per year at about $200 per year. Brake maintenance would probably bring the total to about $270 per year therefore the annual saving from a 3% reduction would be about $8 per year.

The fuel and maintenance savings for a typical car, through speed control measures which reduce mean traffic speeds by 3%, are therefore estimated to total $42 per vehicle per year.

7.2.2 Gaseous Emissions

As mentioned earlier, Hyden (1993) reports that a trial urban speed limiter experiment produced a 5% reduction in NOx emissions and a 1.4% reduction in CO emissions. Changes to HC emissions were not reported but are likely to be less than those achieved for NOx. Further reductions could be expected from the effects of smoother traffic flow resulting from wide spread use of speed limiters (similar benefits are claimed for ITS: Guensler et al 1995, Little et al 1995).

At this stage it is difficult to gauge the effects of speed limiters on gaseous emissions from motor vehicles. To place the effects of potential emissions reduction in context, the results of the emissions testing program analysed by Paine (1996) have been used to prepare Table 9. In this table it is assumed that a 3% reduction in mean traffic speeds will reduce NOx by 3% and CO and HC by 1%. For comparison, the effects of tune-ups (averaging $152 per vehicle) are also shown.

Table 9. Possible Effects on Exhaust Emissions of a 3% Reduction in Mean Traffic Speeds

Item	CO	HC	NOx
Average exhaust emissions/vehicle/ year	253 kg	19 kg	26 kg
Assumed reduction due to speed limiting	1%	1%	3%
Predicted annual saving due to speed limiting	2.5 kg	0.2 kg	0.8 kg
Measured savings due to tune-up of vehicles	63 kg	3.4 kg	2.3 kg

Similarly, the effects of speed limiters on noise emissions from motor vehicles cannot be reliably estimated at this stage but vehicles driven at excessive speeds are likely to produce higher noise levels than conservatively driven vehicles.

7.2.3 Stress

The discussions with the Melbourne coach company also revealed one of the major, and unexpected, benefits of top speed limiters was a reduction in driver stress. Drivers no longer need to continually monitor and adjust speed. There are fewer gear changes and less pressure from following drivers. Although not from this particular company, these effects were evident on the tachograph chart mentioned earlier in which the disconnection of the speed limiter was clearly evident for some parts of the journey.

A reduction in mean traffic speeds would also result in a safer, less stressful environment for non-motorists, including people in residences, shops and parks adjacent to major roads.

7.3 Travel Times & Network Efficiency

Hyden (1993) reports an increase in travel time of 33 seconds over an 18km journey for trials of vehicles fitted with automatic speed limiters (i.e. speed limiters which adjust to the statutory speed limit). He reports that this represents a 2% increase in travel time but the effects are likely to be less if all vehicles were speed limited due to the effects of smoother traffic flow. Sliogeris (1992) refers to a US study of the effects of the 55mph national speed limit: in effect, every minute lost through driving more slowly was offset by an equivalent increase in life expectancy.

Plowden & Hillman (1984) point out that speeding in urban areas "can often result in no corresponding saving in journey time but only in a longer delay at the next junction or traffic light. When speed does bring an advantage to a particular driver it is sometimes only at the expense of others, with no net gain to the community".

The small reduction in mean traffic speeds resulting from in-vehicle speed control measures is unlikely to have a negative effect on network efficiency. Network capacity is generally constrained by locations where the traffic is moving at much lower speeds than the statutory speed limit therefore speed control measures would not apply in these circumstances. On the other hand, fewer accidents, and therefore less major network disruptions, could be expected due to smoother flow, smaller speed differentials between vehicles and fewer lane change manoeuvres. Sweet (1991) notes that "over half of all traffic congestion is caused by accidents and other incidents that result from driver's actions and poor judgement".

It is concluded that, overall, there would be no disbenefits in terms of travel times and network efficiency, from the use of in-vehicle speed control devices which have the effect of reducing mean traffic speeds by 3%.

7.4 Insurance Effects

Discussions with a car insurance provider indicated that, in general, it was unlikely that a car fitted with speed limiters would attract lower insurance premiums or other incentives. The effect on claims needs to be of the order of several percent to justify a change in premium category. However, there might be scope for large clients to negotiate a special premium package on the basis of all company vehicles being fitted with speed limiters. Also speed limiters would make high-performance vehicles less attractive for thieves (this also has road safety implications).

8 Benefit cost analysis

There are several scenarios which have been examined:

1 Deviant drivers are required to fit a top speed limiter or VMD

2 All new vehicles are fitted with a top speed limiter (limited to 120km/h)

3 All new vehicles are required to have a speedometer scale not exceeding 120km/h with the needle vertical at 60km/h in the case of analogue speedometers.

4 All new vehicles are required to be fitted with an automatic speed limiter and the road infrastructure is provided with speed limit transmitters

5 In addition to item 4, automatic speed limiters are introduced on a voluntary basis for existing vehicles.

6 Speed alarms are introduced on a voluntary basis, to take advantage of the speed limit transmitters at a lower cost than automatic speed limiters.

7 All vehicles are fitted with an automatic speed limiter (very unlikely, but included in the analysis as a gauge of sensitivity)

8 All new vehicles are required to have a VMD

Other possible scenarios can generally be derived from the above cases. Benefit cost parameters are based on the RTA Economic Analysis Manual (RTA 1996).

The recommendation that the ADR tolerance on speedometers be reduced has not been assessed because it it understood that it would involve nil costs (manufacturers already specify tight tolerances) and any crash savings would probably be linked to other initiatives such as reduced enforcement tolerances.

8.1 Estimated initial and ongoing costs

8.1.1 Vehicle equipment

There is very little reliable information about the costs of the speed control devices for cars. In some cases the following estimates are based on comparisons with similar existing equipment for trucks.

Table 10. Estimated Costs for Speed Control Devices

Device	Supply & Fit $	Net Annual $	Comment
Top speed limiter (retro-fit or non EMS)	1000	0	Based on truck speed limiters. Annual costs offset by fuel savings (est $10).
Top speed limiter (new vehicle with EMS)	0.5 (50 cents)	0	Assumes most EMS chips can be readily re-programmed. Many already have a speed limiter function. Net savings due to fuel savings but only where vehicles currently travel in excess of the seeting. so savings are negligible across all target vehicles.
Vehicle Monitoring device	1000	10	Based on truck VMDs. Some annual costs offset by fuel savings of $40.
Automatic speed limiter (with receiver)	800	-20	Annual costs offset by fuel savings ($40)
Automatic speed alarm	300	-10	Based on Howie 1989. Smaller fuel savings.
Speedometer up to 120km/h	1	-	Could be more expensive for some imported vehicles.

In view of the uncertainty about some of these costs the benefit cost analysis included a range of costs per vehicle for speed limiters and speedometers.

8.1.2 Roadway devices

In the case of the road infrastructure, the costs will depend on the type of roadside transmitter chosen. For the purpose of the analysis the cheapest, most practical system will be assessed. It is unlikely that more expensive radio transmitter systems could be justified solely for the purpose of a speed control system and they are more likely to be part of an overall ITS strategy.

Howie (1989) reports that the estimated cost of marking the Melbourne metropolitan area with pavement barcodes was $6,000,000.

Currently in NSW there is no central inventory of speed zoning. If we assume there are 5,000 speed zones in NSW and that each zone has four inbound access points then the total number of speed zone changes is estimated to be about 20,000. The initial cost of providing a simple, passive signal such as magnetic nails or magnetic strip, is estimated to be $500 per inbound speed zone change. The cost of equipping 20,000 locations is therefore estimated to be $10,000,000. Both of these techniques are claimed to be durable and an annual maintenance cost of 10% has been assumed (note that replacement costs are covered in the benefit cost calculations). Pavement barcodes are likely to be more expensive to install and maintain (about double the above estimates).

8.2 Results of benefit cost analysis

Details of the benefit cost analysis of the eight scenarios are set out in Appendix E. It is stressed that several of the assumptions are speculative but, on balance, the analysis provides a reasonable basis for comparing the scenarios. The results are presented in Table 11.

Table 11. Results of Benefit Cost Analysis

Scenario	Initial Cost	Annual Cost	Annual Crash Savings	Benefit Cost Ratio
1. Deviant speeders required to fit speed limiters (or VMD) *Note that the "costs" are equivalent to a fine.*	$90m for 90K veh.	$450K	$19m	1.47:1
2. All new vehicles fitted with a top speed limiter set at 120km/h	$2.1m for 210K veh.	Nil	$1.3m	90:1
3. All new vehicle require speedometers with 120km/h max	$2.1m for 210K veh.	-	$0.68m	22.6:1
4. All new vehicles fitted with automatic speed limiters & roadways fitted with transmitters	$178m for 210K veh & roads	($3.2m) net savings due to fuel savings	$11m	0.57:1
5. Scenario 4 plus 20% of existing fleet fitted with automatic speed limiters	$658m for 810K vehicles & roads	($15.2m) net savings	$44m	0.63:1
6. 20% of existing fleet fitted with automatic speed alarms & roadways fitted with transmitters	$190m for 600K veh & roads	($5m) net savings	$19m	0.90:1
7. All vehicles fitted with automatic speed limiters & roadways fitted with transmitters	$2,410m for 3m veh & roadways	($59m) net savings	$162m	0.64:1
8. All new vehicles fitted with VMD	$210m for 210K veh.	$2.1 net cost	$11m	0.31:1

8.3 Discussion

The second scenario, speed limiting new vehicles to 120km/h, produced a very high estimated benefit cost ratio (90:1). This is based on the assumption that most new vehicles have electronic engine management systems and that these systems can be readily modified to provide the 120km/h speed limiting function (such an opportunity would not have existed a decade ago when speed limiting was apparently considered in the USA). A cost of 50 cents per vehicle has been assumed for this analysis. If this cost was $10 per vehicle then the estimated benefit cost ratio for the second scenario reduces to 4.5:1. A very pessimistic cost of $100 per vehicle produces an estimated benefit cost ratio of 0.45:1.

With a speed limiting setting of 130km/h the estimated benefit cost ratio is 26:1 - based on 50c per vehicle initial cost and elimination of 3% of rural speed-related crashes. Similarly, a speed limiter setting of 140km/h produces an estimated benefit cost ratio of 9:1 - based on elimination of 1% of rural speed-related crashes. Although these are still favourable ratios the estimated annual number of crashes affected is small and therefore the estimates are less reliable.

The other scenario showing a strong favourable benefit cost ratio is the third one: speedometers on new vehicles to have a maximum scale of 120km/h (22.6:1). This approach has the extra, uncosted, benefit of improved speed discrimination at urban speeds. In this case a cost of $1 per vehicle was assumed for the analysis. If this cost was $10 then the estimated benefit cost ratio reduces to 2.26:1 - still favourable.

Although the unfavourable benefit cost ratio (0.90) makes implementation by way of regulation unlikely, scenario 6 offers some interesting possibilities. For a relatively moderate investment in the roadway infrastructure (estimated $10 million) motorists are given the opportunity to fit devices which automatically detect changes to speed limits and either activate an alarm or adjust the vehicle's speed. Avoidance of speeding penalties might provide sufficient incentive for many motorists to fit such devices and the cost would be similar to that radar detectors (which are now banned in NSW).

From a marketing viewpoint, an automatic speed control feature would make cruise control systems more attractive. It is estimated that the annual crash savings would be at least $19 million if 20% of vehicle were so fitted. Therefore, if the cost to motorists of equipping cars is regarded as voluntary, then the return on the cost of roadway transmitters is very high (estimated benefit cost ratio 12.9:1).

9 Conclusions & Recommendations

9.1 Technology

It is recommended that the 10% tolerance for speedometers provided under ADR 18 be reviewed. A 2% tolerance on underestimating speed would be appropriate based on the available technology and industry practices and this should not involve extra manufacturing costs.

Speed limiter technology which has been developed for heavy vehicles can be readily applied to cars and other light vehicles. Many new cars have electronic engine management systems and it is understood that these can be modified, at a very low cost per vehicle, to provide an effective top speed limiter.

None of the cruise control systems surveyed had a top speed limiter function but the cost of such a feature should be minimal.

Reference to statutory speed limits is noticeably absent from Intelligent Transportation System (ITS) strategies. There are now available several relatively cheap methods of transmitting speed limit information to vehicles - estimated statewide installation cost $10 million. Vehicles could then be fitted with *automatic speed limiters* which prevent the vehicle from being driven in excess of the posted speed limit or *speed alarms* which sound a warning if the posted speed limit is exceeded.

Vehicle monitoring devices (VMD), such as tachographs are an alternative to speed limiters for recividist drivers and they are less vulnerable to tampering. In-vehicle crash recorders might also help to modify speed behaviour.

If a new safety feature is introduced by way of new vehicles (e.g. through ADRs) then it can take six years after implementation for the feature to account for 50% of annual vehicle kilometres travelled. In addition to this time, it can take several years for an ADR to be implemented. In assessing speed control strategies, consideration should therefore be given to measures which also affect existing vehicles.

Strong objections to speed limiters can be expected from some motorists and manufacturers, irrespective of the potential road safety and environmental benefits of such devices.

9.2 Speed and crashes

NSW police-reported crash data indicates that, during 1994, speed was involved in 21% of fatal crashes, 12% of serious injury crashes and 7% of other crashes. More detailed studies suggest that speed is involved in approximately double those indicated by the police-reported crash data and therefore an analysis based on that data should be conservative.

Overseas research indicates that substantial crash savings can be achieved through small reductions in mean traffic speeds. It is estimated that a 3% reduction in mean traffic speeds would save 71 fatal, 342 serious injury, 1191 other injury and 2335 non-casualty crashes per year in NSW.

9.3 Speed limits and safe speeds

The driving task of judging a vehicle's speed is becoming more difficult with the trend to quieter, smoother vehicles. Some roadways are known to be over-designed and can induce unsafe traffic speeds. Motorists often do not appreciate the distance they travel between the point when a hazard first became visible (but not necessarily seen) and the point where their foot hits the brake pedal. In summary, motorists cannot be expected to make correct judgements about appropriate travel speeds for the conditions. Objectively set speed limits fulfil the purpose of setting an upper limit but there needs to be an improvement in the credibility of speed limits. Automatic speed limiters in vehicles would enhance the credibility of speeds limits.

It is likely that exceeding a 60km/h speed limit by 15 km/h would carry with it a far greater risk of serious injury (particularly to vulnerable road users) than exceeding a 100 km/h speed limit by 15 km/h. Automatic speed limiters would be an effective countermeasure in lower speed limit zones.

The trend to a variety of speed limits along a transport route places a greater burden on drivers to pay attention to changing speed zones. An automatic speed limiter would assist motorists to drive within the speed limit at all times and wide spread use of automatic speed limiters would allow greater flexibility in setting speed limits.

9.4 Effects of speed limiters

The introduction of speed limiters for heavy vehicles in Australia has been generally successful. Anecdotal reports of tampering suggest a need for improved enforcement and higher penalties. *It is recommended that repeat offenders be required to fit vehicle monitoring devices and that the ADR be reviewed to determine if a simple means of checking speed limiters can be incorporated in the design.*

In regard to overtaking, the main effect of a speed limiter is that "the driver of a high performance vehicle would no longer perform certain manoeuvres which he now regards as safe". The time taken to overtake a vehicle can be substantially reduced by travelling at excessive speeds but only at a much greater risk of a severe crash.

To overcome the tenuous argument that speed limiters make overtaking less safe, alternative approaches could be considered such as making the vehicle less comfortable to drive at excessive speeds for long periods (e.g. a device which increases the force required to depress the accelerator pedal).

Small savings in fuel consumption, tyres and brake maintenance should result from the use of speed limiters. The estimated overall saving is $42 per vehicle per year for measures which reduce mean traffic speeds by 3%. Small reductions in emissions and noise should also occur.

Overall travel times and network efficiency should not be adversely affected by speed limiting and other measures which result in a 3% reduction in mean traffic speeds. There might be advantages due to a reduction in accidents.

It is estimated that 10% of rural speed-related crashes could be prevented by speed limiting all cars to 120km/h. In 1994 there were at least 86 fatal, 440 serious injury and 813 other injury crashes in rural areas which were speed related.

It is estimated that 50% of all speed-related crashes could be prevented by use of automatic speed limiters in all cars, so that the posted speed limit cannot be exceeded. In 1994 there were at least 135 fatal, 718 serious injury and 1439 other injury crashes which were speed related. The savings would be due to the effects on mean traffic speeds as well as elimination of crashes involving excessive speeding.

9.5 Recommended scenarios

Based on the assumptions set out in this report, the scenarios showing the most promise are, in order of merit (benefit cost ratio in brackets):

- All new vehicles fitted with a top speed limiter set at 120km/h at a cost of 50 cents per vehicle (90:1)

- All new vehicles require a speedometer scale no more than 120km/h at a cost of $1 per vehicle (23:1)
- Deviant motorists (worse 3%) required to only drive speed limited or, preferably, VMD equipped vehicles (1.5:1 if the $1000 cost of retro-fitting fitting device is included, although this is more of a penalty for the driver than a cost to the community)
- Roadways are fitted with simple speed limit transmitters (eg coded magnetic strips or nails) at a statewide cost of about $10 million and about 20% of vehicles are voluntarily equipped with sensors and speed control devices or alarms at a cost of $300 per vehicle (0.9:1 - the incentive in this case is avoiding speeding penalties. If only the roadway components are costed the ratio is 13:1)
- Roadways are fitted with speed limit transmitters and new vehicles plus 20% of existing vehicles are fitted with automatic speed limiters (0.6:1)

It is recommended that consideration be given to an ADR which requires cars to be speed limited to 120km/h.

It is recommended that ADR 18 be revised to require a maximum speedometer reading of 120km/h and, in the case of analogue displays, that the pointer be vertical at 60km/h.

It is recommended that further research be undertaken into the feasibility of roadway speed limit transmitters and in-vehicle devices to receive these signals and into driver attitudes to automatic speed limiters.

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Appendix A

Press Reports Concerning Speed Control

Appendix B

Survey of Vehicle Manufacturers

A survey of current popular model cars to determine if they have any form of speed control devices fitted. In all 11 motor companies were contacted and staff interviewed along the following lines:

Are any of your current model cars fitted with any form of speed control. This may include a speed control built into a cruise control or engine management system?.

Has any of your vehicles' Engine Managenent Systems the ability to determine the vehicle speed?

Are there aftermarket speed control devices available for any of your vehicles including any that might be built into an add-on cruise control? If so;

1. What are the estimated supply and fit costs and are there any annual maintenance costs?
2. Are any such installations available for viewing or test driving?
3. How tamper-proof are the available systems

The persons interviewed were senior management from their product engineering area and/or Single Uniform Type Inspection (SUTI) homologation officers.

In brief, the responses indicated that there are no specific speed limiters fitted and no one was aware of or any aftermarket devices to control vehicle speed in accordance with prescribed speed limits. However, some vehicles have speed limiters set in the high speed range as a product protection device.This is attained through the engine management system (EMS) either by fuel shut-off or engine RPM limiting. Three companies have speed alarms fitted. These are preset by the driver and give an audible alarm when the preset speed is attained.

All companies interviewed had cruise control available for their vehicles, some as standard equipment others as an option. There is presently no speed limiting function built into any cruise controls of the companies surveyed.

The following is a listing of the companies involved in the survey and the person interviewed..

Ford

Person Interviewed Mr.Peter Spence Chassis and Power Train Supervisor

Mr. Spence stated that no specific speed limiters were fitted to the Ford range

Mr. Spence stated that the current Falcon has an EMS speed control set at between 180-220 km/h. An option of an audible "over speed alarm" is available at a cost of $320.00 supplied and fitted and is standard equipment on vehicles where a trip computer is fitted (such as the Fairmont and Fairlane range). He indicated that it should be possible to change the EMS potential speed to a lower speed.

Holden

Person Interviewed   Mr. Michael Goonan   Manager ADR compliance

Mr.Goonan stated that the Holden range is not fitted with any specific speed limiter. However, he is of the opinion the EMS chip has the potential to be programmed to a specific speed. There is no function of the cruise control option that will act as a speed limiter.

The current Holden range is fitted with an audible speed alert system which alerts the driver when a preset speed is reached.

Honda

Person Interviewed   Mr. Bill Finnegan Training Instructor Tech. and Service

Mr. Finnegan stated that the Honda range of vehicles are not fitted with Speed Limiters. However, engine rpm is limited through the EMS to the equivalent of a maximum speed of 180km/h. This is achieved by fuel cut-out on 75% of the fuel injectors. On home consumption vehicles (Japan) an audible alarm system is mandatory and is triggered through the speedo when the vehicle reaches 100km/h.(apparently this is a national requirement). This alarm is factory set and is not able to be switched off or altered by the driver

Mercedes Benz

Person Interviewed   Mr Barry Layton Manager Vehicle Regulation

Mr Layton stated that Mercedes Benz has no speed limiter fitted.It has a speed control built into the EMS which controls maximum vehicle speed to 210 km/h.in Australia, 250km/h. in Europe. The cruise controls fitted do not have an inbuilt speed limiter.

Volvo

Person Interviewed   Mr. David Rean

Mr Rean stated that the Volvo range (being fuel injected) are speed govened through the fuel pump in the high rev. range. He understood that speed control requirements applied in Saudi Arabia.

Rover

Person Interviewed   Mr. John Lindsay

Mr. Lindsay stated that the Rover range of vehicles are not speed limited. There is an audible speed warning device fitted which can be preset by the driver. It might be possible for the EMS to determine vehicle speed.

Toyota

Person Interviewed   Mr. Greg Gardiner

Mr. Gardiner stated that the Toyota range of vehicles are not fitted with speed limiters. However the EMS does limit speed. On 400 series Lexus, the top speed is govened at 250km/h,.on the Camry to 190km/h.

Audi/VW

Person Interviewed   Mr. Gerhard Dous

Mr. Dous stated that the Audi/VW range of vehicles are not fitted with speed limiters and there is no provision in cruise controls fitted to speed limit the vehicles. The existing Audi EMS is set at 250km/h.

Mitsubishi

Person Interviewed   Mr. Brian Ludlam

Mr. Ludlam stated that Mitsubishi cars were not equipped with speed limiters, and there is no provision in the cruise controls fitted to speed limit Mitsubishi cars. However, the EMS could accomodate speed limiting functions.

Nissan

Person Interviewed   Mr Tony Carraturo, Manager Product support

Mr. Carraturo stated Nissan cars are not fitted with speed limiters, nor is there any provision in the cruise controls fitted to speed limit the Nissan vehicles. The EMS is set to control engine RPM. No other information was available.

Mazda

Person Interviewed   Mr Robert Cook

Mr. Cook stated that Mazda cars are not fitted with speed limiters, nor is there any provision in cruise controls fitted to speed limit Mazda vehicles. Vehicles for home consumption (Japan) are limited to 100km/h.national speed limit.On reaching this speed the speedo beeps as an alarm.

Appendix C

Relationship Between Traffic Speed & Crash Severity

Nilsson (1993) reports a fourth power relationship between mean traffic speed and number of fatal crashes (all other factors unchanged). This is based on emperical results from over 50 studies of the effects of changed speed limits. It is important that mean traffic speed is used because the change in mean traffic speed is generally less than the change in statutory speed limits and is more closely related to the risk of a crash.

Conventional theory is that the probability of an injury crash is proportional to the square of the speed, based on kinetic energy considerations. This does not appear to hold in the case of fatal crashes. Nilsson suggests that the probability of that an injury accident will be a fatal accident is also proportional to the square of the speed and that the combination produces a fourth power relationship but the physical explanation appears to be tenuous.There might be an alternative explanation for the observed relationship with fatal crashes: a manifestation of the (approximate) normal distribution of impact speeds (or more correctly delta-V: the change in velocity) for a given mean traffic speed. *It is stressed that the following analysis is speculative and is presented here to give an indication of a possible line for further research.*

Jones (1982) presents the results of an analysis of injury severity versus crash severity for 510 frontal crashes occuring in Oxfordhsire. Crash severity is measured in terms of delta-V and injury severity in terms of MAIS. The frequency distribution for delta-V is presented (Jones Table 11). It appears that this can be reasonably approximated by a normal distribution. Jones reports that the mean delta-V was 22km/h and the mean delta-V for serious injury (MAIS>=3) was 45km/h for belted front-seat occupants and 38km/h for unbelted front-seat occupants. For comparison, Evans (1992), in a study of 2-car crashes in the USA between 1982 and 1991, gives data which indicates that, for belted drivers, the mean delta-V for reported crashes was 21km/h, the mean delta-V for serious/fatal crashes was 37km/h and the mean delta-V for fatal crashes was 52km/h. Evans' data indicate that the probability of a fatality reaches 0.5 for a delta-V of 100km/h and the probability of a serious injury or fatality reaches 0.5 for a delta-V of 74km/h (again for belted drivers - the total number of fatally and seriously injured drivers in the sample was 641 and a weighting technique was applied to derive the above probabilities).

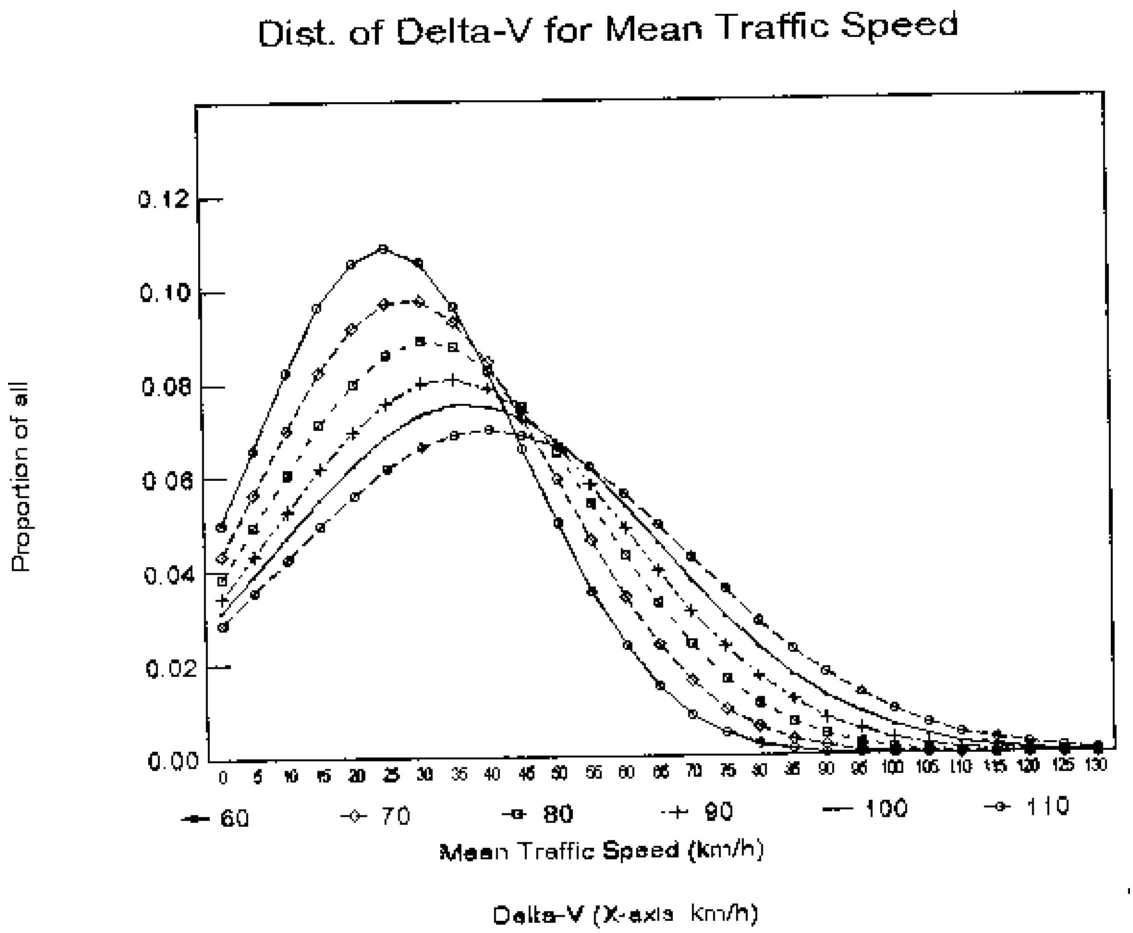
In a study of the effects of the 55mph speed limit in the USA, Altshuler (1984) indicates that the probability of a fatality reaches 0.5 for a delta-V of 80km/h. Although these results are older than those obtained by Evans, and generally involved unbelted drivers, the value of 80km/h will be used as a critical speed for this analysis. At a delta-V of 80km/h Evans' data indicate the probability of a fatality for a belted driver is 0.3.

Unfortunately Jones makes no reference to statutory speed limits or mean traffic speeds. It is assumed from the description of the study that most crashes occurred in urban areas therefore, for the purpose of this tentative analysis we will assume that the delta-V distribution observed by Jones is for a 60km/h mean traffic speed. As the mean traffic speed increases we can expect the mean delta-V to increase (but not as rapidly as the mean traffic speed) and the standard deviation to increase. The following parameters have been used in the analysis:

Tentative Statistical Parameters for Distribution of Delta-V

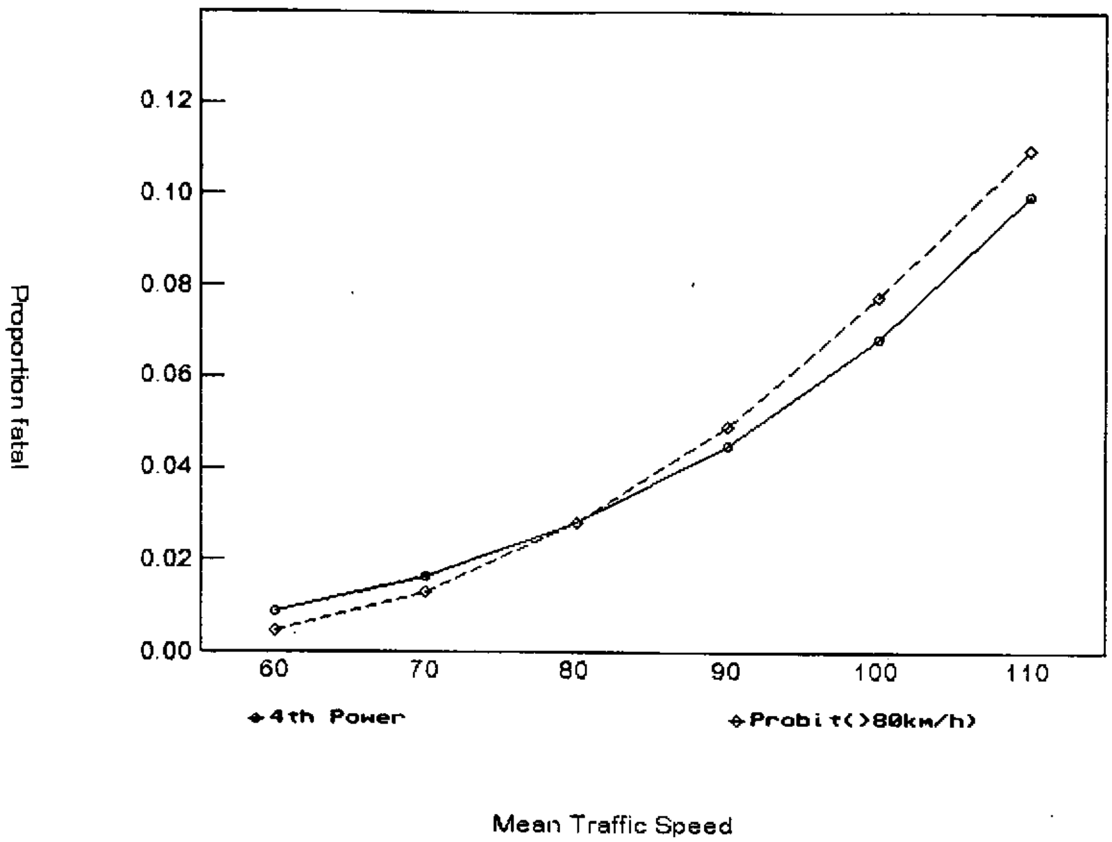
Mean Traffic Speed (km/h)	**60.00**	**70.00**	**80.00**	**90.00**	**100.00**	**110.00**
Mean Delta-V	**25.00**	**28.00**	**31.00**	**34.00**	**37.00**	**40.00**
S.D. Delta-V	**20.00**	**22.00**	**24.00**	**26.00**	**28.00**	**30.00**
% of Delta-V over 80km/h	**0.5%**	**1.3%**	**2.8%**	**4.9%**	**7.8%**	**11%**
4th Power comparison	**0.9%**	**1.6%**	**2.8%**	**4.5%**	**6.8%**	**10%**

The distribution of delta-V for the range of mean traffic speeds is illustrated below.



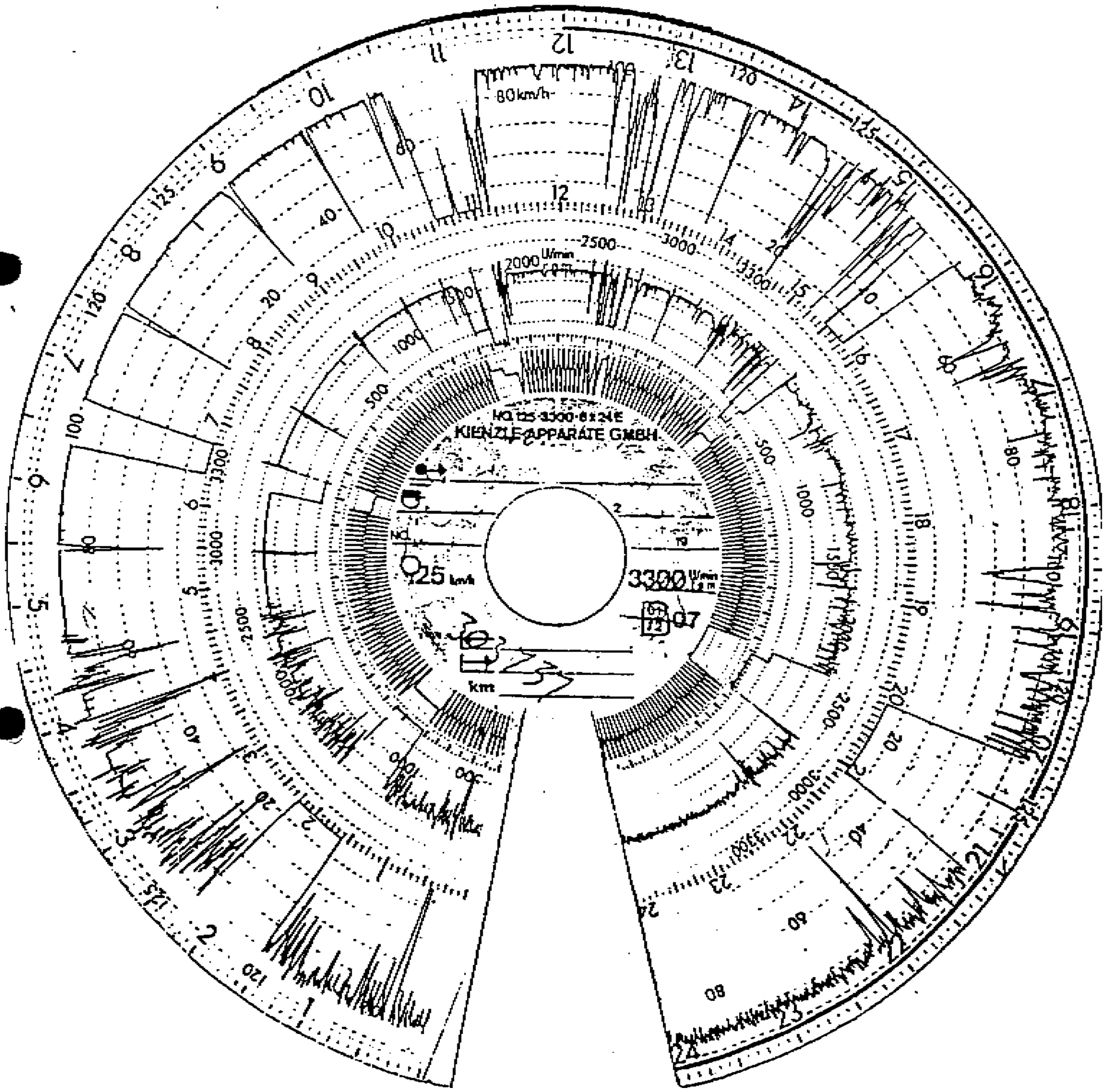
The figure overleaf shows the comparison between the proportion of crashes with a delta-V over 80km/h (the nominal critical speed for fatalities) and a 4th power relationship (tied to the 80km/h value).

Probit (Normal) Method Vs 4th Power



Appendix D

Tachograph Chart Showing Intermittent Speed Limiter Operation



Appendix E

Details of Benefit Cost Analysis

The following pages contain the results of cost benefit analyses of the countermeasures described in Section 8 of the report. In accordance with the RTA Economic Analysis Manual, the benefit cost ratio is derived from

PV (Annual Crash Savings - Annual Operating Costs) / Initial Costs

A benefit cost ratio greater than one indicates that the savings exceed the costs.

The Present Value (PV) is based on a 10 year evaluation period and a 7% discount rate.

The generic costs for crashes,as at March 1996, are:

Fatal crash	$929,700
Serious injury crash (hospital admission)	$163,300
Other injury crash	$25,700
Non-casualty crash	$11,700

See Section 8 of the report for a description of the assumptions used in the analysis.

Benefit-Cost Analysis of Speed Control Devices								
Countermeasure:		**1. Deviant speeders required to fit speed limiters**						
Independent Parameters								
Evaluation period		10	years					
Base year		1996						
Discount rate		7	%		PV Factor $1=	$7.02		
Costs								
% of car population		3	% of	3000000	=	90000	vehicles targeted	
		Per Veh.	Tot. Veh.	Roadway		Total		
Initial cost		$1,000	$90,000,000	$0		**$90,000,000**	(equivalent to fines)	
Annual cost		$5	$450,000	$0		**$450,000**		
Residual value		$0	$0	$0		**$0**		
Accident savings per year								
				Fatal	Serious Inj	Other Inj	Property	
Potential crashes influenced (note 1)				86	440	813	1731	
Effectiveness of countermeasure (%) (note 2)				10	10	10	10	
Estimated savings (number of crashes)				8.6	44	81.3	173.1	
Assumed cost per crash				$929,700	$163,300	$25,700	$11,700	
Estimated crash savings ($)				$7,995,420	$7,185,200	$2,089,410	$2,025,270	**$19,295,300**
Benefit-Cost Calculation								
Net annual savings		$18,845,300		PV(savings) =	$132,361,501.21			
Benefit/Cost ratio =		**1.47**						
Note 1	Speed related crashes in rural areas							
Note 2	Proportion of country speed-related crashes estimated to involve speeds over 120km/h							

Benefit-Cost Analysis of Speed Control Devices								
Countermeasure:		**2. All new vehicles fitted with top speed limiter set at 120km/h**						
		(50 cents per vehicle)						
Independent Parameters								
Evaluation period		10	years					
Base year		1996						
Discount rate		7	%		PV Factor $1=	$7.02		
Costs								
% of car population		7	% of	3000000	=	210000	vehicles targeted	
		Per Veh.	Tot. Veh.	Roadway		Total		
Initial cost		$0.50	$105,000	$0		**$105,000**		
Annual cost (note 3)		$0	$0	$0		**$0**		
Residual value		$0	$0	$0		**$0**		
Accident savings per year								
				Fatal	Serious Inj	Other Inj	Property	
Potential crashes influenced (note 1)				86	440	813	1731	
Effectiveness of countermeasure (%) (note 2)				0.7	0.7	0.7	0.7	
Estimated savings (number of crashes)				0.602	3.08	5.691	12.117	
Assumed cost per crash				$929,700	$163,300	$25,700	$11,700	
Estimated crash savings ($)				$559,679	$502,964	$146,259	$141,769	**$1,350,671**
Benefit-Cost Calculation								
Net annual savings		$1,350,671		PV(savings) =	$9,486,547.90			
Benefit/Cost ratio =		**90.35**						
Note 1	Speed related crashes in rural areas							
Note 2	Proportion of country speed-related crashes estimated to involve speeds over 120km/h							
	times proportion of these that are new vehicles: 10% x 7% = 0.7%							
Note 3	Net saving due to reduced fuel consumption							

Benefit-Cost Analysis of Speed Control Devices								
Countermeasure:		**2a. All new vehicles fitted with top speed limiter set at 120km/h**						
		(cost of speed limiter $10/vehicle)						
Independent Parameters								
Evaluation period		10	years					
Base year		1996						
Discount rate		7	% (based on NRTC advice)		PV Factor $1=	$7.02		
Costs								
% of car population		7	% of	3000000	=	210000	vehicles targeted	
		Per Veh.	Tot. Veh.	Roadway		Total		
Initial cost		$10	$2,100,000	$0		**$2,100,000**		
Annual cost (note 3)		$0	$0	$0		**$0**		
Residual value		$0	$0	$0		**$0**		
Accident savings per year								
				Fatal	Serious Inj	Other Inj	Property	
Potential crashes influenced (note 1)				86	440	813	1731	
Effectiveness of countermeasure (%) (note 2)				0.7	0.7	0.7	0.7	
Estimated savings (number of crashes)				0.602	3.08	5.691	12.117	
Assumed cost per crash				$929,700	$163,300	$25,700	$11,700	
Estimated crash savings ($)				$559,679	$502,964	$146,259	$141,769	**$1,350,671**
Benefit-Cost Calculation								
Net annual savings		$1,350,671		PV(savings) =	$9,486,547.90			
Benefit/Cost ratio =		**4.52**						
Note 1	Speed related crashes in rural areas							
Note 2	Proportion of country speed-related crashes estimated to involve speeds over 120km/h							
	times proportion of these that are new vehicles: 10% x 7% =0.71%							
Note 3	Net saving due to reduced fuel consumption							

Benefit-Cost Analysis of Speed Control Devices								
Countermeasure:		**2b. All new vehicles fitted with top speed limiter set at 120km/h**						
		(cost of speed limiter $100/vehicle)						
Independent Parameters								
Evaluation period		10	years					
Base year		1996						
Discount rate		7	% (based on NRTC advice)		PV Factor $1=	$7.02		
Costs								
% of car population		7	% of	3000000	=	210000	vehicles targeted	
		Per Veh.	Tot. Veh.	Roadway		Total		
Initial cost		$100	$21,000,000	$0		**$21,000,000**		
Annual cost (note 3)		$0	$0	$0		**$0**		
Residual value		$0	$0	$0		**$0**		
Accident savings per year								
				Fatal	Serious Inj	Other Inj	Property	
Potential crashes influenced (note 1)				86	440	813	1731	
Effectiveness of countermeasure (%) (note 2)				0.7	0.7	0.7	0.7	
Estimated savings (number of crashes)				0.602	3.08	5.691	12.117	
Assumed cost per crash				$929,700	$163,300	$25,700	$11,700	
Estimated crash savings ($)				$559,679	$502,964	$146,259	$141,769	**$1,350,671**
Benefit-Cost Calculation								
Net annual savings		$1,350,671		PV(savings) =	$9,486,547.90			
Benefit/Cost ratio =		**0.45**						
Note 1	Speed related crashes in rural areas							
Note 2	Proportion of country speed-related crashes estimated to involve speeds over 120km/h							
	times proportion of these that are new vehicles: 10% x 7% =0.71%							
Note 3	Net saving due to reduced fuel consumption							

Benefit-Cost Analysis of Speed Control Devices								
Countermeasure:		**2c. All new vehicles fitted with top speed limiter set at 130km/h**						
		(cost of speed limiter 50c per vehicle)						
Independent Parameters								
Evaluation period		10	years					
Base year		1996						
Discount rate		7	% (based on NRTC advice)		PV Factor $1=	$7.02		
Costs								
% of car population		7	% of	3000000	=	210000	vehicles targeted	
		Per Veh.	Tot. Veh.	Roadway		Total		
Initial cost		$0.50	$105,000	$0		**$105,000**		
Annual cost (note 3)		$0	$0	$0		**$0**		
Residual value		$0	$0	$0		**$0**		
Accident savings per year								
				Fatal	Serious Inj	Other Inj	Property	
Potential crashes influenced (note 1)				86	440	813	1731	
Effectiveness of countermeasure (%) (note 2)				0.2	0.2	0.2	0.2	
Estimated savings (number of crashes)				0.172	0.88	1.626	3.462	
Assumed cost per crash				$929,700	$163,300	$25,700	$11,700	
Estimated crash savings ($)				$159,908	$143,704	$41,788	$40,505	**$385,906**
Benefit-Cost Calculation								
Net annual savings		$385,906		PV(savings) =	$2,710,442.26			
Benefit/Cost ratio =		**25.81**						
Note 1	Speed related crashes in rural areas							
Note 2	Proportion of country speed-related crashes estimated to involve speeds over 120km/h							
	times proportion of these that are new vehicles: 10% x 7% =0.71%							
Note 3	Net saving due to reduced fuel consumption							

Benefit-Cost Analysis of Speed Control Devices								
Countermeasure:		**3. All new vehicles require speedometers with scales up to 120km/h**						
Independent Parameters								
Evaluation period		10	years					
Base year		1996						
Discount rate		7	%		PV Factor $1=	$7.02		
Costs								
% of car population		7	% of	3000000	=	210000	vehicles targeted	
		Per Veh.	Tot. Veh.	Roadway		Total		
Initial cost		$10	$2,100,000	$0		**$2,100,000**		
Annual cost		$0	$0	$0		**$0**		
Residual value		$0	$0	$0		**$0**		
Accident savings per year								
				Fatal	Serious Inj	Other Inj	Property	
Potential crashes influenced (note 1)				86	440	813	1731	
Effectiveness of countermeasure (%) (note 2)				0.35	0.35	0.35	0.35	
Estimated savings (number of crashes)				0.301	1.54	2.8455	6.0585	
Assumed cost per crash				$929,700	$163,300	$25,700	$11,700	
Estimated crash savings ($)				$279,840	$251,482	$73,129	$70,884	**$675,336**
Benefit-Cost Calculation								
Net annual savings		$675,336		PV(savings) =	$4,743,273.95			
Benefit/Cost ratio =		**2.26**						
Note 1	Speed related crashes in rural areas							
Note 2	Proportion of country speed-related crashes estimated to involve speeds over 120km/h							
	times proportion of these that are new vehicles x 50%: 10% x 7% x 50%= 0.35%							

Benefit-Cost Analysis of Speed Control Devices								
Countermeasure:		**4. All new vehicles fitted with automatic speed limiters**						
		& transmitters provided on roadway.						
Independent Parameters								
Evaluation period		10	years					
Base year		1996						
Discount rate		7	%		PV Factor $1=	$7.02		
Costs								
% of car population		7	% of	3000000	=	210000	vehicles targeted	
		Per Veh.	Tot. Veh.	Roadway		Total		
Initial cost		$800	$168,000,000	$10,000,000		**$178,000,000**		
Annual cost (note 3)		($20)	($4,200,000)	$1,000,000		**($3,200,000)**		
Residual value		$0	$0	$0		**$0**		
Accident savings per year								
				Fatal	Serious Inj	Other Inj	Property	
Potential crashes influenced (note 1)				135	718	1439	3732	
Effectiveness of countermeasure (%) (note 2)				3.5	3.5	3.5	3.5	
Estimated savings (number of crashes)				4.725	25.13	50.365	130.62	
Assumed cost per crash				$929,700	$163,300	$25,700	$11,700	
Estimated crash savings ($)				$4,392,833	$4,103,729	$1,294,381	$1,528,254	**$11,319,196**
Benefit-Cost Calculation								
Net annual savings		$14,519,196		PV(savings) =	$101,976,757.01			
Benefit/Cost ratio =		**0.57**						
Note 1	All speed related crashes							
Note 2	Proportion of speed-related crashes estimated to be influenced by automatic speed limiter							
	times proportion of these that are new vehicles: 50% x 7%= 3.5%							
Note 3	Net savings due to fuel savings							

Benefit-Cost Analysis of Speed Control Devices								
Countermeasure:		**5. All new vehicles fitted with automatic speed limiters + 20% of existing fleet**						
		& transmitters provided on roadway.						
Independent Parameters								
Evaluation period		10	years					
Base year		1996						
Discount rate		7	%		PV Factor $1=	$7.02		
Costs								
% of car population		27	% of	3000000	=	810000	vehicles targeted	
		Per Veh.	Tot. Veh.	Roadway		Total		
Initial cost		$800	$648,000,000	$10,000,000		**$658,000,000**		
Annual cost (note 3)		($20)	($16,200,000)	$1,000,000		**($15,200,000)**		
Residual value		$0	$0	$0		**$0**		
Accident savings per year								
				Fatal	Serious Inj	Other Inj	Property	
Potential crashes influenced (note 1)				135	718	1439	3732	
Effectiveness of countermeasure (%) (note 2)				13.5	13.5	13.5	13.5	
Estimated savings (number of crashes)				18.225	96.93	194.265	503.82	
Assumed cost per crash				$929,700	$163,300	$25,700	$11,700	
Estimated crash savings ($)				$16,943,783	$15,828,669	$4,992,611	$5,894,694	**$43,659,756**
Benefit-Cost Calculation								
Net annual savings		$58,859,756		PV(savings) =	$413,406,295.75			
Benefit/Cost ratio =		**0.63**						
Note 1	All speed related crashes							
Note 2	Proportion of speed-related crashes estimated to be influenced by automatic speed limiter							
	times proportion of vehicles fitted with limiters: 50% x 27%= 13.5%							
Note 3	Net savings due to fuel savings							

Benefit-Cost Analysis of Speed Control Devices								
Countermeasure:		**6. 20% of existing fleet fitted with speed alarm**						
		& transmitters provided on roadway.						
Independent Parameters								
Evaluation period		10	years					
Base year		1996						
Discount rate		7	%		PV Factor $1=	$7.02		
Costs								
% of car population		20	% of	3000000	=	600000	vehicles targeted	
		Per Veh.	Tot. Veh.	Roadway		Total		
Initial cost		$300	$180,000,000	$10,000,000		**$190,000,000**		
Annual cost (note 3)		($10)	($6,000,000)	$1,000,000		**($5,000,000)**		
Residual value		$0	$0	$0		**$0**		
Accident savings per year								
				Fatal	Serious Inj	Other Inj	Property	
Potential crashes influenced (note 1)				135	718	1439	3732	
Effectiveness of countermeasure (%) (note 2)				6	6	6	6	
Estimated savings (number of crashes)				8.1	43.08	86.34	223.92	
Assumed cost per crash				$929,700	$163,300	$25,700	$11,700	
Estimated crash savings ($)				$7,530,570	$7,034,964	$2,218,938	$2,619,864	**$19,404,336**
Benefit-Cost Calculation								
Net annual savings		$24,404,336		PV(savings) =	$171,405,843.85			
Benefit/Cost ratio =		**0.90**						
Note 1	All speed related crashes							
Note 2	Proportion of speed-related crashes estimated to be influenced by speed alarm							
	times proportion of vehicles fitted with alarm: 30% x 20%= 6%							
Note 3	Net savings due to fuel savings							

Countermeasure:		**6a. 20% of existing fleet fitted with speed alarm**						
		& transmitters provided on roadway.(neglect vehicle costs)						
Independent Parameters								
Evaluation period		10	years					
Base year		1996						
Discount rate		7	% (based on NRTC advice)		PV Factor $1=	$7.02		
Costs								
% of car population		20	% of	3000000	=	600000	vehicles targeted	
		Per Veh.	Tot. Veh.	Roadway		Total		
Initial cost		$0	$0	$10,000,000		**$10,000,000**		
Annual cost (note 3)		$0	$0	$1,000,000		**$1,000,000**		
Residual value		$0	$0	$0		**$0**		
Accident savings per year								
				Fatal	Serious Inj	Other Inj	Property	
Potential crashes influenced (note 1)				135	718	1439	3732	
Effectiveness of countermeasure (%) (note 2)				6	6	6	6	
Estimated savings (number of crashes)				8.1	43.08	86.34	223.92	
Assumed cost per crash				$929,700	$163,300	$25,700	$11,700	
Estimated crash savings ($)				$7,530,570	$7,034,964	$2,218,938	$2,619,864	**$19,404,336**
Benefit-Cost Calculation								
Net annual savings		$18,404,336		PV(savings) =	$129,264,354.60			
Benefit/Cost ratio =		**12.93**						
Note 1	All speed related crashes							
Note 2	Proportion of speed-related crashes estimated to be influenced by speed alarm							
	times proportion of vehicles fitted with alarm: 30% x 20%= 6%							
Note 3	Net savings due to fuel savings							

Benefit-Cost Analysis of Speed Control Devices								
Countermeasure:		**7. All vehicles fitted with automatic speed limiters**						
		& transmitters provided on roadway.						
Independent Parameters								
Evaluation period		10	years					
Base year		1996						
Discount rate		7	%		PV Factor $1=	$7.02		
Costs								
% of car population		100	% of	3000000	=	3000000	vehicles targeted	
		Per Veh.	Tot. Veh.	Roadway		Total		
Initial cost		$800	$2,400,000,000	$10,000,000		**$2,410,000,000**		
Annual cost (note 3)		($20)	($60,000,000)	$1,000,000		**($59,000,000)**		
Residual value		$0	$0	$0		**$0**		
Accident savings per year								
				Fatal	Serious Inj	Other Inj	Property	
Potential crashes influenced (note 1)				135	718	1439	3732	
Effectiveness of countermeasure (%) (note 2)				50	50	50	50	
Estimated savings (number of crashes)				67.5	359	719.5	1866	
Assumed cost per crash				$929,700	$163,300	$25,700	$11,700	
Estimated crash savings ($)				$62,754,750	$58,624,700	$18,491,150	$21,832,200	**$161,702,800**
Benefit-Cost Calculation								
Net annual savings		$220,702,800		PV(savings) =	$1,550,124,112.11			
Benefit/Cost ratio =		**0.64**						
Note 1	All speed related crashes							
Note 2	Proportion of speed-related crashes estimated to be influenced by automatic speed limiter							
Note 3	Net savings due to fuel savings							

Benefit-Cost Analysis of Speed Control Devices								
Countermeasure:		**8. All new vehicles fitted with Vehicle Monitoring Device (VMD)**						
Independent Parameters								
Evaluation period		10	years					
Base year		1996						
Discount rate		7	% D29		PV Factor $1=	$7.02		
Costs								
% of car population		7	% of	3000000	=	210000	vehicles targeted	
		Per Veh.	Tot. Veh.	Roadway		Total		
Initial cost		$1,000	$210,000,000	$0		**$210,000,000**		
Annual cost (note 3)		$10	$2,100,000	$0		**$2,100,000**		
Residual value		$0	$0	$0		**$0**		
Accident savings per year								
				Fatal	Serious Inj	Other Inj	Property	
Potential crashes influenced (note 1)				135	718	1439	3732	
Effectiveness of countermeasure (%) (note 2)				3.5	3.5	3.5	3.5	
Estimated savings (number of crashes)				4.725	25.13	50.365	130.62	
Assumed cost per crash				$929,700	$163,300	$25,700	$11,700	
Estimated crash savings ($)				$4,392,833	$4,103,729	$1,294,381	$1,528,254	**$11,319,196**
Benefit-Cost Calculation								
Net annual savings		$9,219,196		PV(savings) =	$64,751,774.85			
Benefit/Cost ratio =		**0.31**						
Note 1	All speed related crashes							
Note 2	Proportion of speed-related crashes influenced by VMD							
	times proportion of these that are new vehicles: 50% x 7% = 3.5%							
Note 3	Saving due to reduced fuel consumption offsets admin costs							