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The policy of the publisher is to provide a medium for expression of views and for debate, within the traffic safety community, on a wide range of issues. The journal provides authors of papers with the opportunity to have their work submitted to the Editorial Board for peer review. Encouragement also is given to interested persons and organisations to submit articles, photographs or letters for publication. The publisher reserves the right to reject submissions or, with approval of the author, edit articles. No payment is offered for articles submitted.

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Cover photo: Do bull bars create an additional danger to pedestrians? That question is addressed in our third peer reviewed paper in this edition of the Journal.

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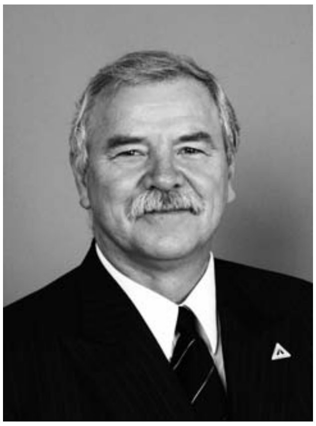
From the President



Dear ACRS Members,

I would like to wish all members a Happy New Year, Gung Hay Fat Choy or Xin Nian Kuai Le! May you all have a good year and above all a safe one.

I am pleased to report that ACRS started its new year by welcoming our new Executive Officer Linda Cooke. Linda has qualifications in Law and Management. In recent years she has held various senior appointments at the Australian National University, including Executive Officer to the ANU's Deputy Vice-Chancellor and consultant on human resource issues. We have all been eagerly awaiting Linda's arrival and already we are excited by her enthusiasm and help. I would ask all members to warmly greet her and make her welcome. I can see that Linda's contribution to the cause will be most valuable.

A recent hot topic that crossed my desk, and is the subject of a recent Chapter Seminar in Victoria, is the issue of speed enforcement and in particular speed cameras. I have heard numerous calls from individuals that their introduction is simply revenue raising for state government coffers. I find this response rather strange when one considers that driving a vehicle within the speed limit will not result in any infringements. My response to complaining drivers is: Do they seriously think that breaking the law is acceptable? Is that what they are condoning? I also point out that speed limits are set so that if a crash is imminent and one is travelling at the speed limit, the crash should be survivable. It's all a matter of physics and energy.

Having moved to NSW, I also find it amusing that the State Government is reluctant to introduce more speed cameras, and in particular mobile speed cameras. They are also concerned about directly linking the revenue from such speed cameras to road safety improvements thus exposing themselves to the "revenue raising" claims. I also noticed a significant increase in driving speed in Sydney when compared to Melbourne. I am continuously tailgated and tooted at when driving at the speed limit, though I am not sure if this is also because of my Victorian number plates!

It is well documented in literature that increased speeds result in increase crash risk. However, having said that, I am also aware of situations where drivers are sometimes not aware that they are exceeding the speed limit and would value aids to help them remain within limits. Intelligent Speed Adaptation (ISA) is just such a system that may well help with this problem. I am keen to see its introduction. I have a trigger in my vehicle set at 60 km/hr that rings every time I exceed it. It helps me maintain my speed at or below this limit when I am in a 60 km/h zone. It also helps me focus attention on whether I am driving too fast within any particular speed zone.

However I have often found myself in an zone where I don't know what the speed limit is. Via a GPS system and mapping software, ISA will inform the driver either through sound or visually, the speed limit where the vehicle is travelling. I firmly believe the sooner we can introduce this system as mandatory for all new vehicles, the sooner we will begin to see reductions in crashes. I am also a firm believer in technology that helps the drivers and indeed all road users, survive travelling or using our road system.

The new year also saw ACRS put a submission into the NSW Staysafe Parliamentary committee's inquiry into Young Driver Safety and Education Programs. The submission is listed on the ACRS website and members can familiarise themselves with its details.

Another issue that I would like to point out to members is the opportunity of acquiring Professional Register status. I would strongly encourage those members who have a desire to pursue a career in road safety to give serious consideration to having their qualifications and experience assessed for entry to the ACRS Register of Road Safety Professionals. Registration provides a genuine high level professional qualification, comparable with the high level qualifications of other professions. Those on the Register are able to use the abbreviation 'RRSP' after their name.

As authorities involved with road safety projects become increasingly aware of the Register of Road Safety Professionals, they are likely to prefer to employ RRSP-qualified people to work for them.

Finally, I am sure you will be pleased to know that it was decided the College should make an appeal to our new Prime Minister, the Honourable Kevin Rudd, to include Road Safety as a key topic in the upcoming 2020 summit. A copy of the letter is included in this Journal. I will keep members posted in regard to the outcome of that appeal. However, I dare say members will soon find out if we were successful in getting our voice heard.

I wish you all safe travels.

Raphael Grzebieta
President

Linda Cooke, ACRS Executive Officer

The following letter was posted to the Prime Minister on 14 February 2008

The Hon. Kevin Rudd MP
Prime Minister of Australia
Parliament House
CANBERRA ACT 2600

Dear Prime Minister,

I am writing to you on behalf of the Australian community and the victims of road crashes and their families and friends, and also as the President of the Australasian College of Road Safety and as the Acting Director and Chair of Road Safety at the NSW Injury Risk Management Research Centre at The University of New South Wales. I am appealing to your well known sense of caring and concern for the safety of us, your fellow Australians. I am respectfully asking that Road Safety be placed as one of the priority items on your Australia 2020 Summit.

My work has exposed me to the personalised trauma and destruction that is occurring on our roads on a daily basis. Road Trauma is a significant issue for all Australians. Road safety falls under the Minister for Infrastructure, Transport, Regional Development and Local Government.

However, the effects of road trauma are felt across a large number of portfolios such as education, health and ageing, trade, defence, to name a few. Hence, it requires a whole of government approach and hence leadership at Prime Ministerial level. My reasons for such a request are outlined below.

Since 1925, when vehicle crash statistics were first recorded, Australia has lost over 172,000 lives. This is almost twice the number of lives lost in all the wars Australians have been involved in (around 103,000) and four times the number of Australian lives lost in war since 1925 (around 40,000). For every life lost in a car crash there are 10-12 seriously injured with debilitating life-long effects (around 2 million injured so far). If we count all the Australian victims of natural and man-made disasters to date such as: Cyclone Tracy (77), all bushfires (Ash Wednesday, Black Friday, Canberra, etc, around 375), Thredbo (18), Bali bombings (206), Granville Train Crash (83), etc, the total number comes to around 850. This pales in number compared to road crashes. What is of concern is the road toll has been holding steady since December 2004 at around 7.7 per 100,000 population, i.e. reductions in road trauma have now stalled for three years. This means we are unlikely at this stage to reach the target of 5.6 road deaths per 100,000 in the National Road Safety Strategy by 2010 despite the good work by ATC, the Australia Transport Safety Bureau and Road Safety stakeholders.

If we consider the financial cost it is of the order of $17 billion per annum. This is equivalent to the respective budgets for defence and education and half the health budget. The number of injury related hospitalisations resulting from road crashes is around 11%. Traffic crashes are one of the leading causes of unintentional injury and death among young people. When a senior executive, a farmer, or a highly skilled worker in a mining company is seriously injured or killed in a car crash, the consequences for the business entity are often irrecoverable, leading to considerable disruption, grief and substantial financial loss or even collapse of the business entity. Hence any benefits gained by reducing road trauma have a significant and direct financial benefit across a number of sectors and age groups.

I would further add that the road design and construction industry is a major contributor to Australia's economy and employment. An efficient and safe road transport system underpins our nation's economy. Hence, government investment into roads to assist with increased transport efficiency is of the order of billions of dollars. However, it is important that the systems are properly designed and constructed to maximise road safety benefits in order to maintain transport efficiency. Whilst current road safety efforts have focussed on behavioural and vehicle safety systems, there appears to be a lack of awareness by the engineering profession of the vital role they must now play in regards to implementing the "Safe Systems" approach to reducing road trauma in any future road investment.

For example, Australia's roads have been and are predominantly designed on the basis of US standards - roads are wide and there is plenty of room to speed and provide for reckless driving behaviour. It is also an expensive method of road construction. In effect we have modelled our road system on the design standards from a country which now has the worst road safety record of all the OECD nations (43,000 deaths per annum and 16 deaths per 100,000 population). In contrast, Europe is now making enormous road safety gains utilising a different road safety systems mindset that considers road design and construction in combination with safer vehicles. The roads are more economical, costing much less to build than the US counterpart, while still maintaining excellent transport efficiency. They are based on the notion that crashes are inevitable. Hence roads should be designed to firstly minimise crashes, and then make them survivable when they do happen. The result is a leaner, more efficient and yet vastly safer road system (5 deaths per 100,000 population).

My road safety colleagues acknowledge that there have been a lot of good things that have been done in Road Safety in Australia, and that Australia has led the way in many instances. Indeed Road Safety comprises a large number of road authorities and consulting firm's external earnings from various international contracts as a result of our successes, contributing significantly to our economy. But we know the continued loss of life is unnecessary and is very much preventable if only we have the leadership to introduce more change and vision of the "Safer Systems" approach. The current perception is that there are "no more silver bullets" in road safety to reduce road trauma. That it is all too hard. This view is quite wrong. There are still significant opportunities as a number of strategies can still be implemented. Hence, my appeal to you is to add Road Safety as a priority issue in your 2020 Summit. Such action would help focus Australia's leaders and the Australian community on how we can prevent an average of FIVE Australians being killed and a further SIXTY maimed for life each and every day.

Prime Minister, as new leader of our great nation, what better gift could you give, I suggest, to Australians and their families than to add Road Safety to the 2020 Summit agenda to help rid Australia of road trauma.

I and my colleagues look forward to hearing from you.

Yours Most Respectfully

Prof. Raphael Grzebieta
President of the Australasian College of Road Safety

Diary

27 – 30 May 2008 – Australian Trucking Convention, incorporating the 2008 ATA Safety Summit, National Convention Centre, Canberra.
- For further information see www.atatruck.net.au

31 July – 1 August 2008 – 23rd ARRB Conference: ARRB08 Collaborate – Research – Partnering with Practitioners.
- For further information see: www.arrb.com.au/conferences

18 - 19 September 2008 – Joint ACRS-Travelsafe Committee of Queensland Parliament Conference on 'Motivating Behaviour Change Among High Risk Road Users'
– For more information contact eo@acrs.org.au

August 2008 – AITPM National Conference, Perth.
- For further information see; http://www.aitpm.org.au

5-8 October 2008 ASPACI Conference , Melbourne – Dynamic Testing of Vehicles Fitted with Electronic Stability Control for Crash Investigation.

10-12 November 2008, Australasian Road Safety Research, Policing and Education Conference, Adelaide.
- For further information contact:
http://www.roadsafetyconference2008.com.au

Letter to the Editor

Dear Sir,

I write as a Local Councillor in suburban Adelaide. We are currently discussing an issue which involves traffic safety for children (in this case primary) outside of their school. The school is asking for traffic lights as they see this as their best option.

This is predominately a residential area which is in a Heritage Conservation Zone. Lights and more resultant luminous signage does not fit with the management plan for this Heritage Zone. Residential car parking in front of homes near any proposed lights will be permanently restricted.

I have been reading up on the concept of "shared space" and "naked roads" championed by the Dutch traffic engineer the late Hans Modermann, and which has gathered momentum in Europe. Instead of adding lines, lights and signage, to problem areas he has also removed any that may be already present. The idea is one of traffic integration, not segregation, of accountability of all who make up the traffic. Apparently speed of vehicles is reduced by up to 30% as drivers have to watch and have eye contact with those who are also using the roads.

I wonder if this "shared space" concept is being utilised anywhere yet in Australia and would welcome further commentary on this topic.

Judith Weaver

[Editor: If any reader is able to help Judith Weaver with suggestions or information on this topic, please send them to the ACRS office.]

Quarterly News

Chapter News

Australian Capital Territory and Region

After a relatively quiet 2007, the Chapter has plans for a number of activities this year. The first is a seminar in March or April this year on on-road cycling, which is an increasingly controversial issue in Canberra. Other possible seminar topics are road safety media strategies and speed enforcement.

New South Wales (Sydney)

2007 Seminars

Older Drivers: The NSW Chapter held a seminar at Parliament House, Sydney, on the theme of older drivers on 3 October 2007. The timing of the seminar was selected to provide an opportunity to promote informed discussion in relation to the Roads and Traffic Authority discussion paper on older driver licensing and testing. Approximately 40 people attended the seminar, which was chaired by Professor Mark Stevenson. The program included four presentations.

Robin Anderson, Road Safety Consultant, spoke on his findings from his Churchill Fellowship international study of issues and strategies for older drivers. Jeff McDougall, Australian Driver Trainers Association, discussed some of the issues around the testing of older drivers from the driver trainers' perspective. Shona Blanchette described what has been learnt from a seniors' driving safety assessment and coaching program operating in Sydney. Neryla Jolly, School of Applied Vision Sciences, University of Sydney, described her research into vision change with ageing, and driver performance.

Motorcycle Safety: A seminar on improving our understanding of motorcycle safety issues through motorcycle crash investigation and data analysis was held on Thursday 1 November 2007 at the George Institute for International Health, Sydney. The seminar was timed to coincide with Motorcycle Awareness Week. The seminar was chaired by Mr Guy Stanford, Chairman, Motorcycle Council of NSW and attended by thirty five people. The program included three presentations: Liz de Rome, LdeR Consulting, provided an introduction by describing the most common types of motorcycle crashes in terms of road design, condition, road user movements and human factors. Fred Schnerring of Jamison Foley spoke from his experience as a crash investigator about the differences in evidence between motorcycle and other vehicle crashes. Jim Ouellet, Motorcycle Accident Analysis, USA, addressed some of the misconceptions about the causes of motorcycle crashes and reviewed the most frequent types and common causes. This seminar was reported in the national motorcycle magazine Two Wheels, in a nine page article for riders on how to avoid crashing, which was based on the information presented.

2008 Seminars

The Chapter thanks the Motor Accidents Authority for its commitment to fund the Chapter seminar program for 2008. The program will include seminars on the Role of Trauma Systems in Supporting Road Safety, and on Public Health Advertising and how it might be applied to road safety. The remainder of the program is yet to be determined.

Funding support from the Roads and Traffic Authority

The Chapter is pleased to report that the Roads and Traffic Authority has agreed to provide funding support of $5,000 per annum for College activities in New South Wales for the triennium 2008-2010. The grant follows the meeting between the then NSW Chair, Professor Mark Stevenson, Ms de Rome and Mr McDougall, with the Hon. Eric Roozendaal MLC, Minister for Roads, Dr Soames Job, General Manager, Road Safety Strategy, Roads and Traffic Authority, and Mr Darren Holder, of the Minister's office, in July 2006, and subsequent correspondence from the Canberra Office.

Queensland

A seminar on Older Drivers, with Robin Anderson as the keynote speaker, is planned for 28 March 2008. The Chapter members are actively involved in working with the ACRS Head Office and the Travelsafe Committee of the Queensland Parliament in planning a joint international conference in August 2008 on 'Motivating Behaviour Change Among High Risk Road Users'.

South Australia

The 22 November 2007 seminar on Older Drivers with Robin Anderson as keynote speaker attracted 40-50 attendees. The next seminar is on the topic of 'Drugs'. The Chapter is grateful for ongoing sponsorship from the Motor Accident Commission. Paul Simons, the Chapter representative on the ACRS Executive, will also be representing the Chapter on the organising committee for the Road Safety 2008 Research, Policing and Education Conference to be held in Adelaide, and requests that any suggestions on possible keynote speakers be emailed to him.

Victoria

The Chapter is planning to hold a seminar on the 21 February at VicRoads on the issue of "Why the focus on speed?". Presenters will include Dr Bruce Corben from MUARC who will explore the speed/crash relationship and Dr Jeff Archer, also from MUARC, who will examine the relationship between speed limits, speed and travel times. A third presenter is yet to be nominated.

Western Australia

The Chapter Committee expects to meet this month to plan the program for the year.

Australian News

ACRS Member Awarded for Research in Road Safety

The College congratulates Dr Rebecca Ivers RRSP, who has received a National Health and Medical Research Council (NHMRC) award for Excellence in Health and Medical Research in relation to her work in road safety. Over the past five years, Dr Ivers, working at the George Institute for International Health, has built a research program that aims to shape health and transport-related policy, particularly in the field of road traffic injury prevention. Her research, which spans Australia and developing countries in the Asia Pacific region, ranges from hypothesis-generating observational research to intervention research which has direct relevance to policy. Current Australian projects include a cohort study of 20,000 novice drivers, a large case-control study of heavy-vehicle drivers and studies examining the effectiveness and use of motorcycle protective clothing. Dr Ivers is also developing new research work in the area of Indigenous road injury.

Licensing of Older Drivers

NRMA Motoring & Services' President Alan Evans has clarified that media reports did not reflect the NRMA's true position on this issue of S-plates for senior drivers. The NRMA does not support the introduction of S-plates for senior drivers. He has stated that it is not NRMA policy, nor will it be. He has confirmed that S-plates were not included in the NRMA's submission to Government. "S-plates were an idea raised by some NRMA Members during our community consultation on the licensing of older drivers, but it is not a notion accepted by us," Mr Evans said.

Australian Automobile Association Requests Government Action

The Australian Automobile Association (AAA) has called on governments to make Australian roads safer and lower national fatalities of 1,611 deaths (2007). This is an increase from the previous year (1,598 fatalities). In addition, thousands more were admitted to hospital with serious injuries, at an estimated cost to the Australian economy of $17 billion per year.

The organisation has identified better and safer road design – particularly eliminating roadside hazards such as poles and trees and installing wire rope barriers. It was noted that roadside hazards accounted for around 40% of those deaths. The AAA spokesman said that, while the Federal Government had committed billions to road infrastructure in the lead up to the 2007 Federal election, there was now a real need to ensure it was invested in better designed roads that protected Australian motorists and their families.

The increase should be sobering for those behind reports focussing on the Christmas road toll. The Australian newspaper reported the Christmas-New Year toll as 44, the second lowest in a decade. This compared with 62 last year and 78 the previous year, it said. Victoria recorded the highest number of fatalities (16), followed by WA (11), NSW (7), Qld (4), SA and ACT (2 each) and NT and ACT (one each).

Road Improvements

Nerang South upgrade

An upgrade of the Nerang South (Nielsens Road) interchange on the Gold Coast, costing $45 million, is the first major step in the upgrade of the Pacific Motorway between Nerang and Tugun. The work will include the replacement of two roundabouts with synchronised traffic lights and the widening of the current bridge over the motorway. This construction will be a major step in the eventual upgrade of 23km of the M1 from Nerang and Tugun.

Townsville Port

A Port Access Road in Townsville will be built as a two-lane highway initially, including a rail overpass as part of the Stuart Bypass and bridges over Sandfly Creek and Ross River.

Traralgon Bypass route

The Victorian Government has determined the route for the future Princes Highway East–Traralgon Bypass. The section of the Traralgon Bypass, west of Traralgon Creek Road, is close to the existing highway between Morwell and Traralgon. The route was recommended by the Traralgon Bypass Supplementary Inquiry Advisory Committee, which conducted public hearings into the four options proposed for this project. The Advisory Committee's report is available at the Department of Planning and Community Development website www.dpcd.vic.gov.au

Bakewell Underpass, Adelaide

The $41million Bakewell Underpass in Adelaide, on one of the major thoroughfares for tourists arriving at the Adelaide Airport, has been opened. It features: two traffic lanes in each direction; on-road bicycle lanes (1.8 metres) on each side of the road; a wide shared use path (3.15 metres wide) on the southern side at a higher level than the road; two bridges carrying road traffic along James Congdon Drive and trains on metropolitan and freight lines. Both bridges also cater for pedestrian and cyclist traffic; and Adelaide's first dedicated 24/7 bus and taxi lane providing direct access to West Terrace via Glover Avenue.

Port Wakefield Road, Adelaide

This is the largest road project in Adelaide in almost 50 years. The first $30 million upgrade of a 12 km section of Port Wakefield Road on the Northern Expressway. This is the first section of a $564 million project involving an extension of the Sturt Highway and greater traffic capacity for Port Wakefield Road to provide freeway conditions from beyond Gawler to the start of the Port River Expressway.

New Zealand News

Work-Related Road Safety Workshops

The New Zealand Government plans to run a series of workshops on work-related road safety in Wellington, Auckland and Christchurch during March 2008. More details are available from Anita Dransfield, Event Coordinator, Tel: 0-9-528 6092, Fax: 0-9-521 1784, **E-mail: pacificpr@ihug.co.nz.**

European News

ETSC Claims Speed is the Main Enemy of Road Safety

Excessive and inappropriate speed is the number one road safety problem in European countries and deserves a special focus according to the European Transport Safety Council's new 'speed Monitor' publication. Excessive speed is defined as driving above the speed

limits, while inappropriate speed is defined as driving too fast for the prevailing conditions, but within the limits. These two types of speeding cause about one third of fatal accidents and speeding is an aggravating factor in all accidents, say the ETSC, and they conclude that "Managing speed is therefore the most important measure to reduce death and injury on our roads"

Measures are being taken in a number of European Union countries to address the speeding problem. In Austria, Italy and Luxenbourg tougher penalties are being introduced for speeding. In Belgium and Ireland plans are in hand for a large increase in fixed speed cameras. Finland is running a pilot program this year to test the effectiveness of time over distance cameras (section control). This technology has already proved effective in the Netherlands, Austria, and Italy. France continues to increase the number of its speed radars. There are now 1950 radars in total, 2/3 of which are fixed radars.

In Germany the debate continues over the no-speed-limit autobahns, but pressure is increasing to introduce a 130 kph limit on them. In 2006 338 deaths were attributed to speed on these no-limit motorways. In contrast, the UK's Parliamentary Advisory Council for Transport Safety (PACTS) is focusing attention on vehicle speeds on town/city roads where there are many pedestrians in close proximity to vehicles. PACTS is calling for the implementation of 20mph (32 km/h) zones in such situations. PACTS notes that a 20mph zone survey across the UK and in other European countries found child road accidents fell by 67% and cyclist accidents by 29% with the introduction of this lower speed limit. PACTS also recommends that all fleet vehicles be fitted with intelligent speed adaptation (ISA) systems to improve road safety. ISA systems automatically reduce a vehicle's speed in poor weather or at night. Fleet drivers are being targeted because between a quarter and a third of all road traffic incidents involve at-work drivers in the UK.

Asian News

India

The new 'people's car', the Tata Nano, is soon to be launched onto India's roads. Its low price will open up private motoring for many more people, but its introduction raises two serious problems – increased pollution and safety problems, due to its very basic engineering. For more information on the Nano's safety issues, visit www.arrivesafe.org/news.php.

North American News

H.R. 6: Energy Bill Includes Complete Streets

The Energy Bill (H.R. 6) signed into law by President Bush on December 19, 2007 included a 'sense of Congress' supporting complete streets (see section 1133). This represents a significant statement of support and promotion of the inclusion of complete streets when roadways are constructed or rehabilitated. [Ed: The philosophy of 'complete streets' is summed up in this statement from the Complete the Streets website: The streets of our cities and towns ought to be for everyone, whether young or old, motorist or bicyclist, walker or wheelchair user, bus rider or shopkeeper. But too many of our streets are designed only for speeding cars, or worse, creeping traffic jams. They're unsafe for people on foot or bike — and unpleasant for everybody. Now, in communities across the country, a movement is growing to complete the streets. States, cities and towns are asking their planners, engineers and designers to build road networks that welcome all citizens. (Source: Complete Streets News, Feb 08 and www.completestreets.org)

Contributed Articles

On the Road to Safety - Milestones to Progress

By Mark V Rosenker, Chairman of the US National Transportation Safety Board

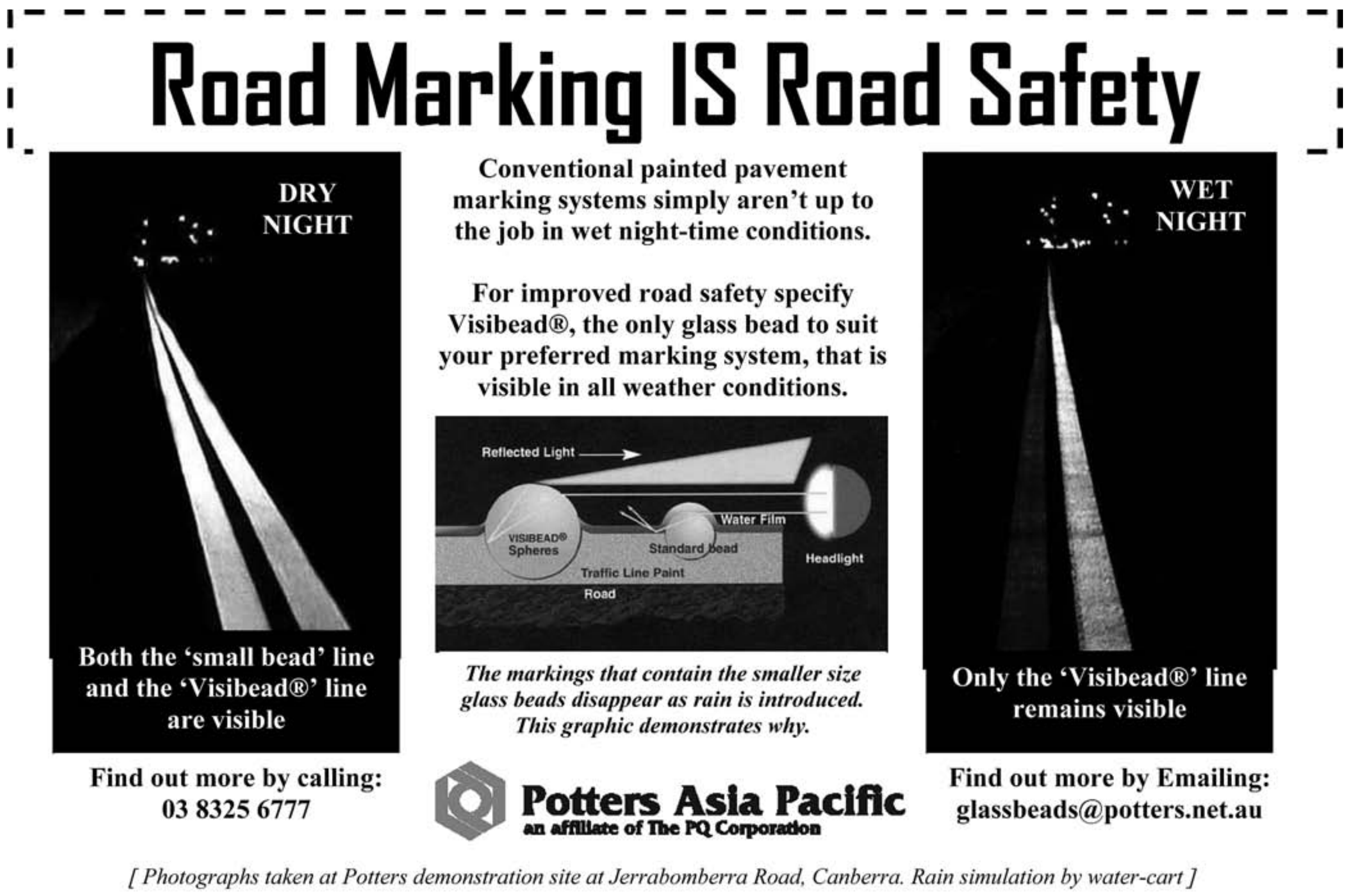
(This paper was presented by Mr Rosenker at the ACRS Seminar on Intelligent Transport Systems held in Canberra on 30th October 2007)

Well over 200 million vehicles are registered in the USA and their operation results in 3 million injuries and 43,000 fatalities annually. Those numbers are dramatic, but in the 1990s, highway fatalities dropped approximately 10% and the fatality rate, even with a substantial increase in vehicle miles travelled, dropped even more.

These improvements were attributed to reduced speed limits, increased use of seat belts, airbags, crash-absorbing vehicle frames, and campaigns to reduce drunk driving.

Unfortunately, those decreases in fatalities and injury rates have levelled off since the 1990s. So, while we have accomplished much in the past decade to improve the crashworthiness of automobiles, we have reached some practical limits in combating the physical forces involved in crashes. It is time to move beyond crash mitigation and enter a new era where technology will help us prevent accidents. I recognize that this will be a tough battle to win. Less than 1 % of accidents are fatal, so to save lives, we have to prevent a lot of crashes.

Let's look at our current state of technology in that regard. I see three distinct milestones along the road to highway safety: technology for crash avoidance, telematics to better inform the driver about the vehicle and the highway, and command and control systems.



Crash Avoidance

The first milestone, crash avoidance technology, is in the foreseeable future. In fact, manufacturers already offer this technology in many current car models. These systems affect stability control, rollovers, lane departures, and rear-end collisions. In recognition of these advancements in vehicle performance, the National Highway Traffic Safety Administration (NHTSA), our vehicle regulator, is currently revising its New Car Assessment Program (NCAP). The NCAP 5-star rating, which tests new cars and ranks their crashworthiness, was designed to help new car buyers factor crashworthiness into their buying decisions. However, for the '06 Model Year, 95% of new cars received a four- or five-star rating. With every car getting nearly the same score, the ratings don't provide new car buyers with a clear measure for determining which car is the safest. NHTSA is seeking to refine the ratings system to provide consumers with more meaningful information.

The good news is that the similarity of these scores DOES reflect marked improvements in the crashworthiness of new cars. In the future, the NCAP program is seeking to evaluate improvements in crash avoidance, rollover resistance, and other safety features. For example, electronic stability control, required on vehicles sold in the USA by 2012, should significantly reduce run-off-the-road crashes and resulting rollovers. Once a vehicle leaves the road, it is "tripped" into rollover by soft soil, ditches, and other conditions: 7 out of 8 single-vehicle rollovers occur after the vehicle leaves the road. Although the proportion of crashes that result in rollover are low, they are significant, causing serious injuries and fatalities for most of the vehicle occupants. So, solving this problem means keeping vehicles on the road and reducing speed prior to crash impact to reduce the possibility of rollovers. We have good evidence that electronic stability control can help prevent road departures.

Depending on the manufacturer, crash avoidance systems may combine a variety of technologies and go by a variety of names. BMW has dynamic stability control, dynamic traction control, dynamic brake control, and variable active steering. Jaguar offers roll stability control that includes computer active technology suspension. GM has StabiliTrak. In addition to mitigating the number of fatalities and injuries, such technologies can provide a huge economic benefit. Every day, 19,000 crashes occur on American highways. These crashes incur an enormous cost: $230 billion a year - that's nearly $800 for each and every US citizen. We can no longer be satisfied with trying to protect people who get into crashes. We must instead use the technology at our command to prevent crashes from happening.

Telematics

The second milestone on our road to safety is telematics and it is actually a whole series of markers from today into the future. Telematics are wireless, location-based services for vehicles and drivers that trace their history back to the days when your neighborhood mechanic linked into your engine diagnostics to give you a report on the health of your car's various systems. Today, sophisticated technology provides not only on¬board navigation and entertainment services but also the means to a higher level of safety. We're all familiar with vehicle-based systems like General Motor's On Star, but research is well on its way to making road-based systems, vehicle-to-vehicle systems, and vehicle-to-infrastructure systems a viable means of promoting even greater roadway safety.

For example, vehicle-centered services, such as remote diagnostics, remote vehicle access, and automatic collision notification, are currently available on many cars. Survivability increases with quicker emergency response, which is directly related to this technology. For example, Broward County, Florida, has a severe incident response program that automatically notifies first responders and saved 360 hours of on-scene emergency response time last year.

In addition to coordinating first responders and traffic management equipment, such automatic crash notification systems can reduce the likelihood of pedestrian fatalities after an accident by keeping motorists from leaving their vehicles. It can also decrease the likelihood of secondary crashes by expediting the removal of disabled vehicles.

In addition to vehicle-based systems, road-based systems are being incorporated into our highway infrastructure. Vehicle Infrastructure Integration, a DOT initiative, will provide drivers with a sophisticated means for obtaining information about their vehicles and the road. What more do drivers need to know? How about location-specific weather conditions, route-specific road closures, and work zone status, to name a few? Location-specific weather and roadway information can be acquired directly from sensors that run beside or are embedded in the roadway.

Such sensors provide real-time information about fog, standing water, or freezing rain. Adverse weather is associated with 800,000 injuries and more than 7,000 fatalities in the USA annually (approximately 1 in 5 fatalities): These systems may well be one way to reduce those numbers and improve highway safety significantly. Telematics is often associated with cameras used to identify drivers who run red lights. But telematics can do more. For example, systems like Traficon, which operate within the highway infrastructure, are available to detect accidents, stopped vehicles, wrong-way drivers, lost cargo, and smoke and fire, and can be used to monitor pedestrians. The CAR 2 CAR communication consortium in Europe is currently developing information standards with plans to do a demonstration next year and frequency allocation by 2010.

We'll eventually see basic connectivity for the life of the vehicle without the need for ongoing subscription payments, working through a shared message handling utility on behalf of all manufacturers. Highway information that you and your car can access directly will eventually be as affordable and common as FM radio.

The USA broadcast spectrum for this technology has been identified (5.9 GHz), and geostationary satellites and ground-based towers are planned for 2012 with limited rollout by 2009. NHTSA currently is collecting public comments on a proposal to establish guidelines for information sharing specifications and data exchange formats to make traffic and travel information available to public agencies and private enterprises.

Further down the road, I predict that we will see a migration of communication and entertainment to fully portable devices like cell (mobile) phones and PDAs that are based on the individual rather than the vehicle. Meanwhile, vehicle-and road-based data services will continue to mature. Already, commercial fleet operators use data communications to track truck locations, plan routes, and schedule maintenance.

As of last year, NHTSA has published a final rule that standardises the collection and retrieval of light vehicle event data recorder (EDR) information. In the future, I think such transmissions will include vehicle software upgrades, malfunction and diagnostic reports, and the capability to order parts, and receive recall and service notifications.

Vehicle-to-vehicle and vehicle-to-infrastructure demonstrations are being conducted by Intelligent Transportation Systems (ITS) America. There were 135 exhibitors registered for the ITS Annual Meeting and Exposition in Palm Springs, FL earlier this year. The price of these technologies is pushing telematics into the market place.

The cost of digital cameras has dropped below $10. Applications that emit and receive infrared pulses to detect range, sense rain, dim headlights, warn of impending lane departures, or monitor blind spots are at a price point for fleet-wide applications. And satellite-connected operating systems like On-Star offer ever-more-powerful services through audio and video streaming of traffic, weather, and parking information. These technologies hold great promise for providing drivers with a powerful set of tools for closely monitoring their vehicles, the weather, the roadway, and, in time, other vehicles as well.

Command and Control

The third milestone along the highway to safety is automated vehicle control. Electronic devices and automated systems used in commercial aviation offer clear examples of how technology can improve our ability to operate in complex environments. With the introduction of electronic safety devices, we can trace the decline in commercial aviation accidents rates. Beginning in the 1950s, radio navigation aids (VOR/DME), radar, and ATC control technology dropped the number of accidents per year from 4 to 1.

Further refinements came with long-range radar, precision approaches, and secondary radar. Beginning in the late 70s, early automation offered Area Navigation (RNAV) and Traffic Collision Warning Systems (TCAS). The aviation industry has since implemented computerised flight management systems, wind shear alert systems, Ground Proximity Warning Systems (GPWS), and fly-by-wire electronic control of aircraft. We are now seeing real-time weather and traffic displays in the cockpit, precision landing systems for zero visibility conditions, hybrid vision, and remotely operated Unmanned Aerial Vehicles (UAVs).

Technological advances have made commercial aviation the safest mode of transportation and I believe new technologies may enable us to repeat those successes in highway travel. In addition to seat belts and airbags, which have greatly increased survivability, automated command and control systems will help prevent crashes, not just mitigate their effects. To that end, Integrated Vehicle-Based Safety Systems is a new US Department of Transport (DOT) vehicle safety initiative to build and field-test integrated crash warning systems to prevent rear-end, lane change, and roadway departure collisions on light vehicles and heavy commercial trucks. These systems are being deployed in cars as well.

Let me offer a practical example of how this technology can be used. Every parent's nightmare is to back over a young child in the driveway. Nearly 200 fatalities and approximately 7,000 such injuries were reported in the USA last year, though that is surely only a fraction because many of these events are not reported as highway fatalities because they occur on private property. Back-over avoidance systems are being marketed as "parking aids" using ultrasonic or radar technology to warn drivers as they approach an object. Initial evaluations indicate that camera-based systems offer the greatest potential, but driver use of these systems is still under evaluation.

The Motor & Equipment Manufacturers Association recently had an Advanced Safety Technology Ride and Drive Event in Washington DC. A dozen companies brought vehicles to showcase their technologies for both heavy duty trucks and passenger cars. Camera technologies for Blind Spot Warning Systems (by Delphi), Mirror-Integrated Rear Camera Display (by Gentex), Park 4U (by Valeo), and Total Blind Zone Management (by Magna) were impressive.

One out of every four crashes occurs at highway intersections. We have the capability to manage the traffic at those intersections by measuring an approaching vehicle's estimated time of arrival, speed, and range in order to extend the green light to prevent collisions. Another crash-avoidance technology is the adaptive cruise control system, such as the system available in the Mercedes S class. This system uses two radar frequencies to keep the car at a safe following distance and can even bring the car to a complete stop.

If the car detects conditions for a frontal collision, it not only sounds an alarm but also applies the brakes to stop the car. The system also has "night view assist," an infrared camera system offering a video dash display of the upcoming road that extends more than 100 feet beyond the low-beam headlights. Several other manufacturers, Honda, for example, now equip certain models with crash mitigation braking systems that tighten seat belts and apply brakes before a collision occurs. With the development of adaptive cruise control with lane monitoring and active steering (or evasive steering) underway, we are approaching the technical feasibility of autopilot systems.

I am confident that highway automation will greatly improve safety, but I am not naive about what it will take to see these benefits. We have work to do to ensure that the safety promises of these systems become reality. System integration, for example, is an important issue. Different manufacturers make anti-lock brakes, stability control systems, collision avoidance - and these systems and all their sensors must work in concert to avoid a variety of road hazards. Developers of these technologies must consider how the systems will be used, where displays will be located, how much information is needed, what information has priority, when the systems should be active, and how the systems should function in an emergency. Privacy is another issue that must be addressed for the public to embrace these technologies with enthusiasm.

In the end, it is the public, and their ability and willingness to make use of these systems, that will determine how effective they will be, and how soon. I made some earlier aviation comparisons, but the distinctions between drivers and pilots must be factored into the development of these technologies. Unlike pilots, drivers receive minimal qualification training, no recurrent training, no medical evaluation, and their education and language skills vary widely. Drivers may be totally inexperienced in their vehicle type, may have conducted no trip planning, and may view driving as secondary to other personal activities in the car.

Further, many drivers don't take the time to understand their cars and how their own driving habits may affect their safety. Let's face it: most drivers by and large don't even read their owners manuals. But manufacturers are taking steps to fill this need. Last November, Audi launched a series of video podcasts to explain features of its new car. It was available through the Audi web site and on iTunes, with downloads of 2000/day. They characterised it as a "bridge" between the owner's manual and the driving experience. Toyota Lexus 460's innovative self-parking system comes with an instructional DVD. Many manufacturers also use email contact to distribute information to owners. As safety systems evolve, manufacturers will be faced with ever¬more-difficult challenges in training drivers to take full advantage of the technology available.

The bottom line is that, no matter how well crash avoidance and other systems work, they will be more effective once drivers understand how the car and their driving performance can prevent crashes. Yes, we must test and evaluate all of these technologies to determine how these systems can affect the likelihood and seriousness of accidents. And to that end, I encourage our research community to work with industry and government to move quickly to deploy these available technologies. I fully expect that the Safety Board will be an active participant in understanding the implications of advanced highway technology. But in the end, we recognise that the driver must take responsibility. OUR job is to give drivers the tools they need to make the most of that responsibility.

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ANCAP's Growing Role in Road Safety Promotion

By Lauchlan McIntosh AM, ACRS Fellow and Chair of ANCAP Ltd.

This article was originally prepared for the SAE Magazine.

In 2007 the Australasian New Car Assessment Program (ANCAP) established itself as ANCAP Australasia Ltd after operating as a joint venture of motoring organisations and government agencies since 1993. ANCAP tests the relative crashworthiness of new cars, to provide comparative information for new car buyers.

The ANCAP Tests

ANCAP uses 4 internationally recognized crash tests; offset frontal, side impact, pedestrian and pole impact test in testing new car models. Crash tests are undertaken by independent specialist crash test laboratories. In all tests crash test dummies are used to facilitate the scientific measurement of the various forces in the crash test. The data gathered is then assessed, using internationally recognized protocols, and scores are determined for various parts of the crash test. Additionally, ANCAP awards bonus points for other safety features. The overall score is then translated into a star rating, between 1 to 5 stars.

ANCAP's Public Face

In 2007 with a new Board we set up a small management secretariat, a new Web site, hosted a media day, added a new member, programmed additional advertising, supported stakeholder advertising, engaged with the Federal Government and Opposition, briefed the New Zealand Minister, some State Ministers and senior officials, introduced a voluntary " Stars on Cars" program for manufacturers to advertise their crash test results in the showroom; and set a new five star standard for 2008, with Electronic Stability Control as a mandatory requirement. We were sponsors at two major road safety conferences and saw an increase in the number of manufacturers, car testers and reporters actively publishing ANCAP results. Our Web site was used widely and the latest Australia's Best Cars Awards factored ACNAP ratings into their assessment. Fleet managers have taken a greater interest in new car safety features and crash test results and some manufacturers are actively advertising the safety ratings to promote their cars to these fleet managers.

From Safety Tester to Safety Promoter

In 2007 ANCAP has moved from being a test and report operation into a more positive promoter of the successes of improved safety features in new cars. To do this we have maintained our rigor and independence, but have been able to build on the increasing recognition of the value of safer cars in the broader system approach to improving road safety outcomes, ie safer drivers in safer cars on safer roads. This system approach to safety is commonplace in a modern workplace, but in our community we have yet to embrace it in considering how to improve our road safety performance. Perhaps road deaths from crashes, euphemistically labelled the "road toll" are a really a politically similar inconvenient truth to the concerns over climate change. The community seems to too easily accept that safety on the roads is the other drivers problem.

The National Road Safety Strategy 2001-2010, agreed by all the Federal, State and Territory governments, set a target to reduce road deaths by 40% by 2010. However there were a total of 130 road deaths in October 2007, a 7.4% increase over the October 2006 figure. On an annual basis, we have achieved only about a 10% reduction in 7 years so will need to achieve a 30% reduction in 3 years to meet the target. Too many people are killed, injured or permanently disabled unnecessarily in road crashes. At present the annual economic cost is around $18bn.

The Monash University Accident Research Centre has estimated that if everyone bought the safest car in each class (small, medium, or large) road trauma involving light passenger vehicles could be reduced by 26 per cent. This is potentially one life saved every day in Australia. If each vehicle incorporated the safest design elements for vehicles in its class, then such trauma could be reduced by 40 per cent. This is potentially two lives a day and while injury reductions are difficult to estimate, the savings may be as high as over 20 serious injuries every day. Image the reduction the workload for our trauma centres across the country, not to mention the reduction in personal suffering.

ANCAP's Future Role

So ANCAP has an important future in 2008. We have a vital role to assist the community to understand how vital it is to buy safe equipment, how important it is to be prepared to pay for the best features, to encourage the manufacturers to make these best features in every model they sell, and to do so in a non regulatory environment if at all possible.

In 2008 we will be expanding our demonstration events particularly to fleet managers, we will expand the advertising of the "stars on cars" program and we will continue to expand our relationships with manufacturers, car dealers, consumers and governments.

New technologies in car safety are accelerating into the market. A challenge for ANCAP will be to keep up with the relative value of these technologies, to assist in the promotion to consumers of these new valuable life saving technologies. We are only a small part of what is needed to ensure Australia meets its national road safety targets. As Chair of ANCAP my role will be that of a facilitator to encourage our stakeholders and our audiences to move forward such that the benefits of safety features in the new car fleet are in the highest possible demand.

AusRAP rates highways in New South Wales and Queensland for safety

By Greg Smith, Research Manager, Australian Automobile Association

This article was contributed by the SaferRoads Program

SaferRoads
www.aaa.asn.au/saferroads

Traffic and crash data used in this report was supplied to AAA by Queensland Main Roads

Introduction

During December 2007, Australian Automobile Association clubs, RACQ and NRMA Motoring and Services, published Australian Road Assessment Program (AusRAP) reports which explore the role of roads in road safety. They used differing, though complementary, methods of identifying risky sections of highways. The results of these reports are summarised in this article.

Prior to examining the results of the reports, it is instructive to consider how Queensland and NSW are performing overall in road safety. Perhaps the broadest measure of performance is the number of deaths per population against the National Road Safety Strategy target.

The Strategy was released by Commonwealth, State and Territory Governments in November 2000 and came into effect in January 2001. The target of the Strategy is to reduce Australia's road fatality rate per 100,000 population from 9.3 to no more than 5.6 in 2010 — a 40 % reduction (see Figure 1).

Seven years after the Strategy was introduced, Australia is well behind target. Between January 2005 and December 2007, the national road fatality rate did not fall below 7.6 deaths per 100,000 population, and in fact the fatality rate in Queensland increased from 7.8 to 8.6 in that period.

New South Wales however, is fairing much better than Queensland and is ahead of the national average, with a fatality rate of 6.4 in December 2007. We are not entirely sure of the reason for the relatively good performance compared with Queensland, but it is no doubt the result of a combination of factors.

Nonetheless, the fact remains that the prospect of reducing Australia's overall road fatality rate by 40% by 2010 is now very slim. Greater efforts are needed to address the significant social and economic costs of road trauma.

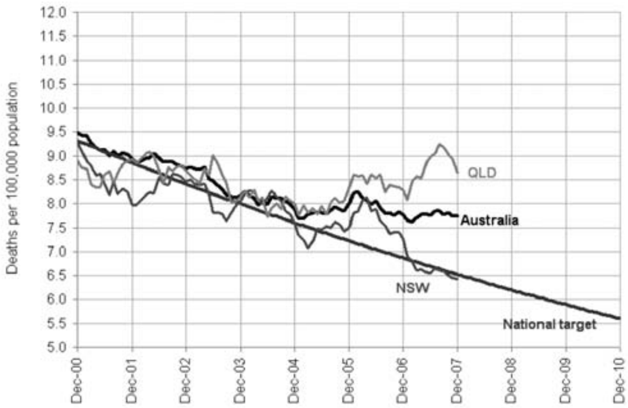

Figure 1 Australian, Queensland and New South Wales road fatality rates versus the National Road Safety Strategy target

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How safe are Queensland's highways?

The Queensland report presents risk maps for 7,561km of the State's rural road network, comprising 4,784km of AusLink national network and 2,777km of selected sections of State highways. The risk maps are based on casualty crashes (where at least one person was killed or injured) on rural highways generally zoned at speed limits 90km/h or higher1.

The length of roads analysed for the risk maps represented 4% of the total road network in Queensland, yet carried some 40% of the state's traffic and experienced 442 road deaths (28% of all Queensland road deaths) for the period 2001-05.

During that period 5,083 casualty crashes and 315 deaths occurred on the AusLink national network while 2,321 casualty crashes and 127 deaths occurred on the selected State highways.

Results are reported using two types of risk maps: collective risk (average annual casualty crashes per kilometre of road) and individual risk (average annual casualty crashes per 100 vehicle kilometres travelled).

The maps are colour-coded to denote relative levels of risk across the range of low, low-medium, medium, medium-high and high. Figure 2 below shows the collective risk map for Queensland. (See Figure 2 below)

Road links are classified as 'best' or 'worst' according to how each road link scored when looking at both risk map types in combination. There were no best links in the low or low-medium bands but 41 could be classified as worst links by falling into the high or medium-high risk category for both collective and individual risk.

Overall, these worst links represented 1% of Queensland's total road network but carried 20% of the state's traffic and experienced 16% of the state's road deaths.

Of all the roads analysed, the section of Bruce Highway from Caloundra to Cairns accounted for 44% of deaths and 35% of casualty crashes. It rated medium–high or high for both collective and individual risk along much of its length. The worst section of Bruce Highway was the 40km section between Cooroy and Gympie.

It carried around 12,700 vehicles per day and experienced 181 casualty crashes and 27 deaths between 2001 and 2005. This highlights that drivers should exercise extra care when travelling the Bruce Highway and road authorities should immediately look at implementing remedial upgrades to reduce the risk to road users.Accordingly, other links of major concern which rated high for both collective and individual risk and thus deserve attention include:

AusLink roads

- Bruce Highway – Innisfail to Cairns
- Warrego Highway – Helidon to Toowoomba State Highways
- Brisbane Valley Highway – Ipswich to Forest Hill – Fernvale Road
- Captain Cook Highway – Cairns to Port Douglas

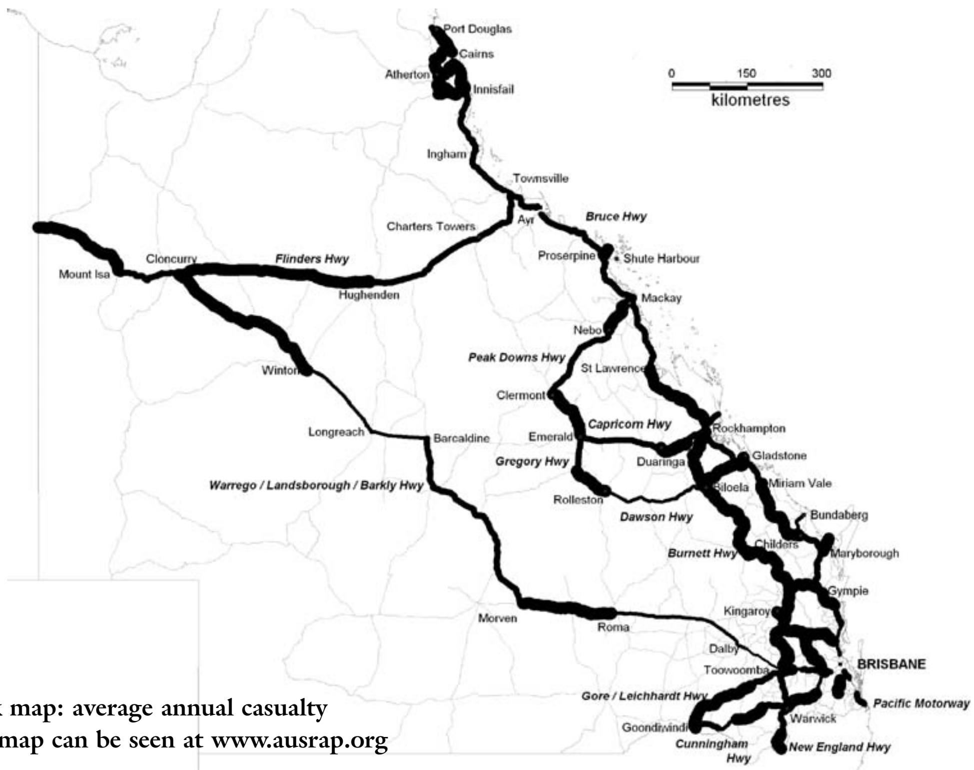


Figure 2 : Collective risk map: average annual casualty
A colour version of this map can be seen at www.ausrap.org

1 Traffic and crash data used in this report was supplied to AAA by Queensland Main Roads

- D'Aguilar Highway – Caboolture to Kilcoy, Harlin to Kingaroy
- Gillies Highway – Gordonvale to Atherton
- Kennedy Highway – Barron Falls to Mareeba
- Maryborough to Hervey Bay Road
- Mount Lindesay Highway – Park Ridge to Beaudesert

Star Ratings for the AusLink National Network in NSW

Where the Queensland report focuses on the rates at which crashes occurred, the NSW report rates roads according their design and layout. Star ratings involve an inspection of a number of design elements such as lane and shoulder width and the presence of safety barriers, which are known to have an impact on the likelihood of a crash and its severity. Between 1 and 5 stars are awarded to road links depending on the level of safety which is 'built-in' to the road.

The NSW report is the second star rating report for the AusLink National Network. The first, published in October 2006, contained an analysis of AusLink in all States and Territories except New South Wales. At the time, data for NSW had not been made available, though the NSW Roads and Traffic Authority (RTA) has since provided AAA with the necessary data.

In NSW, 13 AusLink National Network highways totalling 4,637km in length were star rated. Of this total length, 8 per cent of the network is rated 2 star (red), 68 per cent is 3 star (yellow) and 24 per cent is 4 star (light green). There are no significant lengths of 1-star (black) or 5-star (dark green) highway.

Overall, NSW has a higher proportion of 2 star roads, and lower proportion of 4 star roads, than the national average. Australia wide, 3% of the network is 2 star, 55% is 3 star and 42% is 4 star.

One of the more risky sections of road identified in the study was on the Pacific Highway north of Woolgoolga, which received a 2-star rating. This section of road is undivided — meaning head-on crashes are possible; has severe roadside conditions — if a vehicle runs off the road, it is likely to hit a tree or pole; and it has a large number of intersections — where brutal side impact crashes are a risk.

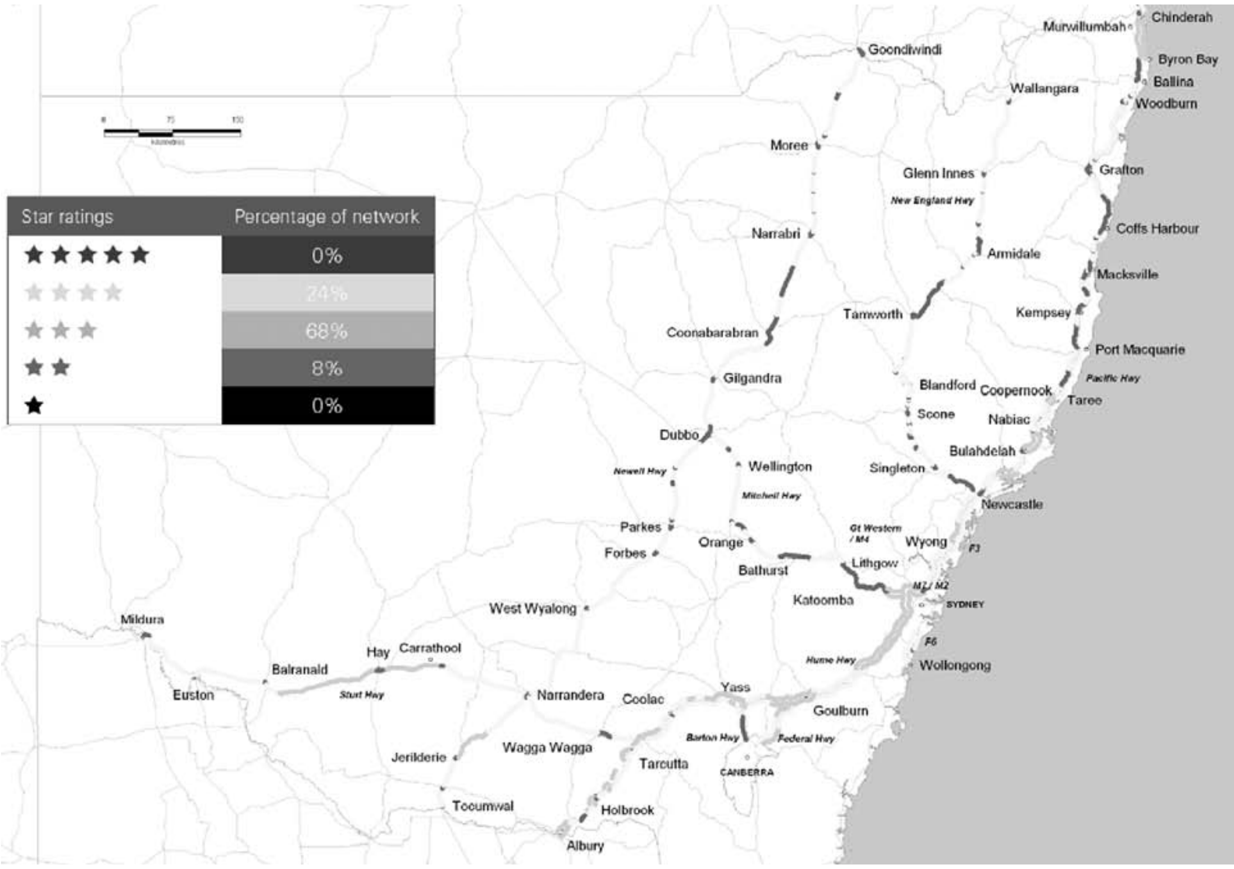


Figure 3 Star ratings for the AusLink National Network in NSW

A colour version of this map can be seen at www.ausrap.org

The study also enabled a demonstration that increased road investment can help reduce this risk. A good example of governments working together and investing to improve safety is the Brunswick Heads to Yelgun section of the Pacific Highway, where major work was completed in July 2007. The Federal and NSW Governments split the $256 million price tag for this project.

Before the upgrade, it rated just 2 stars. Today, it rates 4 stars — it is now divided, has wide lanes, overpass and underpass intersections and has much improved roadside conditions.

The report calls on Federal and State Governments to continue to invest in completing high standard freeway links between Sydney, Melbourne and Brisbane, and between the M2 and F3, the M4 and Sydney Port / Anzac Bridge, and between the F6 and Sydney Port.

It argues that two or three stars are unacceptable on these important, heavily trafficked national highways and upgrades are urgently required to bring them up to 4 stars in the short term and 5 stars in the longer term.

The report also makes a case for improvements in other key highways with sealed shoulders, regular overtaking opportunities, safer intersections and the best achievable level of roadside safety through removal or protection of hazards such as trees, poles and steep embankments.

The bottom line is that safe drivers in safe cars should not die as a consequence of unsafe roads.

Road Safety in Five Leading Countries

By Rifaat Shoukrallah*

* NRMA-ACT Road Safety Trust Churchill Fellow; and

Senior Manager, Traffic Management and Safety, Australian Capital Territory

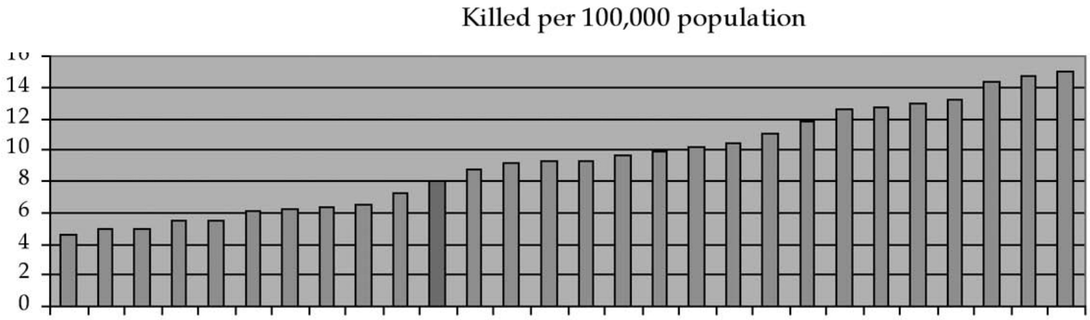
Department of Territory and Municipal Services.

Introduction

Each year, some 600,000 road crashes are reported in Australia killing about 1,750 people and injuring in excess of 200,000. These road crashes cost the community more than $15 billion every year2. Worldwide, approximately 1.2 million people are killed and 50 million people are injured in road crashes each year. The global cost of road traffic injuries is estimated at US$518 billion each year3 .

International road death rates allow Australia's road safety performance to be compared with other OECD nations while taking into account the differing levels of population (a measure of the public health risk associated with road trauma), motorisation and distances travelled (measures of the risk associated with road travel).

Among OECD nations, Australia has the 11th lowest rate in road deaths per 100,000 population; the 9th lowest rate in road deaths per 10,000 registered vehicles and the 7th lowest rate in road deaths per 100 million vehicle kilometres travelled4. While these rates, and rankings, change every year, some countries have consistently displayed better road safety records than Australia. The NRMA-ACT Road Safety Trust Churchill Fellowship allowed me to travel to Sweden, UK, Norway, Japan and Denmark to examine the policies and measures in these countries in an attempt to understand the reasons behind their good performance.



2. Road Safety Towards 2010 (Australian College of Road Safety, 2004)
3. The global burden of disease (WHO)
4. International Road Safety Comparisons: The 2005 Report (Australian Transport Safety Bureau, May 2007)

Road Safety Policies

Road Safety in Sweden is based on Vision Zero, which aims that ‘eventually no one will be killed or seriously injured within the road transport system’5. Zero is not a target to be achieved by a certain date. It is, however, a change from an emphasis on current problems to being guided by what the optimum state of the road system should be.

The vision is based on: Ethics (every human being is unique and irreplaceable) and Science (human physical and mental capabilities are known and should form the basis for road design. Knowledge of our limited ability and tolerance in a crash should guide the choice of solutions). Vision Zero changes the emphasis in responsibility from the road user alone to a shared responsibility by all those who have an effect on, or participate in, road traffic (politicians, designers, road managers, the police and others).

The Norwegian Government has also established that Vision Zero shall form the basis for road safety activities: “The vision means that the Government, in addition to conducting a policy with the goal of reducing the total number of accidents, will focus strongly on measures that can reduce the most serious accidents”6. The National Action Plan for Road Safety promotes cooperation between all those involved in road safety and developing the strength of each of these actors. It acknowledges the importance to secure the engagement of local politicians and the population at large.

The vision and central theme of the Danish road safety strategy 2002-2011 is "Every Accident is One too Many". The vision sets a course towards a future road system without any road crashes whatsoever and retains a focus on preventive measures. Road safety initiatives are based on five strategies7 amongst which:

- Road safety starts with you: acknowledging that if all drivers observed the speed limit, fastened their seatbelt and never drank and drove, the number of deaths in road crashes in Denmark would be reduced by at least 40%. More funds are being allocated to national campaigns to change road user behaviour in these areas.
- Four key areas: speeding, alcohol, cyclists, and junctions are the focus of the actions.
- Agreements between private and public enterprises, and transport service suppliers present great potential for crash prevention and should be fostered.

The responsibility of implementing the strategy ‘Tomorrow’s roads: safer for everyone 2000–2010 in the UK’ is shared by many stakeholders, led by the Government’s Department for Transport. The Government’s framework for improving road safety[8] acknowledges the need for new thinking and fresh ideas and not be afraid to challenge conventional wisdom.

The ‘White paper on traffic safety in Japan’ is produced each year and contains the status of traffic crashes, measures being implemented and plans for traffic safety measures. Expert panels develop Fundamental Traffic Safety Programs (FTSP) every five years. The Eighth FTSP (2006 to 2010) acknowledges the need to respond to declining birthrates and an aging society; establishing improved pedestrian safety and raising people’s awareness. The common philosophy of the Eighth FTSP includes[9]:

- The aim is a crash-free society.
- Giving people precedence: a “people first” philosophy giving consideration for those who are weaker than others.
- Dealing with the issue of human error in public transportation by improving the organisational structures and systems of companies providing transport services.
- Encouraging participatory activities by enabling citizens to participate in the planning stages of traffic safety measures run by national and local authorities.

Measures to Improve the Road Traffic Environment

Apart from the traditional road safety measures such as fully controlled intersections, roundabouts, lighting, sealed shoulders, line marking and others, the countries visited have also deployed some specific measures. For example, investments are made in Sweden to reduce the risk of serious human injury on the road network:

- The cross sections of around 1000 km of undivided roads in Sweden have been rearranged to cater for two lanes in one direction, a wire rope guardrail in a painted median and a single lane in the opposite direction (2+1 roads). This arrangement is estimated to have reduced head-on collisions by about 90%.
- Speed limits on the road network have been reviewed to reflect the safety standard of the road. It is now unusual to find a road with a speed of 110 km/h without a median barrier. If barriers are not installed, the speed limit is reduced to 80 km/h.
- A 30km/h speed limit has been established in built-up areas emphasizing that this must be the limit if pedestrians and cyclists are to survive a collision.
- Guardrails have been erected, and trees and boulders have been cleared away from roadside areas to minimise the damage ensuing from cars veering off the road.

To improve traffic safety in Norway, long-term as well as short-

5. Vision Zero – an ethical approach to safety and Mobility (Claes Tingvall and Narelle Haworth, 1999)
6. Vision Strategy and Targets for Road Traffic Safety in Norway (Ministry of Transport and Communications, 2006)
7. Every Accident is one too many (The Danish Ministry of Transport, 2000)
8. Tomorrow’s roads – safer for everyone (Department for Transport, UK, 2000)
9. White Paper on Traffic Safety in Japan (International Association of Traffic and Safety Sciences, 2006)

term measures are being implemented. Regular road safety inspections are undertaken and the Ministry of Transport and Communications is considering improvements to four-lane dual carriageways with median guardrails, or median rumble strips in some cases, to reduce the number of head-on collisions. Rumbled edge markings; straightening sharp curves; and improving visibility are also being implemented to reduce the number of single-vehicle crashes. To reduce their severity, roadside obstacles are being removed and forgiving utility poles are being used. Many of the above measures were applied to the national demonstration project for Vision Zero established in the Lillehammer district.

Nearly half of all road crashes in Denmark happen at intersections. The two typical factors involved are speeding and failure to observe priority rules. In that context, roundabouts are implemented at T and cross intersections to reduce speed and conflict points, Stop signs are replacing Give Way signs and traffic lights with refuge islands for pedestrians are also implemented. Apart from these priorities, measures to address "grey areas" (stretches of road with high crash rates) are also used. Because cycling achieves a staggering modal split of 36% of journeys to work in Copenhagen, facilities such as bicycle lanes and storage boxes at intersections are also a priority.

The UK acknowledges that simply building more new roads is not the answer. The emphasis is now on making the best use of the existing network, giving priority to treating the places with the worst safety, congestion and environmental records. The basic road markings, lighting, signs and crossings that help responsible motorists drive safely are now often supplemented with traffic calming features such as humps and chicanes. The old emphasis on curing crash hot spots is giving way to whole route and area treatments. Although the default speed limit in residential areas is 30 mph, home zones with 20 mph speed limit are quickly spreading in residential areas. The use of speed cameras is also being considered at entry/exit points to residential areas.

A safer road network is constantly expanding in Japan as a result of the following:

- The road network is targeted at three different levels by developing Routes for the coexistence of pedestrians and vehicles; creating Zones where pedestrians and bicycles have priority and by implementing Arterial Road Measures: including the placement of right-turn lanes; intersection improvements and other measures.
- “Safe Pedestrian Areas” are identified and have become the focus of area-wide crash prevention measures (to limit travel speeds and to demarcate sections to be used by traffic and by pedestrians). Wide footpaths are also developed along school routes, around train stations and other public facilities.
- Japan eliminates utility poles, constructs pedestrian overpasses with lifts and improves signs and markings to make them more visible to the elderly.

Other Notable Measures to Improve Road Safety

Although the objectives of this fellowship were to study road safety policies and engineering measures in five leading countries, discussions also lead to other road safety activities pursued in these countries that are worth noting:

- Automatic Speed Control using speed cameras has proven to have positive effects on road safety in Sweden (800 cameras). Fixed cameras are also used in the UK (700 in London) and in Norway (360) while mobile speed cameras are used in Denmark.
- The Home Office Review of Road Traffic Penalties in the UK and the Government in Norway are considering a range of offences with a view to render penalties more appropriate and proportionate to the seriousness of offences.
- The UK police developed schemes that offer retraining rather than prosecution to drivers who have committed careless errors. The ‘National Driver Improvement Scheme’ has been adopted by over 30 forces. For example, a PC based Speed Awareness Course has been developed. It is a ‘hazard perception’ exercise and speed offenders can attend the course to offset losing points off their license.
- Japan will implement the “Cross-generation Sharing Project,” in which people from three generations meet to learn about traffic safety, and the “Seniors Home Visit Project,” in which traffic safety guidance is provided at home to seniors unable to attend seminars. Traffic safety clubs are established within seniors’ clubs and retirement homes. Classes for drivers between 65 and 70 years of age teach them the changes occurring in their physical functioning, their driving tendencies and the characteristics of crashes in which they are commonly involved.
- The ‘Think’ campaign in the UK has been very successful. The powerful drink-drive advertising has helped make drinking and driving socially unacceptable, and a substantial fall in drink-related casualties was achieved.
- Norway concentrates on the use of safety belts, speed reduction, cycling and walking to school in their awareness campaigns. Knowing that about 95% of drivers and passengers already wear seat belts, trying to reach the remaining 5% was a challenge. Instead, the campaign targeted those who already wear seat belts urging them to remind and encourage others to do the same. The ’speak Out’ campaign targets 16 to 24 year olds about dangerous driving and asks people to speak to the driver about any dangerous habits and not to accept being in the same vehicle.

- Impressive market research takes place in Denmark to identify the target audience for each safety message and how to reach them (messages for young drivers are aired at movie theatres showing films that attract young people). A short video was produced using topless girls (speed bandits) to draw young people's attention to speed signs and speed limits. Given that young people forward all sorts of internet messages, this ad reached millions of people in a short time period.
- Japan has stepped up its calls to pedestrians to use reflective material as a means of preventing pedestrian crashes at night. Prefectural police distributed reflective material on street corners, on visits to seniors' homes and at educational events.
- The automotive industry can contribute to road safety by meeting demands set by their consumers (such as governments, municipalities and private businesses). The Swedish Government demands specific safety features in its fleet and is therefore indirectly able to affect manufacturers without the need to change vehicle standards.
- In Norway, studies show that if the person first arriving at the scene of the crash masters first aid, every fifth fatality could be avoided. More emphasis is therefore being put on improved preparedness in the health services.

Reasons for Success

The major findings of this study were not just about the measures deployed but rather about the overall approach to road safety and how the authorities manage it. Road Safety enjoys a high profile, in these countries, through political support at the highest levels. For example, the Prime Minister of Japan chairs the Central Committee on Traffic Safety Measures responsible for formulating the Fundamental Traffic Safety Programs. That political support is usually translated in funding provision.

Holistic approaches to road safety are becoming common including the Swedish 'Vision Zero' and the Dutch 'sustainable Mobility'. This holistic approach is being translated in organisational structures that attempt to consolidate all efforts (policy, engineering, awareness campaigns and education) in one group to allow the choice of treatment across these fields, and sometimes, their integration into a 'solution'. Specialist skills and continuous training are also pursued to develop the 'right' people for the task.

National coordination of road safety works is a strong aspect in these countries. Road safety is a 'strategic aim' and a 'culture' within their organisations. The holistic perspective of recent policies has resulted in closer cooperation between system designers and other players. Cooperation does not stop at Government organisations but also extends to the private sector. Many companies that procure or operate transport services (e.g. Ikea and Carlsberg) are assuming responsibility for their impacts on road safety. Road authorities develop agreements with them to promote road safety and may sponsor initial measures such as alcolocks for the company's fleet.

Road Safety Policies are, more and more, focusing on reducing casualties. A 'People First' philosophy is gaining popularity. Despite the fact that politicians do not generally support targets (as targets admit acceptance of a certain number of deaths), ambitious targets are set to provide the focus for the whole of Government effort. The importance of the availability and quality of data is strongly acknowledged since it informs the decision making process, especially in the common environment of limited budgets.

In depth studies of every death are used to examine whether it could have been prevented. These studies are not necessarily interested into why the crash happened but rather into why the consequences occurred (why did the person die?). System designers assemble stakeholders (e.g. truck operators for crashes involving heavy vehicles) to discuss possible solutions and develop measures for implementation, confirmed in a declaration of intent signed by each stakeholder. Such OLA (Objective data, List of solutions and Addressed action plans)" projects are conducted in Sweden.

Educational/training opportunities, offered as a substitute for prosecution in the UK, have been successful. Victims of traffic crashes (Road Peace in the UK, and Traffic Informers in Denmark) assist the Government in education efforts of school children or others and represent a powerful source of change.

General awareness campaigns to influence road user behaviour are not the norm anymore. Rather, a more targeted approach to specific groups is used. Analysis is undertaken to determine the details of the problem, details of the message; the target audience and how to ensure the target audience sees the message.

As well as the traditional 'blackspot' approach which examines single sites, more and more work is being done at other levels of analysis:

- Arterial Routes are examined either through a comparison of crash rates (reactive) or through risk assessments (pro-active) using a Road Safety Audit approach.
- Scattered crashes are dealt with by area treatments.
- Networks are analysed to identify crash trends and mass engineering, and other, treatments are implemented. Many successful examples exist:

- o One Thousand km of ‘2+1’ roads with median barriers (Sweden).
- o Rumble markings at road edges/medians (Sweden and Norway).
- o Pedestrian facilities/sidewalks (Japan).
- o Physical separation of travel modes (cycling and walking from other modes).
- o Maintaining clear zones at road edges to create more forgiving environments.
- o Speed cameras across the network.
- o Lower residential speed limits (UK and Norway).
- o Lower blood alcohol limits to 0.02g/l (Norway and Sweden).

To stay amongst the leading nations in the field of road safety, these countries are keen to maintain high standards of road safety research and to develop new solutions:

- Japan’s National Police Agency plans to introduce a road safety system that alerts drivers to potential hazards through audio and visual notifications. About 20 different subsystems, each designed to prevent a specific crash type (rear-end collisions, head-on collisions) are being studied. Some of these are expected to be rolled out in 2008 and are currently being tested in Tokyo.
- Intelligent Speed Adaptation (ISA) is a promising method for helping drivers keep to the speed limit. Using GPS technology the system registers the vehicle’s speed and compares it with the permitted speed at the current location. The speed limit data is taken from a road database that contains information on all roads. If the speed limit is exceeded, systems issue a warning (a sound signal or accelerator counter-pressure). ISA has been promoted to private companies in Sweden. Government Departments have also installed it in their vehicles and consideration is being given to its use on taxis and buses as a first step of a wider implementation.

Many differences exist between countries including cultural influences, legislative requirements, the standard of the road network, the use of the various travel modes, the interactions between these modes and others. Importing and implementing ‘foreign’ solutions can only be successful after careful consideration of these matters. Having said that, some of the above findings are worthy of consideration. New projects have already been initiated in the ACT based on these findings.

Lastly, I am very grateful to the Winston Churchill Memorial Trust of Australia for awarding me the fellowship and the NRMA-ACT Road Safety Trust for sponsoring it. The support I received from senior officers in the ACT Department of Territory and Municipal Services is also much appreciated.

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Peer Reviewed Papers

Modelling and Analysis of Crash Densities for Karangahake Gorge, New Zealand

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This paper was originally presented at the Australasian Road Safety Research, Policing and Education Conference held at Surfers Paradise, Queensland, 25-27 October 2006.

Abstract

An 18 km length of New Zealand state highway located in tortuous terrain that displayed a poor safety level (11 injury crashes per year) was selected to trial the "safety improvement potential" approach to safety management of roads. This approach involves comparing the actual safety level over a section of road with the average safety level estimated from a crash prediction model.

This paper presents the results of applying a crash prediction model specifically developed for the New Zealand state highway network to analyse the safety performance of the 18 km route. The Poisson regression model is believed to be one of the first to successfully relate crash rates to road geometry and road condition. Therefore, the relative effectiveness of various engineering based countermeasures to bring about an improvement in the current safety level was also able to be assessed. The countermeasures investigated included realignment, high friction surfacing and road smoothing. It was determined from the modelling studies that a more consistent level of crash risk throughout the 18 km route could be achieved through either increasing friction levels or increasing the radius of the horizontal curves at specific locations.

Key Words: crash risk modelling, road surface condition, road geometry

1 Introduction

Transit New Zealand's safety programme has, for the most part, been reactive, eliminating crash "grey-spots" and "black-spots" across New Zealand's state highway network. However, there are now indications that the rate of road safety improvement is levelling off because the "grey-spot/black-spot" improvement process can be viewed as a screening exercise; as the analysis progresses, the number of sites progressively decreases because problem areas become less obvious. For example, between 1981 and 1985, 46% of reported injury crashes occurred at sites with 3 or more crashes per annum, whereas between 2000 and 2004 this percentage has dropped to 35%.

To continue to make gains in the safety level of state highways, the approach of "safety improvement potential" is being advocated whereby the actual safety level over a road section is compared with the average safety level estimated from a crash prediction model. This approach is seen as a more accurate method for identifying road safety problems as it reduces selection biases related to the random nature of crashes.

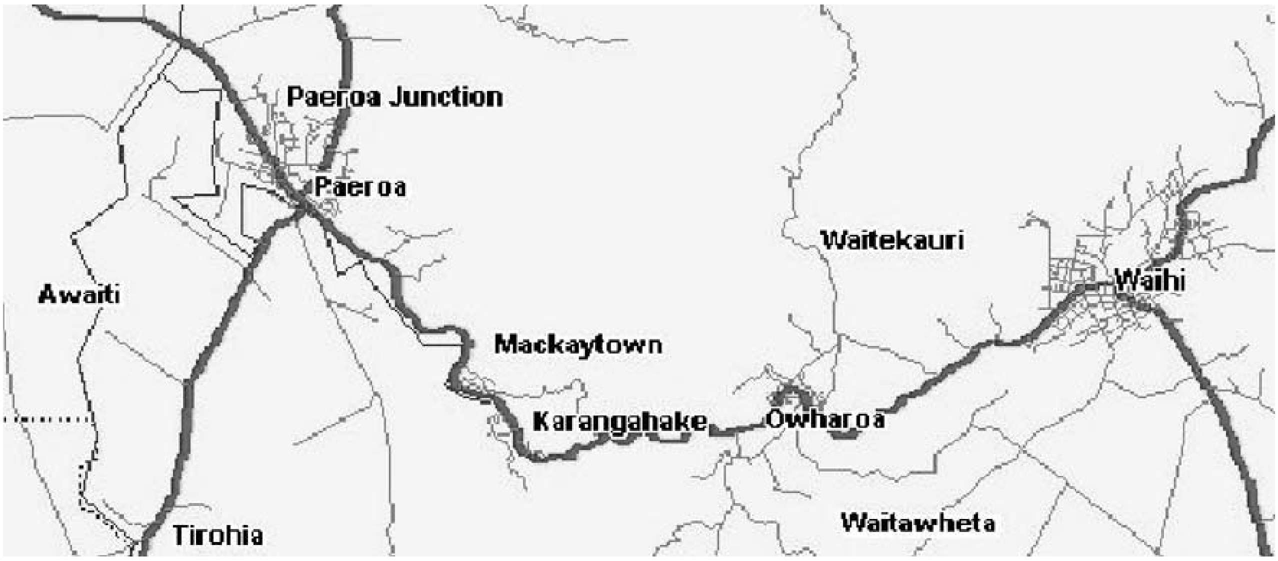
A crash prediction model has been developed that allows proactive identification of engineering-related safety deficiencies on New Zealand's state highway network (1). The model itself and an example application are presented in the appendix to this paper for ready reference.

The road and traffic data required as input to the model are all found in Transit New Zealand's Road Assessment and Maintenance Management (RAMM) state highway database and comprise absolute gradient, horizontal curvature, lane roughness, skid resistance, friction demand site category as defined in Transit New Zealand's T/10 specification (2), traffic flow (ADT), urban/rural classification and Transit New Zealand administration region. As this Poisson regression based model uses 2nd or 3rd order polynomial functions of these variables to allow for the observed non-linear responses, the model can be incorporated in existing road asset management systems.

The model has been derived from 1997-2002 data that pertains to the entire 22,000 lane-km of the New Zealand state highway network. While the model cannot be expected to apply absolutely everywhere on the network, it does appear to reflect the actual crash data remarkably well.

To illustrate the potential use of the model to analyse the safety performance of the state highway network and to guide safety initiatives, an 18.2 km length of State Highway (SH) 2 between Paeroa and Waihi (RS 73/0.648 and RS 73/18.836) was selected because of its current poor safety level of 10.8 injury crashes per year. This section of SH2 has a "rural" classification and includes the Karangahake Gorge (refer Figure 1).

Figure 1: 18 km section of State Highway 2 investigated, Paeroa to Waihi



This paper summarises the findings of the comparative study of modelled and actual crash densities over a 5 year period from 2000 to 2004. The crash densities were calculated over two length intervals, 0.5 km and 3 km, in an attempt to guide safety initiatives by:

- detecting where there are significant discrepancies between actual and modelled crash densities;
- identifying 0.5 and 3 km road sections that stand out as having significantly higher crash densities than adjoining sections;
- establishing whether or not crash numbers for the entire 18.2 km length of SH2 of interest are significantly higher than would be expected for state highways with comparable road surface condition and road geometry;
- determining where along the 18.2 km length each of the following interventions is likely to be effective in reducing crash numbers: curve realignment; surface treatment to improve skid resistance; and surface treatment to improve ride quality (i.e. reduce

Review of Total Injury Crash Numbers

2.1 Validation of Model Predictions

In applying the model, a check as to its general validity was made by comparing "all" and wet road (abbreviated to "wet") reported injury crashes in Land Transport New Zealand's (formerly LTSA) crash analysis system (CAS) for the five year period 2000 to 2004.

A comparison of modelled and actual "all" and "wet" injury crash numbers occurring over the entire 18.2 km length of SH2 of interest (RS 73/0.64 and RS 73/18.81) is provided in Table 1 on a yearly and 5 year mean basis.

With reference to Table 1, there is reasonable agreement between predicted and observed "all" injury crash numbers when the 5 year mean values are considered. However, "wet" injury crashes are underestimated by the model by about a factor of two.

The main reason for this is that the criteria for classifying a crash as "wet" covers a wider range than in the original analysis. When one does the analysis with the data from the original analysis covering the years 1997-2002, the actual number of

Table 1: Comparison of Model Derived and Actual Crash Numbers

Analysis Period	Number of Injury Crashes					
	All		Dry		Wet	
	Model	Actual	Model	Actual	Model	Actual
2000	12.1	9	8.8	4	3.3	5
2001	12.0	3	8.8	1	3.2	2
2002	12.2	12	8.8	1	3.4	11
2003	12.4	15	9.0	5	3.4	10
2004	12.5	15	9.0	7	3.5	8
5 Year Mean (2000-04)	12.2	10.8	8.9	3.6	3.4	7.2

Derived from subtracting "wet" injury crashes from "all" injury crashes

crashes is larger than the predicted number but not by an amount that is statistically significant.

In a table such as this, the standard errors of the model's predictions will generally be much smaller than the variability in the crash numbers so estimates of goodness of fit can be based on the Poisson variability of the crash numbers.

2.2 Trend Analysis

Comparing the yearly crash numbers given in Table 1, the model predictions of "all" injury crashes shows a gradual upward trend in crash numbers (i.e. 0.1 crashes per year) over the 5 year analysis period from 12 to 12.5 crashes per year. This gradual upward trend is mirrored in the "wet" injury crashes. Therefore, the ratio of predicted dry road to wet road injury crashes remains fairly constant at about 2.6 i.e. there are 2.6 times as many dry road crashes as wet road crashes.

In contrast, the actual crash numbers vary substantially between years with a noticeable drop to only 3 "all" injury crashes in 2001. Since 2001 there has been an increasing trend, which seems to plateau at about 15 "all" injury crashes. There is similar substantial variation in the number of "wet" injury crashes. However, in neither case is there sufficient data to draw any conclusions about trends.

2.3 Relative Safety Performance of Analysed Route

There is close agreement between the modelled and actual 5 year mean values of "all" injury crashes, which correspond to 12.2 and 10.8 crashes respectively. Because the model has been derived from data for the entire state highway network, its estimates of injury crash numbers represent those that can be expected on average over the network. As a consequence, it can be inferred that the likelihood of having a crash on SH2 between Paeroa and Waihi (i.e. Karangahake Gorge) is no more nor no less than other sections of the state highway network that display similar road and traffic characteristics. However, actual crash numbers are dominated by crashes that occur under wet conditions. Therefore, a very effective crash reduction initiative would be to target interventions that will improve the wet weather performance of this section of SH2. One such intervention could be to reduce the depth of surface water through attention to drainage path length, surface slope and texture depth.

3 Comparison of Actual and Modelled Crash Densities

3.1 Analysis Period

Because of the random nature of road crashes, the choice of the analysis time period may have a significant impact on the accuracy and reliability of the safety assessment. Overly long periods may introduce biases in the analysis when current conditions differ from those prevailing when the crashes occurred. Overly short periods reduce the number of crashes considered and the statistical accuracy.

The accepted minimum analysis period is 3 years (3). For this safety assessment, an extended analysis period of 5 years, spanning 2000 to 2004, was chosen as figure 2 shows very little inter-year variation in the predicted crash densities over this period implying that road related factors affecting crash occurrence have remained relatively stable. Accordingly, comparisons of modelled and actual yearly crash densities used for detecting where actual crash densities are much higher (black spots) or lower (white spots) than expected for the measured road condition and geometry are based on 5 year mean crash densities.

These comparisons have been confined to "all" injury crashes on the grounds that the accuracy and reliability of the safety assessment will be better than for "wet" injury crashes as a consequence of there being more crashes on which to base the assessment.

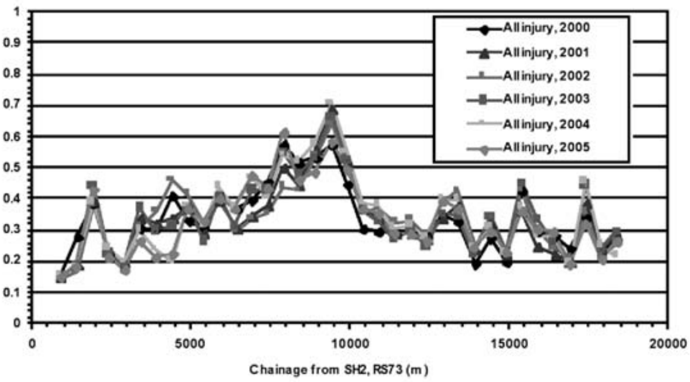


Figure 2: Temporal and spatial distribution of predicted "all" injury crash densities based on 0.5 km analysis length

3.2 Comparison of 0.5 km "All" Injury Crash Densities

Figure 3 graphically shows the level of agreement between modelled and actual average yearly crash densities across both increasing and decreasing lanes of SH2 between Paeroa and Waihi. The agreement is generally as close as one could expect.

One possible point of difference is the 0.5 km length located at RS 73/17.14 – 17.64. While this might be simply a chance occurrence, the higher crash rate may indicate an additional risk at this point not properly captured by the model, or it might be due to higher traffic in the vicinity of Waihi that is not captured by the ADT data.

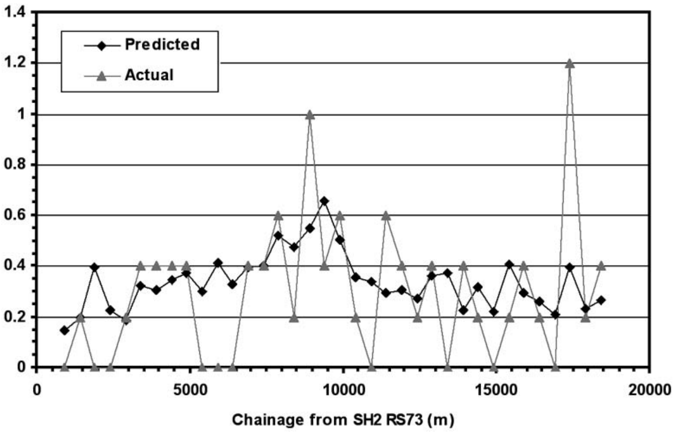


Figure 3: Spatial distribution of modelled and actual "all" injury average yearly crash densities based on 0.5 km analysis length for the period 2000 – 2004

3.3 Comparison of 3 km "All" Injury Crash Densities

Figure 4 is the same as Figure 3 except that the analysis length has been increased from 0.5 km to 3 km. The 6 fold increase in analysis length results in a significant improvement in the level of agreement between modelled and actual crash densities. There is only one location where the observed yearly crash density per 3 km is clearly greater than predicted (2.4 cf. 1.7). This 3 km length is located at the very end of the section of SH2 of interest i.e. RS 73/15.64 -18.64. At this location, factors other than road condition or road geometry, such as roadside encroachment and traffic operation, should be investigated to determine the cause of the higher than expected crash density.

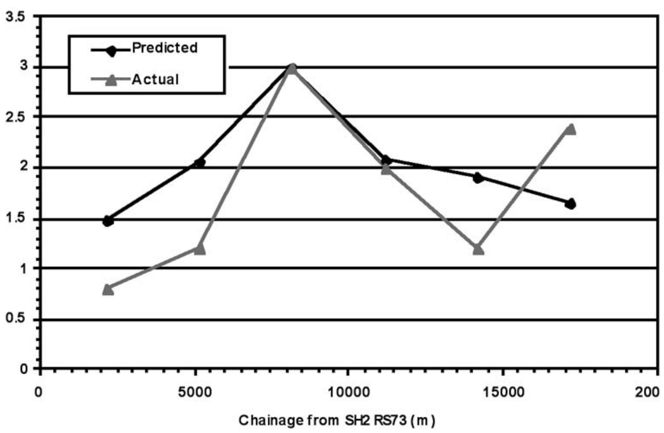


Figure 4: Spatial distribution of modelled and actual "all" injury average yearly crash densities based on 3 km analysis length for the period 2000 – 2004

Figure 4 also highlights a peak crash density of 3 and this occurs over the 3 km length located at RS 73/6.64 – 9.64. As the modelled and actual crash density distributions are in perfect agreement with regard to the location and magnitude of the maximum crash density, there appears to be scope to reduce the maximum by 1 crash per year to the yearly average value of 2 injury crashes per 3 km through appropriate attention to road condition and road geometry.

3.4 Comparison of Site Safety Level

Statistical procedures given in PIARC's Road Safety Manual (3) were used to calculate the safety level in terms of crash frequency (m) and the associated uncertainty in m at the 95% confidence interval for the entire 18.2 km length of SH 2 between RS 73/0.648 and RS 73/18.836.

From Table 1, the model gives a total of about 61 "all" injury crashes over the 5 year period 2000-2004 whereas only 54 "all" injury crashes were reported over the corresponding period. The resulting safety level statistics are summarised in Table 2. These statistics confirm that the model used is capable of providing safety level (m) estimates that are sufficiently reliable for safety management purposes.

Table 2: 95% Confidence Interval Safety Level Statistics for SH 2 RS 73/0.648 – 18.836

Crash Statistic	Derived from Model	Derived from Actual "All" Injury Crash Numbers
Crash Frequency, m (crashes/year)	12.2	10.8
Lower m value (crashes/year)	9.3	9.0
Upper m value (crashes/year)	15.7	12.9
Probability of exactly 10 crashes/year	78%	64%

4 Effectiveness of Engineering Based Countermeasures

4.1 Countermeasures Investigated

With reference to the various crash prediction model parameters listed in Table A1 of the Appendix, the only engineering based countermeasures available to produce a more constant level of crash risk over the 18.2 km length of SH2 between Paeroa and Waihi are to:

- reduce lane-roughness to provide improved tyre-to-road contact;
- increase the radius of curves to reduce required friction and speed variations along the route;
- increase the level of skid resistance to provide greater margins of safety for braking and cornering manoeuvres.

As the cost of these countermeasures can be very high, particularly in the case of increasing the radius of a curve, their relative effectiveness in reducing crashes was determined by applying the crash prediction model to the 2005 (latest) RAMM road condition and road geometry data to obtain baseline crash numbers. The values of lane-roughness, horizontal curvature and skid resistance were then factored in turn to produce a 25% improvement in each of these parameters (i.e. horizontal curvature and skid resistance values were scaled by 1.25 whereas lane roughness was scaled by 0.75 and expected crash numbers recalculated).

4.2Predicted Changes in Crash Numbers

The effect of each countermeasure on site safety level is summarised in Table 3. Increased skid resistance is shown to be clearly the most effective approach for ameliorating "all" injury crashes over the section of SH2 of interest.

Figures 5 and 6 show spatially the resulting absolute and relative change in "all" injury crash numbers per 3 km respectively.

Table 3: Change in Expected "All" Injury Crashes over the Analysed Route (SH2, RS 73/0.648 – 18.836)

Scenario	Number of "all" injury crashes	Reduction in "all' injury crash numbers		
		Total Length	per 0.5 km	per 3 km
2005 baseline	11.93	-	-	-
25% increase in horizontal curvature	10.64	1.29	0.036	0.22
25% increase in skid resistance level	9.68	2.25	0.063	0.38
25% decrease in lane roughness	11. 64	0.29	0.008	0.05

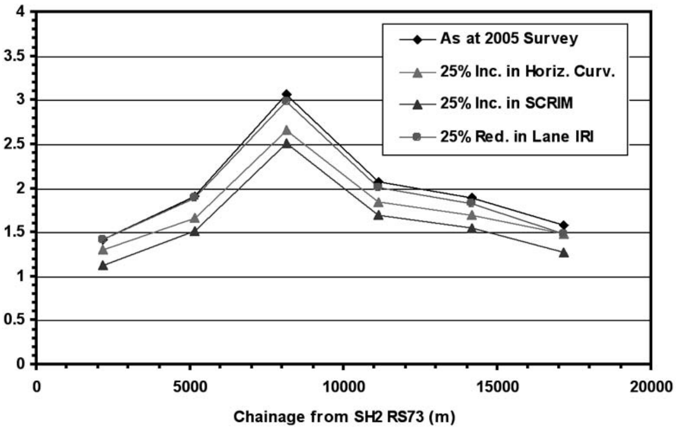


Figure 5: Predicted impact of different countermeasures on "all" injury crash densities –3 km analysis length

With reference to these figures it can be seen that either increasing the level of skid resistance or increasing curve radius will have a similar effect in reducing the number of "all" injury crashes and that this effect extends over the entire 18.2 km length, though it is most pronounced over the 3 km length situated between RS 73/6.64 and RS 73/9.64. In contrast, smoothing (i.e. reducing lane roughness) is expected to produce only localised crash reductions at RS 73/6.64, RS 73/9.39, RS 73/16.39 and RS 73/17.39, though Figure 6 suggests that there is likely to be some safety benefit in reducing lane roughness of SH2 over the 11 km length between Karangahake and Waihi (i.e. RS 73/8.14 - 18.836).

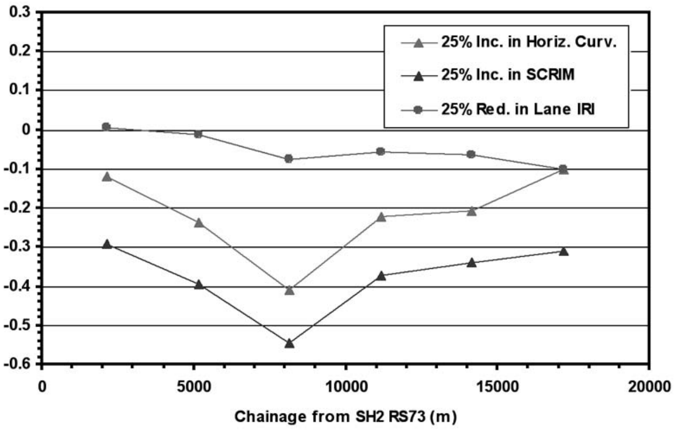


Figure 6: Predicted change in crash density relative to 2005 baseline resulting from adoption of various engineering related countermeasures – 3 km analysis length

Conclusions

1 The trial application has achieved its objective of demonstrating the value of the concept of potential for improvement at a route or road network level for guiding engineering-based road safety initiatives.

2 In determining the potential for improvement over a route, crash prediction models that account for the interactions between traffic, geometric, road condition and weather variables are required. Such models do not need to be overly complex, as it was shown that 2nd and 3rd order polynomials functions are adequate to allow for observed non-linear responses of the key variables.

3 The crash prediction model developed for specific application to New Zealand's sealed state highway network in its current form is sufficiently robust for the following four applications:

- To improve the understanding of the factors affecting crash risk and the relative importance of different factors.
- To improve the management of the highway network by estimating the effect on crash numbers of changes in standards for curvature, skid resistance and roughness.
- To identify black spot regions where, because of factors not included in the model, crash rates are much higher than predicted by the model. It may also be possible to detect white spots where crash rates are lower, although this is less likely to be successful.
- To use the model to help evaluate the effect of an actual change in road construction or management policy in a Transit New Zealand administration region by comparing the observed and predicted number of crashes.

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Appendix

A1 Model Form

A model, which relates a variety of road characteristics exponentially to crash risk, has been developed from a statistical analysis that investigated the dependency of observed crash rates to road condition and road geometry data acquired during annual surveys of the State Highway network. The analysis assumed that the crashes were statistically independent and the number of crashes that occur in each 10m road segment follow a Poisson distribution (of course, for most segments the number of crashes was zero). The fundamental form of the model is given below.

Expected number of crashes per year per 10 m = ADT.eL … (A1)

where: ADT = is the average daily traffic

L = is the weighted sum of the values of the various road characteristics such as:

- absolute gradient
- horizontal curvature
- T/10 skid-site category
- skid resistance (SCRIM Coefficient)
- lane roughness (IRI)
- log10(ADT)
- year
- TNZ administration region
- urban/rural classification

The exponent, L, is the sum of a number of variables that are either assigned values depending on the road characteristic (e.g. Urban / Rural road) or are the product of a coefficient multiplied by the value of the road characteristic (e.g. A x Curvature). These values and coefficients were determined by fitting the road data to the variables using the method of maximum likelihood.

The expected number of crashes per year equation given above can be converted to an equation for crash rate (number of crashes per 108 vehicle-km) by multiplying by the factor, 108/(ADT.365.Road Length). Crash data has been analysed over 10m sections, giving a road length of 10-2 km.

Therefore, substituting equation A1 gives the crash rate as:
crash rate (crashes per 108 vehicle.km)

= ADT.e^L x 10^8 = ADT.eL x 108/(ADT.365.10-2)

This simplifies to:

$$\text{crash rate } \frac{10^{10}}{365} e^{L} = \ldots \text{ (A2)}$$

The values and ranges of the parameters are as follows:

year: 1997 to 2002 (beyond these years requires estimation of the yearly coefficient)

region: R1 to R7 (= TNZ Administration Regions, where:

R1=Auckland, R2=Hamilton, R3=Napier, R4=Wanganui, R5=Wellington, R6=Christchurch and R7=Dunedin)

urban_rural: U (urban) or R (rural)

skid_site: T/10 site category 1, 3 or 4 (category 2 has been combined into category 4)

curvature: 100 to 10000m radius (absolute value used, i.e. does not differentiate left from right hand curves). For radii outside this range use 100m for values less than 100m and 10000m for values greater than 10000m

ADT: average daily traffic, unlimited range of values

gradient: 4 to 10 (absolute value is used, and values less than 4 are set equal to 4)

SCRIM: 0.3 to 0.7 SCRIM Coefficient

IRI: 2.0 to 10.0 IRI (m/km) lane roughness

The predicted crash rate is found by applying equation A2, in which L is first evaluated using Table A1. L is the sum of various terms, which are calculated using the coefficients in Table A1. Terms corresponding to categorical variables (i.e. year, region, urban_rural, skid_site) simply take the value of the corresponding coefficient in Table A1, while terms associated with the continuous variables (i.e. curvature, ADT, gradient, SCRIM Coefficient and IRI) are found by multiplying the variable by the corresponding coefficient.

The model coefficients for the calculation of "all-injury" crashes (including fatals) and "wet" crashes (i.e. all injury and fatal crashes occurring on road surfaces considered to be in a wet condition) are given in Table A1.

The model allows the number of crashes expected to occur over a year on a specific 10 m section of state highway to be calculated. Estimates of yearly crash numbers over lengths greater than 10 m are obtained by summing the component 10 m estimates. Therefore, the calculation of the number of crashes per year expected over the 18.2 km of SH2 between RS 73/0.648 and RS 73/18.836 required the summation of 1,820 component estimates of yearly crash rate per 10 m.

The coefficients for gradient shown in Table A1 don't seem very sensible – more slope reduces crash risk. This is because of an interaction between gradient and the T/10 skid-site category 3 classification. This shouldn't have a serious impact on the predictive power of the model but needs to be rectified in the next upgrade of the model.

A2 Example Calculation

The following example shows the procedure for calculating the crash rate using the simplified 'All Crashes' model coefficients from Table A1. First the exponent, L is evaluated, as shown in Table A2.

The exponent, L, is then used to calculate:

- Expected number of crashes per year per 10m =
- The crash rate in terms of 108 vehicle–kilometres travelled using equation A2 i.e.

$$\frac{10^{10}}{365}e^{L} = \frac{10^{10}}{365}e^{-13.937} = 24.3$$

Table A1: Coefficients for the Crash Prediction Model

Parameter	All Crashes		Wet Road Crashes	
	coefficient	standard error	coefficient	standard error
constant	2.095	1.76	1.015	3.43
year: 1997	0.000		0.000	
year: 1998	-0.060	0.03	-0.240	0.07
year: 1999	-0.053	0.03	-0.027	0.06
year: 2000	-0.118	0.03	-0.331	0.07
year: 2001	0.000	0.03	-0.203	0.07
year: 2002	0.198	0.03	-0.002	0.07
region: R1	0.000		0.000	
region: R2	0.108	0.03	0.192	0.07
region: R3	0.210	0.05	0.101	0.10
region: R4	0.306	0.04	0.565	0.08
region: R5	0.224	0.04	0.053	0.09
region: R6	0.105	0.04	0.146	0.09
region: R7	0.124	0.04	0.045	0.09
urban_rural: R	0.000		0.000	
urban_rural: U	-0.157	0.03	-0.272	0.06
skid_site: 4	0.000		0.000	
skid_site: 3	1.595	0.04	1.528	0.08
skid_site: 1	1.697	0.08	1.175	0.20
$\log_{10}(\lvert curvature\rvert)$	-5.360	0.29	-7.426	0.57
$[\log_{10}(\lvert curvature\rvert)]^2$	0.759	0.05	1.048	0.09
$\log_{10}(ADT)$	0.707	0.31	2.380	0.71
$[\log_{10}(ADT)]^2$	-0.173	0.04	-0.401	0.10
$\lvert gradient\rvert$	-2.598	0.70	-2.913	1.33
$\lvert gradient\rvert^2$	0.314	0.11	0.396	0.21
$\lvert gradient\rvert^3$	-0.012	0.01	-0.017	0.01
SCRIM - 0.5	-1.637	0.16	-3.551	0.33
$[(SCRIM-0.5)]^2$	-0.090	1.30	3.344	2.48
$\log_{10}(iri)$	-10.540	4.48	-7.348	8.48
$[\log_{10}(iri)]^2$	19.219	8.48	10.916	15.65
$[\log_{10}(iri)]^3$	-9.850	4.99	-3.563	8.89

Table A2: Example Application 'All Crashes' Crash Prediction Model

parameter	parameter value	calculation value	corresponding coefficient †	product (value x coefficient)
constant		1	2.095	2.095
year 2002	1	0.198	0.198	
region R2	1	0.108	0.108	
urban_rural	Rural	1	0.000	0.000
skid_site	4 *	1	0.000	0.000
log10(|curvature|)	300	2.477	-5.360	-13.277
[log10(|curvature|)]2	300	6.136	0.759	4.657
log10 (ADT)	10000	4	0.707	2.828
[log10 (ADT)]2	10000	16	-0.173	-2.768
|gradient|	0 **	4	-2.598	-10.392
|gradient|2	0 **	16	0.314	5.024
|gradient|3	0 **	64	-0.012	-0.768
(SCRIM-0.5)2	0.45	-0.05	-1.637	0.082
(SCRIM-0.5)2	0.45	0.0025	-0.090	0.000
log10 (iri)	3	0.477	-10.540	-5.029
[log10 (iri)]2	3	0.228	19.219	4.375
[log10 (iri)]3	3	0.109	-9.850	-1.070
				∑= -13.937 = L

Notes:
† coefficients taken from Table A1
* skid_site category 2 has been combined with skid _site category 4
**gradients between 0 and 4 default to a value of 4

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Road Safety Engineering Risk Assessment – Recent and Future Research

By Blair Turner and Michael Tziotis

This paper was originally presented at the Australasian Road Safety Research, Policing and Education Conference held at Surfers Paradise, Queensland, 25-27 October 2006.

Abstract

The Australian Road Research Board (ARRB) has been conducting an extensive range of research aimed at identifying and measuring the level of risk associated with different road stereotypes, and at the reduction in this risk resulting from changes in road design standards and from remedial treatments. This Austroads funded research is designed to aid policy makers and practitioners in assessing risk and prioritising treatment on their roads so as to achieve optimal crash risk reduction for the available budget.

Research topics include the development of crash rates databases, investigation of risk reduction for safety treatments in different environments, the implications of varying design standards, information on local road safety schemes, use of crash cost as an indication of severity, an in-depth investigation of rural head-on, intersection and run-off-road crashes, the safety implications of road deterioration, an investigation of crash risk migration, and the effect of using multiple countermeasures.

This paper provides examples of the results from some of this research.

Introduction

The management of the road network to provide safe road transport is a key performance indicator for road authorities, and fundamental to providing the community with a 'safe road system', a key objective of the Australian National Road Safety Strategy. To assist authorities manage road based crash risk, ARRB Research is undertaking a major Austroads' funded research program to assess risk involving road, traffic and roadside infrastructure. The results will provide road authorities with more effective tools to reduce road crashes and injuries. The initial research program was aimed at developing a basis for prioritising the treatment of deficiencies identified by road safety audits. ARRB used the results of this research to develop the Road Safety Risk Manager (RSRM), a CD-based 'expert system' to assist in the prioritisation of road safety treatments. Ongoing research is aimed at better defining the relationship between road elements and crash risk.

This paper reports on results from the most recent two years of research, and highlights forthcoming research. Results are provided on the following areas of research:

- development of crash rate databases
- investigation of risk reduction for safety treatments in different environments
- the implications of varying design standards
- information on local road safety schemes
- use of crash costs as an indication of severity
- an in-depth investigation of rural head-on, intersection and run-off-road crashes
- the safety implications of road asset deterioration
- an investigation of crash risk migration
- the effect of using multiple countermeasures at a site.

Research Results

Crash rate databases

The key objective for this task was to collect data from each of the Australasian jurisdictions in order to build crash rate databases, primarily to determine the different levels of risk associated with various road types. Crash rates are more useful than crash numbers because they take into account exposure (traffic volumes). This allows the calculation of overall risk for different road types, and can be used for comparisons (e.g. for divided versus undivided roads, sealed versus unsealed roads, undivided major urban versus undivided major rural, roundabouts versus traffic signals, or T intersections versus X intersections etc.). Specific road sections or intersections can be compared with this average to determine the high risk locations.

Crash, traffic and road inventory data was requested from each jurisdiction, and where available was combined using geographic information systems (GIS). A lack of spatial coding was identified through this research, as well as a lack of detailed information on traffic volumes. Despite these limitations, crash rates have been identified for the state road network in New South Wales (although this is limited to rural mid-block locations), Queensland, South Australia, Victoria and Western Australia. Data was not collected from New Zealand as comprehensive data on crash rates already exists. Crash rates have also been generated for a case study local government area.

The crash rates generated include information on mid-block and intersection crash rates. The data is provided as an estimate of crash rates for different road environments, including single or divided carriageway, urban and rural roads, number of approaches at intersections and type of traffic control. The information provides a 'snapshot' of crash rates at the current time, but has been designed to allow an update as new information becomes available.

An example of the results for mid-block crash rates (CR) in Victoria is presented in Table 1

Table 1: Victoria - mid-blocks

	100 million VKT 5 Yrs	Fatal crashes	Fatal CR	Injury crashes	Injury CR	All crashes	Total CR
Carriageway							
Single	1046.59	820	0.78	27480	26.26	28300	27.04
Divided	874.28	322	0.37	14444	16.52	14766	16.89
Environment							
Urban	913.34	376	0.41	23651	25.90	24027	26.31
Outer-urban	348.05	231	0.66	7626	21.91	7857	22.57
Rural	659.49	535	0.81	10647	16.14	11182	16.96

Future work will involve further analysis of the database with the opportunity to conduct more thorough analysis on different road environments, and also to conduct some fundamental research. Topics may include the identification of differential crash rates by land use type and estimating the effect on risk of unequal flows on approaches to intersections.

Investigation of risk reduction for various safety treatments in different environments

Based on extensive reviews of literature, estimated crash reductions have been developed for 36 road safety treatment types. Table 2 provides a list of the treatment types addressed

Local and international research has been assessed, and adapted for use in the Australasian context. Where possible, the expected reduction in different road environments has been determined. As an example, Table 3 presents the results for the installation of splitter and median islands at intersections.

A rating scale indicating the methodological robustness of research has been developed, and was a useful tool in assessing the quality of research, and in determining how much weighting to apply to each study that contributed to the final reduction figure (to date this has only been used to qualitatively weight results, but it may be possible to use this scale to apply a numerical weighting).

The rating scale is shown in Table 4

Table 2: Treatment types for which crash reduction estimates were derived

Accesses	Intersection - signal visibility
Clear zone - batter rounding	Line marking - profile edge line
Clear zone - general	Median crossovers
Clear zone - length hazard	Midblock turning provision
Clear zone - point hazard	Off road delineation - guide posts
Delineation - RRPMs	Overtaking
Intersection - advanced warning	Pavement markings - centreline
Intersection - control beacons	Pavement markings - edgeline
Intersection - intersection road types	Pavement markings - speed limits
Intersection - left turn lane	Pavement markings - words and symbols
Intersection - linked signals	Pedestrian/cyclist
Intersection - red light camera	Sight distance
Intersection - right turn phase	Signs - advisory
Intersection - right turn lane	Signs - regulatory
Intersection - right turn lane (extend length)	Street lighting
Intersection - splitter and median islands	Speed (change in limit and change in mean speed)
Intersection - roundabout (single versus multiple lane)	Traffic calming
Intersection - signal timing	Work zones

Table 3: Estimated crash reduction from installation of splitter and median islands

Issue	Environment type	% reduction
Channelisation at intersections – plitter and median islands	Splitter island – all environments	40%
	Splitter island – rural	35%
	Splitter island – urban	40%
	Splitter island – T intersection	45%
	Splitter island – X intersection	40%
	Median island – mountable	15%
	Median island – non-mountable	25%

Due to a lack of robust research evidence, for the majority of treatment types only a medium level of confidence has been applied. Despite this, these estimates are based on the best available information, and should be considered by practitioners when estimating crash reductions for these treatment types.

Areas for further research were identified based on gaps in knowledge. In order to address these gaps, data will need to be collected or trials undertaken.

Based on the poor methodology identified in much of the research, some form of guidance or training in evaluation is required to assist practitioners and those evaluating research. The framework for assessing methodological robustness (see Table 4) may be used to help advise research funders on the confidence they should place in proposed research. With a better understanding of this issue, it is likely that better quality research will be produced.

Table 4: Study rating system

Study type	Descriptive statistics only	Simple statistical analysis	Complex statistical analysis
Simple study – no controls, no traffic volume	1	1	(not likely)
Study without control group but traffic volume	2	2	(not likely)
Study using comparison group/all crashes etc. to control for general crash trends	3	4	5
Study controlling for general crash trends and the regression-to-the-mean effect, generally using controls based on similar sites	3	4	5
Study using matched comparison group, based on crash rates controlling for general trends and regression-to-the-mean	3	4	5

Implications of varying design standards

The purpose of this research was to identify road design elements that affect road safety, and examine the extent to which the variation of standards applied to each element of design (e.g. design speed, sight distance, cross section) affects the safety performance of roads in different environments (e.g. urban and rural).

Through reviews of the relevant literature and an analysis based on data collected from site visits, this part of the project has led to the development of models that may be used by practitioners to determine the appropriate balance between road design standards, road safety benefits and costs. Issues of importance included horizontal and vertical alignment, sight distance, cross section (including pavement width and shoulder type) and roadside elements (e.g. clear zones). As an example, figures for relative risk relating to horizontal alignment have been calculated for use in Australian and New Zealand conditions. These are provided in Table 5. This table indicates that the level of risk at a horizontal curve of 200 m radius is estimated to be 3.9 times that of a curve of 1400 m radius.

However, a lack of reliable information on a number of issues was highlighted and it is recommended that further research be conducted into the relationship between crash risk and the standards adopted for geometric design elements. Key issues where robust information is lacking include the safety of curves with a radius below 500 m, the most effective combinations of shoulder width, lane width and shoulder type, and crash risk and horizontal alignment for typical situations in urban and outer urban areas. It is recommended that the large amount of data collected on geometric alignment and cross section be analysed in association with crash data to develop information on these and other key issues.

Table 5: Relative risk factors for horizontal curvature

Radius (m)	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400
Relative risk	6.0	3.9	3.0	2.7	1.9	1.6	1.4	1.3	1.3	1.2	1.2	1.1	1.0	1.0

Information on local road safety schemes

Based on concerns that treatments implemented on state road networks may differ in type and effectiveness to those used on local road systems, this part of the project sought to provide better knowledge of the success, or otherwise, of treatments used on local roads. This study compared the types of treatments used on local roads with those used on state road networks. Attempts were also made to identify the effectiveness of treatments in these different environments, although this was only possible through an analysis of the predicted benefit of schemes and not actual outcomes. There are weaknesses in using the predicted benefit, as this may differ greatly from actual scheme benefits. Differences in treatments used were identified and are shown in Figure 1.

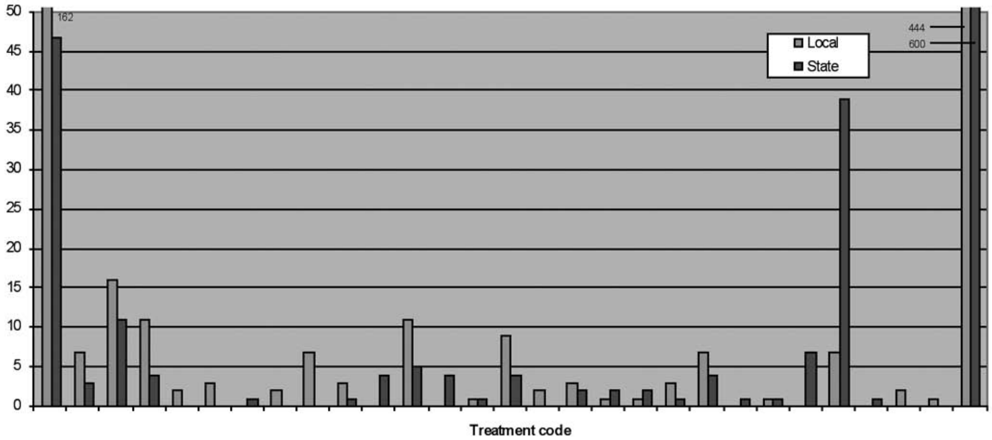

Figure 1: Number of blackspot sites treated, by treatment type

This figure provides information on Australian schemes as approved by the Federal blackspot program between 1996/97 and 1999/2000, 51% (745 projects) of which were on state roads and 49% (706) on local roads. Of interest were the higher proportion of roundabouts installed on local roads, the higher proportion of signals projects on local roads, and the higher proportion of shoulder sealing projects on state road networks. Results from New Zealand's crash monitoring system showed a similar trend.

For the Australian sites, the predicted benefit-cost ratio (BCR) from the blackspot submission was available for analysis, and was used as a proxy for the effectiveness of a treatment type. Across all of the Australian data, the average BCR for all local road treatments was 10.7 and the average for state roads was 8.7. Some marked differences were found in the expected BCR between local and state road treatments. For example, the predicted effectiveness of remodelling of signals and provision of a pedestrian refuge is around double on local roads compared with state roads. The predicted effectiveness of traffic islands and reduced radius on a left-turn slip lane is around double on state roads compared with local roads.

It was concluded that there are differences in the types of treatments used on local roads compared with those used on the state road network. Information on the expected safety benefits indicated that there were also differences for many treatments. It is recommended that where possible, future evaluations of blackspot effectiveness include analysis by state and local road to provide further guidance on this topic.

Use of crash cost as an indication of severity

This part of the research aimed to improve the relevance, accuracy and potential use of crash costs as computed for road user movement crash types. These costs are important in their own right, and as proxy measures of average crash severity. A revised method for estimating these crash costs was developed, and preliminary estimates for 30 June 2005 developed for seven Australian jurisdictions covering twenty crash group categories. Equivalent estimates for New Zealand were not developed, as detailed crash costs already exist. Detail in estimates included cross tabulation by area of operation and speed limit, the latter level having not previously been available in Australian estimates. A measure of reconciliation between road user movement crash costs and severity of outcome crash costs was also achieved.

In-depth investigation of rural head-on, intersection and run-off-road crashes

This part of the research explored the incidence and causes of rural head-on, rural intersection, and rural run-off-road crashes, and identified possible countermeasures to combat these crash types. A literature review on causes and possible countermeasures for each of these crash types was conducted. This review also assessed the level of crash reduction that could be expected from each of these measures. Crash causes for head-on and intersection crashes were also assessed based on an extensive analysis of crash data from each Australasian jurisdiction. Site visits were undertaken at locations throughout Australasia where a high incidence of these two crash types were identified, with similar work planned for run-off-road crashes in the coming year.

The review of the literature revealed that these three crash types were the leading cause of crashes in rural areas. The causes of run-off-road crashes included road alignment, surface condition, shoulder conditions and various behavioural issues, including driver fatigue, inattention and excess speed. Those for head-on crashes were similar (run-off-road crashes sometimes lead to head-on crashes due to over correction), with the addition of overtaking as an issue. Rural intersection crashes were often due to a lack of adequate site distance, excess speed and intersection complexity.

Treatments were similar for rural head-on and run-off-road crashes, and included measures to improve delineation (e.g. warning signs and chevrons), shoulder treatments (including profile edgelines for run-off-road crashes), barriers (including wire-rope barriers), surface treatments, and improved curve geometry / realignment. Head-on crashes were also addressed with the addition of overtaking lanes and improved lane separation.

Treatments for rural intersection crashes included the installation of rural roundabouts, surface treatments, improved sight distance (e.g. removing obstructions), reduced speeds, advanced warning and street lighting. The expected crash reduction from each of these measures was identified where possible.

Safety implications of road asset deterioration

The objective of this project was to provide guidance to road safety managers about the risk associated with sub-standard assets and the risk-reduction benefits associated with their restoration. This will enable safety investments involving the restoration of asset condition to be considered on the same basis as other safety investments such as the provision of new facilities or the remodelling of existing facilities. The following issues were included in the assessment, and where possible, models developed for each:

- skid resistance
- macrotexture
- roughness
- rutting
- drainage
- edge wear
- edge drop
- unsealed shoulder condition
- line marking
- guide posts
- retro-reflective pavement markers
- signs
- roadside vegetation.

Information has been provided on the point at which the asset becomes unsafe. As an example, in the case of edge drop (the drop from the top of the paved surface to the underlying gravel surface), the point at which safety is adversely affected is an elevation change of 75 mm. In addition, information is provided as to the expected increase in crashes at this point (1.5% in the case of edge drop).

Investigation of crash risk migration

This research sought to develop an understanding of the potential for Crash Risk Migration (CRM) to occur with a range of road safety improvement treatments. CRM is defined in this context as a change occurring in a particular part of the network (that may be made in order to improve safety or traffic flow) that may also influence other parts of the network. CRM is examined because its effects have been claimed to have the potential to impact significantly on the evaluation of the success of safety programs, treatments and countermeasures. However, the potential mechanisms of CRM are not well understood. The focus of this study was on situations where CRM may occur as a result of traffic redistribution. Some studies appear to show that CRM may occur due to traffic redistribution.

Although not an exhaustive list, the following treatments were identified as having the potential to cause CRM:

- turn controls or bans
- major changes to a route such as parking changes
- bridge closure
- localised speed limit changes
- intersection changes e.g. signalisation, turn phase timing change, turning lanes
- traffic calming
- lane additions
- addition of overtaking lanes
- pedestrian treatments at intersections and at mid-block locations
- railway crossing control
- mid block turning provision.

Effect of using multiple countermeasures

An extensive amount of research has been conducted on the effectiveness of various treatments in terms of crash reduction. In most cases this research attempts to quantify the effectiveness of single treatments so that advice can be provided to practitioners on which single treatment might be most effective to address crash risk. However, it is often the case that more than one treatment is used at the same location. For example, where there is a problem at a rural bend with vehicles leaving the road, attempts may be made to improve delineation through the use of signs and line markings, and improvements may also be made to the skid resistance of the road surface. When multiple treatments are used, it is difficult to determine the cumulative effect that these treatments have, as the reductions from each measure are not likely to be additive. The purpose of this review was to determine what information is available to assist practitioners in determining the effect of using multiple countermeasures.

Based on an analysis of New Zealand data it was found that multiple treatments were used at around 80% of crash locations. A review of the literature revealed several commonly used equations that attempt to account for the diminishing benefit from using multiple treatments. The most common was of the following form:

$$CRFt = CRF1+(1-CRF1)CRF2+(1-CRF1)(1-CRF2)CRF3+ \ldots$$

where: CRFt = total crash reduction

CRFx = individual crash reductions.

As an example, if three treatments are being considered in one location, with respective reductions of 40%, 25% and 20%, the results would be as follows:

$$CRFt = 0.4 + (1\text{-}0.4) \times 0.25 + (1\text{-}0.4) \times (1\text{-}0.25) \times 0.2$$

$$= 0.4 + 0.6 \times 0.25 + 0.6 \times 0.75 \times 0.2$$

$$= 0.4 + 0.15 + 0.09$$

= 0.64, or a 64% reduction in crashes.

A 64% reduction in crashes is obviously less than the 85% reduction that would be calculated if each reduction was added together.

However, of the equations identified in the literature, none appear to have been validated. An attempt at validation was made based on New Zealand crash monitoring data. An analysis was undertaken on the crash reduction effectiveness of several single treatments, and this information was compared with the effect when using these same treatments in combination.

The results showed that existing equations over-estimate the combined benefits of treatments. Based on the results of this analysis, it is recommended that crash reduction estimates derived using these equations be multiplied by 0.66 to provide a more accurate estimate of actual reduction (in the example above, instead of a 64% reduction, a 42% reduction should be used). It was also recommended that attempts be made to prioritise the combinations of treatments that are most commonly used, and then a program of research undertaken to identify crash reductions from these combinations.

Future Research

There are two more years of Austroads funded research on this topic, and a number of research projects are planned. Research in 2006/07 includes further updating of information on the expected crash reduction from various treatments based on published literature. In addition, based on gaps in knowledge identified in the earlier research (i.e. where there is inadequate published literature), a number of high priority issues will be assessed through an analysis of monitoring data and/or field trials.

The research will also examine the issue of treatment life. In determining the benefits of a safety scheme, treatment life has a large influence (potentially larger than the expected crash reduction), although little robust information exists on this issue. It is planned to provide advice to jurisdictions so that more accurate treatment life figures can be used.

A study will be conducted on crashes on unsealed roads, including a review of literature, and an analysis of crash data including the calculation of crash rates for these types of roads.

A further area of work will involve a review of the automatic collection of road and roadside data of relevance to road safety risk (e.g. horizontal and vertical alignment, road surface condition, and clear zone width). An assessment will be made as to what road features can currently be automatically collected through vehicle mounted sensors, and an evaluation made of priority issues for which it is not currently possible to collect such data. If possible, new data collection techniques will be developed. This project has the potential to increase the accuracy, but decrease the resource demands for safety related data collection. DISSEMINATION OF RESULTS

Project reports are currently being produced providing fuller details on the results of this work. These should be available from early next year from the Austroads website (www.austroads.com.au). ARRB is also producing a series of project newsletters titled the Road safety risk reporter. A number of these have been produced, with more in progress. Links will be provided from this newsletter to full reports where appropriate. Copies of newsletters can be found on the ARRB website at www.arrb.com.au, or by emailing riskreporter@arrb.com.au.

The results of the research program will also be used to update the Road Safety Risk Manager (RSRM) and NetRisk software. The RSRM expert system was launched in 2002 to provide authorities with a tool to manage, prioritise and track the status of road safety treatments on their networks (1). NetRisk is a new tool to identify high risk locations on a road network based on road features (2). The models incorporated in the software continue to be updated as part of the research program and this objective forms an important component of the ongoing research.

Summary

ARRB is involved in an ongoing series of Austroads funded research projects on road safety engineering risk assessment. Results from this research will be disseminated through reports, as well as a newsletter, the Road safety risk reporter. The results will also be made available to practitioners through the Road Safety Risk Manager and NetRisk software.

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Testing the Pedestrian Safety of Bull Bars: Methods and Results

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This paper was originally presented at the Australasian Road Safety Research, Policing and Education Conference held at Surfers Paradise, Queensland, 25-27 October 2006.

Abstract

Thirteen bull bars and five models of vehicle were tested to measure their performance in pedestrian impact tests. Three types of test were selected for the assessment: two tests using an impactor representing the upper leg of an adult pedestrian and a test with an impactor representing the head of a child. The headform impact and one of the upper legform impacts were with the top rail of the bull bar and the second upper legform impact was with the bumper section of the bull bar. Equivalent locations on the vehicles to which the bull bars attach were also tested. The tests were conducted at 30 km/h. The tests showed that the steel bull bars tested presented the highest risk of injury of any configuration tested. Aluminium/alloy bull bars also performed worse than the vehicles tested, but to a lesser extent than the steel bull bars. Overall, the polymer bull bars tested performed best and slightly better than the front of the vehicles tested.

Introduction

Four-wheel-drive (4WD) vehicles are used by many motorists who do most of their driving in urban environments. Much has been spoken and written on the safety implications of these vehicles and the bull bars that are fitted to them. While bull bars are sometimes mounted on 'recreational' 4WDs, they may also be installed on work vehicles, conventional passenger cars and derivatives and heavy vehicles.

The extent to which bull bars are involved in pedestrian collisions and injury is not clear from readily available data. In 1996, the Federal Office of Road Safety estimated that bull bars were certainly involved in 12% of fatal pedestrian collisions but may be involved in as many as 20% (1), although it is not clear how the latter estimate was arrived at, nor whether these figures represent an increased risk of death due to the presence of the

bull bar. More recently Attewell and Glase (2) used Australian crash data to try to estimate the effect of bull bars on fatality statistics. They could not draw firm conclusions due to the incompleteness on the bull bar status of vehicles in their fatality database. Furthermore, there were (and are) few data on bull bar fitment rates, so it was difficult to estimate risks associated with bull bar fitment. Attewell and Glase note that data on bull bar fitment rates would facilitate the estimation of relative risks of injury and death associated with bull bars.

Previous physical tests of the type to be reported in this paper have shown that bull bars can increase the severity of impacts with pedestrians but that not all bull bars are equally dangerous (3, 4). Attewell and Glase (2) conclude that, on balance and given the results of such impact tests, bull bars are likely to increase the risk of injury to pedestrians.

For many vehicle owners who drive their vehicles in mainly urban environments, bull bars rarely perform their ostensible purpose – protecting the vehicle in the event of an animal strike. However, they are (with some exceptions) legal additions to vehicles. Despite discussion on the subject in the media, there is currently no readily available information in Australia on the aggressiveness of bull bars, and consumers and regulators have no information on how much more of a risk to other road users a bull bar will present.

AS 4876.1 2002 - Motor Vehicle Frontal Protection Systems

In 2002, Standards Australia issued Part 1 of a new Standard for frontal protection systems - AS 4876.1 2002 - Motor Vehicle Frontal Protection Systems (5). The term "Frontal Protection Systems" was used because it implies that there may be other ways to protect the front of a vehicle from disabling damage in the event of an animal strike than by fitting a conventional bull bar.

AS 4876 Part 1 deals with the protection of children who might be at some risk of injury if struck by a bull bar and specifies other design requirements of vehicle frontal protection systems. The design requirements cover matters pertaining to the geometry of the bull bar and of the sections used to construct the bar: essentially, bull bars should conform to the shape of the car and not have sharp edges. Two other parts (dealing with effects on airbag deployment and the effectiveness of a device in protecting the vehicle) have yet to be considered.

The test of impact performance is intended to simulate an impact with the head of a child pedestrian. It specifies the use of an EEVC WG17 compliant child headform (6), which is spherical, weighs 2.5 kg, and is launched horizontally at 30 km/h at any part of the bar over 1000 mm from the ground. In practice, this means that many bull bars on the market designed for passenger vehicles will not require any testing at all, as only bull bars fitted to larger vehicles, such as tall 4WD vehicles, are higher than 1000 mm. Note that the Standard applies also to bull bars designed for small buses and light goods vehicles of a gross vehicle mass of less than 3500 kg, but not to heavy vehicles. There is no reason to expect that any safety problems for pedestrians would be less for bull bars fitted to heavy vehicles.

It is conceivable that a manufacturer might claim Standards compliance because of the geometry of the bar without needing to meet any impact performance requirement. Other pedestrian testing protocols, such as those devised by the European Enhanced Vehicle-safety Committee (6) and the European New Car Assessment Programme (7) uses 1000 mm 'wrap-around-distance' as the lower boundary for child headform tests and so it might be inconsistent to single out bull bars for special treatment in this respect. Yet, young adults and the elderly make up the largest proportion of pedestrian casualties in Australia (8) and so there are sound reasons to require bull bars to offer some protection to pedestrians of adult stature too, though it is absent from AS 4876.1. The European Directive on vehicle frontal protection systems, 2005/66/EC, requires tests to measure the risk of injury to adult pedestrians in a collision with a vehicle fitted with a bull bar.

The performance requirement in AS 4876.1 is that the Head Injury Criterion (HIC) value (based on impact acceleration of the child headform) should be 1500 or less. In automotive safety testing, a HIC value of 1500 is not acceptable: a HIC value of 1000 is the normal limit. If a child's head were struck at 30 km/h, a bull bar that complied with the Standard might still be likely to inflict a serious injury. Therefore, compliance with the Standard may not ensure that the bar is safe at impact speeds of 30 km/h.

Australian Standards are consensus documents requiring the agreement of the parties involved in their development including, in this case, the manufacturers of the bull bars. Consequently, as noted in the Preface to the Australian Standard, "Child head impact criteria have been included incorporating values that are considered achievable." A European Union Directive on vehicle frontal protection systems (2005/66/EC) does not share the Australian Standard's view of what is acceptable, and bull bars will be subjected to more comprehensive and demanding testing in Europe than in Australia. Furthermore, compliance with the Directive will become mandatory. No jurisdiction in Australia has yet mandated the testing of bull bars to the Australian Standard.

The aim of this project was to define a test method that will produce data on the risks to vulnerable road users associated with bull bars and to report on the results of testing on a range of bull bars currently available in Australia.

Methods

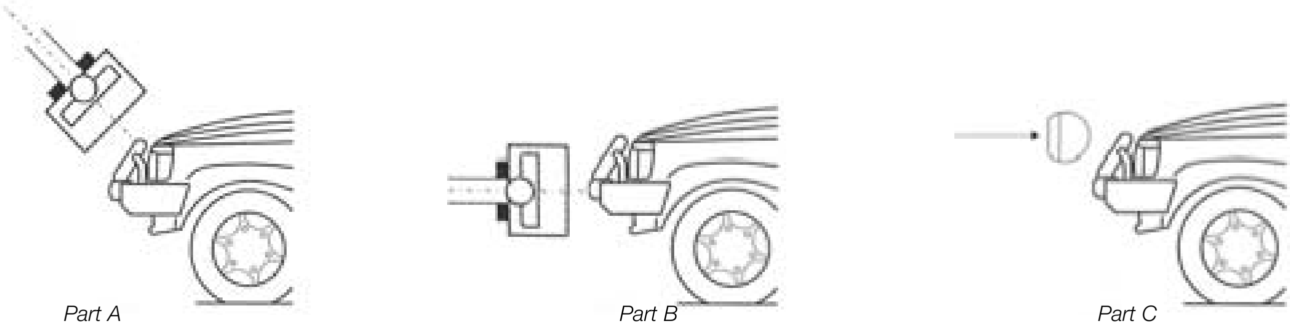
The assessment procedure used for this study focuses on two body regions – the head of a child and the upper leg and pelvis of a pedestrian of adult stature. Each bull bar and vehicle front had three tests conducted on it: a child headform test, an upper legform to bumper test and an upper legform to upper rail/bonnet leading edge test. Each test was conducted at 30 km/h. Figure 1 summarises the types of tests used in this study and the procedures are further outlined in following sections.

A speed of 30 km/h was adopted rather than 40 km/h (as specified in EEVC/Euro NCAP protocols) because a) preliminary testing showed that many of the bull bars were too stiff to yield useful information from impacts conducted at the higher speed and b) it is the speed specified in the Australian Standard (AS 4876.1 2002 - Motor Vehicle Frontal Protection Systems). It is reasonable to assume that tests conducted at 40 km/h would produce more severe impacts than those reported here.

The performance requirements used are the same as those nominated by EEVC/Euro NCAP for pedestrian safety assessment. The European Directive 2005/66/EC nominates higher permissible loads in some tests, but the EEVC/Euro NCAP limits were chosen because:

- The tests were conducted at 30 km/h, rather than at the higher speeds of 35 or 40 km/h, specified by 2005/66/EC, and thus produced lower loads than would have been produced at the higher speeds;
- The chosen performance requirements are more closely aligned with internationally accepted injury tolerance limits.

Figure 1 Schematic of Part A, Part B and Part C tests, using the EEVC WG17 impactors



Part A tests – top of bull bar and bonnet leading edge

An EEVC WG17 upper legform (6) was used to test the top bar of each bull bar and the vehicle bonnet leading edge (Figure 1, Part A), in a similar way to the test specified by Euro NCAP Pedestrian Testing Protocol version 4.1, but at a lower test speed. The legform consists of a simply supported beam that represents an adult femur. The beam is covered in flesh-like foam. The legform is constrained to move in one axis, normal to the orientation of the beam. The legform measures impact forces and the bending moment across the beam. The force is measured at two points: at each of the beam's supports. The total force is given by the sum of the two support forces. The bending moment is measured by strain gauges placed at three points along the beam. The largest value measured by the three strain gauges is used to characterise the bending moment produced in the impact.

For the upper legform test of the top rail of the bull bar and for the comparison test of the bonnet leading edge:

- The geometry of the vehicle and bull bar was measured;
- The angle of the impactor was calculated using the procedure specified in Euro NCAP Pedestrian Testing Protocol version 4.1;
- The centre of the impactor was aligned with of the top rail of the bull bar or the bonnet leading edge of the vehicle and the test was conducted at 30 km/h; and
- The performance requirements were that the peak impact force on the impactor should be less than 5 kN and the peak bending moment below 300 Nm. (Note that these performance requirements are specified by Euro NCAP for impact speeds of 40 km/h.)

Part B tests – bumper section of bull bar and vehicle's standard bumper

An EEVC WG17 upper legform was used to test the bumper section of each bull bar and the vehicle's standard bumper (Figure 1, Part B) in a similar way to the Euro NCAP Pedestrian Testing Protocol version 4.1 testing procedure for a high bumper, but at a lower test speed. It was envisaged that the Part B test would be applied only if the bull bar had significant structural components at bumper height but our assessment was that all bull bars tested had such structures and consequently the test was applied to all bull bars:

- The centre of the upper legform impactor was raised to 500 mm from the ground and aligned with the bumper;
- The impactor speed was 30 km/h and the impact angle was horizontal;
- The performance requirements were that the peak impact force should be less than 5 kN and the peak bending moment below 300 Nm.

Part C tests – bull bar or vehicle leading edge > 1000 mm high

The EEVC WG17 child headform test (6) was applied at the impact speed specified in the Australian Standard AS 4876.1 and an identical comparison test was applied to the car itself. The headform consists of a 2.5 kg sphere, with a triaxial accelerometer mounted at the centre of gravity. The headform measures the impact deceleration, which is then analysed to produce the Head Injury Criterion value for the impact.

Only sections of the bar or leading edge above 1000 mm were subjected to testing, in accordance with AS 4876.1. The centre of the headform was aligned with the centre of the top rail of the bull bar or leading edge of the vehicle. If the centre of the top rail was below 1000 mm from the ground, then the centre of the headform was aligned with the part of the top rail at 1000 mm from the ground (note that the vehicle ride heights were as specified by the vehicle manufacturer).

The test was conducted at 30 km/h and the performance requirements were that the Head Injury Criterion value should be 1000 or less.

Bull bar mounting

Two methods were used to mount the bull bars for testing. In most cases the bull bar was attached to the corresponding vehicle, according to the manufacturer's instructions. However, in some cases, mounting the bull bar to the vehicle would have required modification to the vehicle chassis rails. As the vehicles were to be (separately) crash tested by ANCAP after these pedestrian impact tests, the modifications could not be made, as the subsequent crash test might have been compromised. Instead, a universal chassis rail rig was used.

The chassis rail rig was checked to ensure that the results of the tests would be a valid representation of the bull bar as it would be on the vehicle: this was checked by testing a bull bar on the rig and again on the vehicle. The results from each test (headform and upper legform) were almost identical (within a few percent) and the standard chassis rails were deemed to be an accurate replacement to a vehicle chassis.

Bull bar and vehicle selection

The selection of vehicles was determined by ANCAP's program as this study was coordinated with ANCAP tesing. ANCAP choose vehicles according the largest volume selling vehicles in the particular market segment. The vehicles in this study came from a 4WD testing program and work utility testing program. The vehicles tested were:

- Toyota Landcruiser (100 Series, manufactured Oct 2004);
- Nissan Patrol (manufactured Oct 2004);
- Ford Courier 4WD crew cab (manufactured July 2005);
- Toyota Hilux 4WD crew cab (manufactured Oct 2005);
- Holden Rodeo 4WD crew cab (manufactured Oct 2005).

It was not possible to test every type, material and brand of bull bar available in Australia. The choices were guided by the following criteria:

- For every vehicle, up to three bull bars would be tested;
- One of the bull bars fitted to each vehicle should be an Original Equipment Supplied (OES) product;
- For each vehicle, a steel bull bar would be tested, an aluminium or alloy bull bar and a polymer bull bar;
- Where bull bars of the same brand and material were very similar between two vehicle models that were being tested, results from a single bull bar were used for both vehicle bull bar models.

The bull bars selected for testing are described in Table 1. The brand of each bull bar is not identified, but bull bars were selected from popular brands with national distribution.

The test locations were chosen to reflect moderate to severe impact locations on the bull bars:

- The Part A upper legform impact locations were a mixture of top-rail impacts mid-way between and also closer to the bull bar uprights;
- The Part B impact locations were chosen where the bull bars appeared to be structurally stiff, or where there was a significant mass of material surrounding the impact location;
- For the Part C child headform impacts, locations on the top rail were chosen, either close to or on the main bull bar uprights, subject to the test locations being at least 1000 mm above the ground. For very stiff bull bars, the test was carried out in the centre of the top rail, away from the stiffest part of the bar, to prevent damage to the headform.

For the vehicle comparison tests, locations that were not necessarily directly behind the bull bar test locations were selected but were likely to produce the most severe impact. This was done on the reasoning that any point along the vehicle is equally as likely to be struck as any other point.

Table 1 Bull bar descriptions

Vehicle	Steel bull bar	Aluminium/alloy bull bar	Polymer bull bar
Toyota Landcruiser	Aftermarket bumper replacement	OES bumper replacement	Not available at the time of testing
Nissan Patrol	OES bumper replacement	Aftermarket alloy nudge-bar	Aftermarket bumper replacement
Ford Courier	Aftermarket bumper replacement	OES bumper replacement	Aftermarket bumper replacement
Holden Rodeo	Aftermarket bumper replacement (note 1)	OES bumper replacement	Aftermarket bumper replacement
Toyota Hilux	OES bumper replacement	Aftermarket over-bumper style (note 2)	Not available at the time of testing

Notes:
1. The Holden Rodeo aftermarket steel bull bar was the same brand as, and was almost identical to, the Toyota Landcruiser aftermarket steel bull bar. Tests were performed on the Landcruiser bull bar and the results were used for both bull bars.
2. The Toyota Hilux aftermarket alloy bull bar was almost identical to the Nissan Patrol aftermarket alloy nudge bar, except for the addition of wing sections. Tests were performed on the Patrol nudge bar and the results were used for both bull bars.

Results

Part A test results – top of bull bar and bonnet leading edge

The results (Table 2) show that, by the measure of peak force generated in the test, the polymer bull bars tested produced the lowest force and that the results were at or under the Euro NCAP injury threshold value of 5.0 kN. It should be noted though that the test speed used in this study was 30 km/h and that typical test speeds in Euro NCAP tests are generally higher; so it should not be concluded that the polymer bull bars comply with Euro NCAP testing requirements. Yet, the polymer bull bars tested appeared to be safer than the leading edges of the vehicles that they were mounted to. The results of the bull bar tests were significantly associated with the bull bar material (Kruskal-Wallis test, $n=11$, $P < 0.05$).

bull bars produced the lowest bending moments and were, on average, better performing that the front of the vehicle. Two of the three tests on the polymer bull bars satisfied the performance requirements of the test. As with the peak force, the bending moment results of the bull bar tests were significantly associated with the bull bar material (Kruskal-Wallis test, $n = 11$, $P < 0.05$).

The alloy bull bar test results were generally similar to or worse than those for the fronts of vehicle, and the steel bull bars were much worse. In tests on the steel bull bars, the severity of the impact was so great that the measuring capability of the instrumentation was exceeded in every test.

The polymer bull bars produced, on average, bending moments less than the Euro NCAP injury threshold, but (as noted previously) at a lower impact speed than that which would be specified by the Euro NCAP protocol.

Table 2 Results of upper legform impact (Part A) tests by individual vehicle: peak force (kN)

Vehicle	Bonnet leading edge	Steel bull bar	Aluminium/alloy bull bar	Polymer bull bar
Toyota Landcruiser	7.7	12.4	6.3 3	Not available
Nissan Patrol	6.0	12.4 3	7.4	4.2
Ford Courier	5.7	12.4	8.5 3	5.0
Holden Rodeo	8.4	12.4 2	6.3 3	4.4
Toyota HiLux	4.5	13.3 3	7.4 2	Not available

Notes:
1. Bold figures denote best result
2. Denotes default result taken from another test on an equivalent bar (see Section 3)
3. Denotes results for tests on bull bars that are optionally factory fitted (OES)

The alloy bull bars tested performed similarly to the bonnet leading edge of the vehicles tested, but slightly worse overall. In contrast, steel bull bars produced about twice the impact force as the leading edges of the vehicles. Note that the similarity between three of the results does not reflect any "clipping" of the data that occurred in other tests on the steel bull bars, but indicates very similar performance across the bull bars tested.

The upper legform test also produced measures of the bending moment across the legform. The Euro NCAP limit for bending is 300 Nm. The bending moment results of the upper legform tests are shown in Table 3. Of all bull bars tested, the polymer

Part B test results – bumper section of bull bar and vehicle's standard bumper

Part B tests consisted of an upper legform impact on the bumper section of the bull bar. The measures of impact severity and the threshold values for injury were identical to the part A tests.

The impact force results of the tests are given in Table 4, by vehicle and bull bar (material) type. The results of tests with the vehicle bumper are also given. These latter tests show the performance of the vehicles without the bull bar. The bending moment results of the upper legform tests are shown in Table 5.

Table 3 Results of upper legform impact (Part A) tests by individual vehicle: peak bending moment (Nm)

Vehicle Leading edge	Steel bull bar	Aluminium/alloy bull bar	Polymer bull bar	
Toyota Landcruiser	469	>1025 4	541 3	Not available
Nissan Patrol	364	>1022 3, 4	635	156
Ford Courier	372	>1018 4	732 3	423
Holden Rodeo	608	>1025 2, 4	538 3	299
Toyota HiLux	362	>1007 3, 4	635 2	Not available

Notes:
1. Bold figures denote best result
2. Denotes default result taken from another test on an equivalent bar (see Section 3)
3. Denotes results for tests on bull bars that are optionally factory fitted
4. Over-range result. Peak bending moment clipped to this value

Table 4 Results of upper legform impact (Part B) tests by individual vehicle: peak force (kN)

Vehicle	Vehicle bumper	Steel bull bar	Aluminium/alloy bull bar	Polymer bull bar
Toyota Landcruiser	6.9	12.0	12.2 3	Not available
Nissan Patrol	11.7	13.6 3	7.3	7.1
Ford Courier	11.0	17.1	16.2 3	6.8
Holden Rodeo	4.1	12.0 2	9.4 3	11.9
Toyota HiLux	7.2	17.3 3	7.3 2	Not available

Notes:
1. Bold figures denote best result
2. Denotes default result taken from another test on an equivalent bar (see Section 3)
3. Denotes results for tests on bull bars that are optionally factory fitted

It may be noted that, according to the bending moment produced in these tests, the bull bars performed similarly to or often only slightly worse than the vehicle itself. However, the peak impact force produced by the bumper sections of the steel bull bars and two of the aluminium/alloy bars was considerably higher than that for the vehicle bumper. The bumper section of the bull bar presents a broad, flat surface to the impactor and hence bending across the impactor is not as pronounced as in tests with the top rail of the bull bar. However, the stiffness and mass of the bumper sections is such that the impact force produced is higher than in the tests of the top rails of the bull bars.

While some of the aluminium/alloy bars and the polymer bars performed similarly to the vehicle bumpers, all results, with the exception of one test, exceeded the injury threshold value of 5 kN / 300 Nm. Overall, the results of the bull bar tests were not significantly associated with the bull bar material (Kruskal-Wallis test, $n = 11$, $P > 0.05$).

Table 5 Results of upper legform impact (Part B) tests by individual vehicle: peak bending moment (Nm)

Vehicle	Vehicle bumper	Steel bull bar	Aluminium/alloy bull bar	Polymer bull bar
Toyota Landcruiser	406	412	791 3	Not available
Nissan Patrol	726	362 3	674	426
Ford Courier	693	982	>1034 3, 4	535
Holden Rodeo	88	412 2	640 3	660
Toyota HiLux	378	740 3	674 2	Not available
Average	458	582	763	540

Notes:
1. Bold figures denote best result
2. Denotes default result taken from another test on an equivalent bar (see Section 3)
3. Denotes results for tests on bull bars that are optionally factory fitted
4. Over-range result. Peak bending moment clipped to this value

Table 6 Results of headform impact (Part C) tests by individual vehicle: HIC value

Vehicle	Bonnet leading edge	Steel bull bar	Aluminium/alloy bull bar	Polymer bull bar
Toyota Landcruiser	1524 1	>4749 4	2514 3	Not available
Nissan Patrol	837	>5817 3, 4	2048	1162
Ford Courier	2156	5255	3092 3	612
Holden Rodeo	1160	>4749 2, 4	1246 3	1232
Toyota HiLux	1698	>6384 3, 4	2048 2	Not available

Notes:
1. Bold figures denote best result
2. Denotes default result taken from another test on an equivalent bar (see Section 3)
3. Denotes results for tests on bull bars that are optionally factory fitted
4. Acceleration was clipped. Actual HIC result higher than this value.

Part C test results – bull bar or vehicle leading edge > 1000 mm high

The results of the Part C tests are given in Table 6. The results show that the polymer bull bars produced the least severe headform impacts on average, but were more severe than the results of the tests on the corresponding vehicles in two of the three tests (Patrol and Rodeo). The steel and aluminium/alloy bull bars produced more severe impacts than either the polymer bull bars or the leading edge of the vehicle. In several of the tests of steel bull bars the HIC values listed are artificially low, as the acceleration exceeded the measurement range of the instrumentation. The results of the bull bar tests were significantly associated with the bull bar material (Kruskal-Wallis test, $n = 11$, $P < 0.05$).

Discussion

The results of the tests performed in this study support the view that bull bars increase the risk of injury to pedestrians. However, it is evident from these results that some bull bars are less aggressive to pedestrians than others. The vehicle itself may present a risk to a pedestrian in a crash and hence some bull bars may be less aggressive than the front of the vehicle that they are designed to protect.

Upper legform impact results

The Australian Standard AS 4876.1 does not include an impact that measures injury risk to adult pedestrians. In this study the EEVC WG17 upper legform impactor was used to examine the risk of upper leg injury to an adult pedestrian posed by a vehicle and a bull bar. As in the headform tests, the bull bars were tested at 30 km/h, rather than the 40 km/h nominated by the related EU Directive 2005/66/EC, because the metal bull bars and most of the original equipment bumpers were very stiff. There was concern that the tests at 40 km/h would have produced impacts beyond the range of instrumentation available, which would have meant that a useful comparison between the performance of the bull bars would not have been able to be made.

In tests with the top rail of the bull bars (Part A tests), only the polymer bull bars displayed acceptable impact performance, producing bending moments less than 300 Nm and forces less than 5 kN at 30 km/h. The polymer bull bars were mostly less aggressive in this regard than the leading edge of the vehicles that they were attached to.

Steel bars were very aggressive in Part A tests and an equivalent impact with a pedestrian's upper leg would almost certainly have resulted in severe pelvic and/or femoral injuries.

Part B tests of the bumper sections of bull bars and vehicles were almost uniformly poor, with the steel bars producing the highest impact forces and aluminium/alloy bars the highest bending moments. The original bumper of one vehicle (Holden Rodeo) performed very well in this test. While all polymer bull bars also performed poorly in Part B tests, they were less aggressive than the bumpers they replaced in two of three tests.

Headform impact results

While many of the bull bars performed poorly in the headform tests, it is also clear that the bonnet leading edge of most of the tested vehicles also performed poorly (Table 6). While the leading edges were, in many cases, less rigid than the steel bull bars and some of the aluminium/alloy bull bars, they too have not been designed to be safe in impacts with child or adult pedestrians and in many cases pose a high risk of injury in pedestrian collisions.

Nevertheless, the results demonstrate that the metal bull bars that we tested had a significantly worse impact performance than the bonnet leading edge of the vehicles. In two out of three headform tests, the polymer bull bars also performed worse than the vehicle but to a much lesser degree than the metal bars. However, it should be borne in mind that the vehicles performed fairly, or marginally in two tests and the polymer bull bar performed marginally in both of these cases. Furthermore, unlike the tests on the metal bars, the polymer bull bars were tested directly on the top of the bull bar stanchion, which was probably the stiffest location, making the comparisons less than favourable to the polymer bars.

OES bull bars and aftermarket bars

All of the original equipment supplied (OES) bull bars tested in this study were metal bars. They performed poorly in all tests and, with the exception of one Part A test, they performed worse than the front of the vehicle.

It appears from the results of the tests conducted that OES bull bar manufacturers and most aftermarket suppliers are not designing bull bars with pedestrian safety in mind, nor are the vehicle manufacturers requiring safe designs from OES bull bar suppliers. We would encourage vehicle manufacturers to specify that OES bull bars are tested and, at least, comply with the Australian Standard AS 4876.1 and that the manufacturers of aftermarket bull bars do likewise. Even though the Standard has limitations, compliance with the Standard would represent some improvement on the current situation.

Validity of the results

The primary aim of this study was to define a test method to measure the pedestrian impact injury risk posed by bull bars mounted to vehicles sold in Australia. To illustrate the usefulness of the method, we tested a selection of vehicles and bull bars made of a range of materials. The results appear to show that there are marked differences in performance between bull bars. While we tested as many bull bars as was feasible, the tests were too few and the bull bars were not selected in a manner to unequivocally generalise the differences between bull bars by the material from which they are constructed. We cannot conclude that all steel bull bars on the market are unacceptable, or that all polymer bull bars on the market are acceptable. However, we selected current generation bull bars that that are readily available to consumers, and within the range tested, material type was predictive of relative performance in Part A and Part C tests. There are plausible physical mechanisms that explain the relative performance of the bull bars in these tests, such as the density and stiffness of the materials and bull bar structures, and it is our opinion that thrust of the results might be somewhat generalisable to bull bars manufactured for passenger vehicles, and possibly for larger vehicles as well. It is our opinion that, should a method of evaluating bull bars be widely adopted, there would be changes in design and an improvement in the safety of these devices, whatever material is used.

It might be asked how well do the tests reflect what would happen to actual pedestrians. The chief justification for our choice of methods are: (i) the test tools, methods, and injury criteria are based on internationally recognised protocols that have undergone much development and the results are of a form that can be compared to other areas of crash testing; (ii) the measurements do reflect aspects of an impact that have physical meaning and are plausibly related to physical stresses that would be placed on the body in an impact. Therefore, the relative results of different tests should at least reflect a ranking of injury risk. Also, a study that used an EEVC headform test to reconstruct real crashes showed that the results of the headform tests do relate to actual injury severity (9). It is less clear how the actual values of bending moment and impact force in the upper legform relate to real injury risk.

One other aspect of the tests should be mentioned: The impactor measurements (with the possible exception of bending in the upper legform) do not necessarily distinguish between concentrated loading and distributed loading. For example, two tests with the same head impact result may not indicate differences in risk if one test were of a structure that caused highly concentrated loading and the other test was of a structure that distributed the loading during the impact. The stresses on the skull are higher in concentrated loading and hence we would expect more harmful consequences from such an impact. It is therefore also important to emphasise the geometry of bull bars as an important consideration in bull bar design from a pedestrian-protection point of view.

Conclusions

This paper has proposed a testing protocol for bull bars that goes further than the Australian Standard AS 4876.1 by including tests that represent an impact with the lower extremities of an adult pedestrian. Furthermore, a method is proposed in which performance is appraised against generally recognised injury risk thresholds. The method appears to differentiate the performance of the bull bars in the tests and so may be able to form the basis of a rating system for bull bars.

The tests showed that the steel bull bars tested pose significant risks to pedestrians in the event of a collision. Bull bars constructed of lighter metals (aluminium/alloy) performed better but were still slightly worse than the fronts of the vehicles to which they attach. The polymer bull bars improved same aspects the pedestrian impact performance of the vehicles and may prove to be an acceptable way of protecting the front of the vehicle without causing increased risk of injury to pedestrians.

It should be noted that the vehicles themselves performed poorly, highlighting the lack of any vehicle safety standard in Australia for the protection of pedestrians.

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Road Safety Literature

Recent Publications

Australian Transport Safety Bureau

Australian Transport Safety Bureau, November, 2007, *Road Deaths Australia, Monthly Bulletin.*

Australian Transport Safety Bureau, "Psychosocial factors influencing mobile phone use while driving", Road Safety Research Grant Report 2007-06.

[Enquiries should be directed to: Ms Sandra Hutchinson, Queensland University of Technology (QUT), Telephone, 07 3138 2130].

To assist in the design of future campaigns to counter the use of mobile phones while driving, the study involved the development of an Implicit Association Test to measure attitudes toward speeding. The theory of planned behaviour was used to investigate factors relating to mobile phone use while driving.

Study 1 (N = 47) (a) brought to light behavioural, normative, and control beliefs towards use of mobile phones while driving and (b) assessed situational factors affecting this practice.

Study 2 (N = 801) examined how attitudes, normative pressures, and control factors influenced intention to use a mobile phone while driving (a) in general, and (b) in four scenarios manipulating driving condition (moving versus stationary) and driver motivation (in a hurry versus not in a hurry).

The research also explored the effects of :

- age,
- gender,
- driving purpose,
- perceived risk of apprehension,
- perceived risk of crashing, and
- addictive tendencies towards mobile phone use.

Differences in the underlying beliefs held by participants with strong and weak intentions to use a mobile phone while driving were also assessed.

The perceived risk of apprehension or crashing did not have much impact on participants' intention to engage in this behaviour.

By studying factors that influence drivers' decisions to use their mobile phones while driving (a) we can improve our understanding and (b) provide information for future campaigns designed to reduce this unsafe driving practice.

Other Literature

Boorman M, Papafotiou K, 2007, "The Victorian legislative framework for testing drivers for impairment caused by drugs other than alcohol: an evaluation of the characteristics of drivers detected from 2000 to 2005", pp. 217-223, *Traffic Injury Prevention,* Vol.8, No.3, Taylor and Francis Group.

(Traffic Drug and Alcohol Section, Brunswick, Victoria).

On December 1, 2000, new legislation came into force in Victoria, which required a procedure for the police to be followed in the detection of drivers impaired by drugs other than alcohol.

The use of performance tests, known as the "standardized field sobriety tests", and the analysis of blood samples for the presence of drugs other than alcohol, are the essential parts of the procedure.

The article explains the legislation and the enforcement procedures currently in place in Victoria. It also evaluates the data collected using the framework for the first five years since implementation in Victoria.

Coggan C, Gabites L, 2007, "Safety and local government - Partnerships and collaboration: How to find all those intersections and actually do something about it", pp. 94-105, *Social Policy Journal NZ,* No. 32, New Zealand Ministry of Social Development

(Safe Communities Foundation New Zealand; Wellington City Council

In developing their Long-Term Community Plans to address their obligations under the Local Government Act 2002, territorial local authorities in New Zealand are giving greater attention to safety.

This article provides a case study of the rationale and processes used by the Wellington City Council in its progress to achieving Safe Community status, and the partnerships and collaborations that were part of this process. As a result, it addressed the six criteria required for accreditation as a WHO Safe Community, and part of the International Safe Community Network on 14 June 2006. It demonstrates that to improve community safety it is necessary to develop policies that encourage successful partnerships and networks between individuals, organisations and other providers.

Curtin E, Langlois NE, (University of Sydney) 2007, "Predicting driver from front passenger using only the post-mortem pattern of injury following a motor vehicle collision", *Medicine Science and the Law,* Vol. 47, No. 4, pp. 299-310, Barnsbury Publishing.

An investigation aimed to establish if post-mortem injury patterns can assist in distinguishing drivers from front seat passengers among victims of motor vehicle collisions without regard to collision type, vehicle type or if safety equipment had been used. Post-mortem reports of the injuries sustained by 206 drivers and 91 front seat passengers were used.

Drivers were more likely to sustain the following injuries: brain injury; fractures to the right femur, right posterior ribs, base of skull, right humerus and right shoulder; and superficial wounds at the right lateral and posterior thigh, right face, right and left anterior knee, right anterior shoulder, lateral right arm and forearm and left anterior thigh. Front passengers were more vulnerable to splenic injury; fractures to the left posterior and anterior ribs, left shoulder and left femur; and superficial wounds at the left anterior shoulder region and left lateral neck.

Linear discriminant analysis generated a model for predicting seating position based on the injury patterns. The study indicated that fatalities of driver and front-seat passenger, in motor vehicle collisions, result from different injury patterns, regardless of collision type. The overall predictive accuracy of the model was 69.3%.

It was suggested that larger study is required to improve the predictive accuracy of this model and to ascertain its value to forensic medicine.

Davey J, Richards N, Freeman J, 2007, "Fatigue and beyond: patterns of and motivations for illicit drug use among long-haul truck drivers", pp. 253-9, *Traffic Injury Prevention,* Vol. 8, No.3, Taylor and Francis Group.

(Centre for Accident Research and Road Safety, Queensland University of Technology).

The illicit drug use pattern of long-distance truck drivers was investigated. This is a special interest group in terms of drug-driving research and policy due to (a) high rates of use, (b) involvement of drugs in truck accidents, and (c) the link between drug use and work-related fatigue.

Interviews were conducted at truck stops and loading facilities, in both metropolitan and regional cites throughout Queensland, with 35 long-haul truck drivers.

In a majority of cases, a high rate of legal and illicit drug use (particularly amphetamines) was reported. However, unlike previous studies that focus on fatigue, this research found overlapping and changing motivations for drug use during individual lifetimes. Reference was made to Becker's model of a drug use "career".

In this context, some drivers begin illicit drug use before they commence truck driving. As well as fatigue, powerful motives such as peer pressure, wanting to fit the trucking "image," socialization, relaxation, and addiction were also reported as contributing factors to self-reported driving under the influence of drugs.

The results indicate that these additional social factors may need to be considered and incorporated with fatigue factors when developing effective drug prevention or cessation policies for truck drivers.

Davey JA, 2007, "Older People and Transport: Coping Without a Car", pp. 49-65, *Ageing Society,* Vol. 27, No. 1, Cambridge University Press.

A study was commissioned by the Office for Senior Citizens of the New Zealand government to determine the impact on the quality of life of older people, caused by the lack of transportation.

Face-to-face semi-structured interviews were conducted in 2004 with 28 couples and 43 single people (14 men and 29 women). The average age of the men was 84.5 years and of the women 81.4 years, and all had been without private transportation for at least six months. Information was sought about the experiences and opinions of older people who were without a car for mobility, and how this affected their lifestyle and quality of life, and how they met their transport needs.

The findings reveal variations by:

- gender,
- health status,
- personal outlook, including views on independence and reciprocity.

The authors conclude that while essential transport requirements may be available by alternative means, discretionary trips that contribute significantly to the quality of life, may be eliminated when private transport is unavailable. It is submitted that the findings have implications for local and national policy and planning, extending well beyond the sphere of transport, and illuminate processes of social exclusion among older people.

De Rome L, and Brandon T, 2007, "A Survey of Motorcyclists in NSW",
Motorcycle Council of NSW Inc. 39 pages

De Rome L, Stanford G, and Wood B, 2007, "Positioned for Safety 2010: A Motorcycle Safety Strategic Plan 2007-2010", Motorcycle Council of NSW Inc.
92 pages at MCC006_PFS2010_Web.pdf

Editorial, 2007, "2004 Vehicle Frontal Crash Test Data", pp. 37-46, *Accident Reconstruction Journal,* Vol.17, No. 5.

This article presents frontal crash test data for impact tests conducted on 2004 model-year vehicles. Test speeds and crush dimensions are given in English units. 74 photographs are also included of some of the best-selling 2004 models at the instant of impact.

Editorial, 2007, "2004 Vehicle Rear Crash Test Results", pp. 23-25, *Accident Investigation Quarterly,* No. 45 (Published by Accident Reconstruction Journal).

The USA National Highway Traffic Safety Administration (NHTSA) conducts extensive crash testing to evaluate a vehicle's occupant protection capability. During much of this testing, residual crush data is also recorded. This paper presents this residual data from individual crash test reports for 5 vehicle models.

In the NHTSA frontal crash tests, the test vehicle is propelled into a rigid wall-like structure and moves very little, if any, after impact. Energy absorbed by crushing the vehicle structure essentially equals the kinetic energy the vehicle had at impact.

However, in rear crash tests, calculation of the energy absorbed by the crush of the vehicle is more complex, since both the barrier and test vehicle are moving after impact. If the damage can be equated to what would have been caused by the vehicle rolling backwards into a fixed barrier, normal methods can be used to determine vehicle stiffness parameters. By assuming no significant energy absorption by the barrier, the dissipation of energy equation can be used to find the equivalent impact-into-fixed barrier speed of the test vehicle.

Fastenmeier W, Gstalter H, 2007, "Driving Task Analysis As a Tool in Traffic Safety Research and Practice", pp.952-979, *Safety Science,* Vol. 45, No. 9, Elsevier Publishing.

(Institute for Applied Psychology, Germany)

Justification is given for task analysis involved in car driving, viz. because the interaction between the car drivers' capabilities and the demands of the actual driving task determines the outcome in terms of a more or less safe driving behaviour.

Past approaches to the problem are reviewed and a new procedure for driving task analysis and driver requirement assessment (SAFE: Situative Anforderungsanalyse von Fahraufgaben) is outlined.

Some examples of how the analysis can be applied are given and the future usefulness of this method is discussed.

Fitzharris M, Fildes B, Charlton J, 2006, "Anxiety, acute- and post-traumatic stress symptoms following involvement in traffic crashes", pp. 283-301, *Annual Proceedings of the Association for the Advancement of Automotive Medicine,* No. 50, Association for the Advancement of Automotive Medicine.

(with involvement of: Accident Research Centre, Monash University; Department of Trauma Surgery, National Trauma Research Institute, The Alfred Melbourne).

Anxiety and traumatic stress are common post-crash symptoms. This study documents generalised anxiety post-crash responses, and examines the association between Acute Stress Disorder and Post-Traumatic Stress Disorder (PTSD) with personality and coping styles.

A sample of 62 hospitalised patients aged 18-60, were interviewed (a) prior to discharge, (b) at 2-months post-crash and (c) at 6-8 months post-crash. Anxiety symptoms were common, with 55% of participants experiencing moderate-severe levels prior to discharge, with this decreasing to 11% and 6.5% at 2-months and 6-8 months post-discharge, respeciively. Females reported significantly higher levels of anxiety and acute distress. Neuroticism and generalised coping styles were associated with acute stress responses but not PTSD. These results have important theoretical and practical implications, and indicate that females are at risk of poorer acute anxiety outcomes following injury.

Fitzharris M, Fildes B, Charlton J, Kossmann T, 2007, "General health status and functional disability following injury in traffic crashes", pp. 309-30, *Traffic Injury Prevention,* Vol. 8, No. 3, Taylor and Francis Group.

(Accident Research Centre, Monash University).

A shift to understand the consequences of injury in traffic crashes has risen to greater importance with increasing rates of survival. This prospective cohort study set out to examine general health status and functional disability at 2 months and 6-8 months post-crash.

Sixty-two adults completed interviews prior to discharge and at 2 months and 8 months post-discharge. The participants (excluding those with moderate-severe head injury and spinal cord injury) were otherwise healthy adults aged 18-59 years who were admitted to hospitals.

This study demonstrated significant, ongoing loss of health-related quality of life and impairment associated with injuries sustained in road crashes, highlighting the need for continuing care post-discharge to facilitate a rapid return to optimal health.

Hellinga LA, McCartt AT, Haire ER, (U.S. National Safety Council), 2007, "Choice of teenagers' vehicles and views on vehicle safety: Survey of parents of novice teenage drivers", pp. 707-713, *Journal of Safety Research,* Vol.38 No. 6, Elsevier.

During 2006 some 300 parents were interviewed to determine their decision-making about vehicles driven by teenagers while they were taking their first on-road driving tests and parental knowledge of vehicle safety.

Less than 50% of parents surveyed said teenagers would be the primary drivers of the chosen vehicles. Parents most often cited safety, existing family vehicle, and reliability when explaining the choices for their teenagers' vehicles. About half of the vehicles intended for teenagers were small sports cars, pickups, or small utilities - vehicles considered less safe for teenagers than midsize/large cars or minivans.

Although the majority of parents understood some of the important criteria for choosing safe vehicles, they actually selected many vehicles for their teenagers that provide inferior crash protection.

International Road Federation, December 2007, "Motorcycle Safety". Text at:

http://irfroadsafetymatters.blogspot.com/2007/12/motorcycle-safetyy.html

Kenney K.S. and Fanciullo L.M., 2005, "Automobile air bags: friend or foe? A case of air bag-associated ocular trauma and a related literature review", *Optometry,* pp. 382-386, Vol. 76 No. 7

McEvoy SP, Stevenson MR, Woodward M, 2007, "The contribution of passengers versus mobile phone use to motor vehicle crashes resulting in hospital attendance by the driver", pp. 1170-1176, *Accident Analysis and Prevention,* Vol. 39, No. 6, Elsevier Publishing.

(The George Institute for International Health, The University of Sydney)

There is evidence that mobile phone use while driving (including hands-free) is associated with motor vehicle crashes. However, whether the effects of mobile phone use differ from that of passengers in the vehicle remains unclear. The aim of this research was to estimate the risk of crash associated with passenger carriage and compare that with mobile phone use. A case-control study ('passenger study') was performed in Perth, Western Australia in 2003 and 2004. Cases were 274 drivers who attended hospital following a motor vehicle crash and controls were 1096 drivers (1:4 matching) recruited at service stations matched to the location and time and day of week of the crash. The results were compared with those of a case-crossover study ('mobile phone study') undertaken concurrently (n=456); 152 cases were common to both studies. Passenger carriage increased the likelihood of a crash (adjusted odds ratio), 95% confidence interval, 1.6, 1.1-2.2). Drivers carrying two or more passengers were twice as likely to crash as unaccompanied drivers (adjusted odds ratio 2.2, 95% confidence interval 1.3-3.8). By comparison, drivers' use of a mobile phone within 5min before a crash was associated with a fourfold increased likelihood of crashing (Odds ratio 4.1, 95% confidence interval 2.2-7.7). Passenger carriage and increasing numbers of passengers are associated with an increased likelihood of crash, though not to the same extent as mobile phone use. Further research is needed to investigate the factors underlying the increased risks.

New PW, Sundararajan V. 2007, "Incidence of non-traumatic spinal cord injury in Victoria, Australia: a population-based study and literature review", *Spinal Cord,* Nature Publishing Group.

(Spinal Rehabilitation Unit, Caulfield General Medical Centre, Caulfield, Victoria; Department of Medicine, Monash University, Melbourne; Department of Epidemiology and Preventive Medicine, Monash University, Melbourne).

This study aimed to determine the incidence of non-traumatic spinal cord injury in Victoria. Data collection was from the database of hospital admissions in Victoria.

The study involved all patients admitted to hospital with a new onset of non-traumatic spinal cord injury, or who developed the injury after hospitalization, between 1 July 2000 and 30 June 2006, and identified using a population-based database. Age and gender of non-traumatic spinal cord injury patients were recorded.

It was concluded that non-traumatic spinal cord injury is strongly correlated with age and is more common than traumatic spinal cord injury.

Potts IB, Harwood DW, Richard KR, "Relationship of Lane Width to Safety for Urban and Suburban Arterials", TRB 2007 Annual Meeting – can be viewed at http://www.completestreets.org/documents/10FtLanePaper.pdf

The research found no general indication that the use of lanes narrower than 3.6m on urban and suburban arterials increases crash frequencies. This finding suggests that geometric design policies should provide substantial flexibility for use of lane widths narrower than 3.6m. Inconsistent results were found which suggested increased crash frequencies with narrower lanes in three specific design situations. Narrower lanes should be used cautiously in these three specific situations unless local experience indicates otherwise.

Oxley JA, Charlton JL, Koppel SN, Scully J, Fildes BN, 2005, "Crash risk of older female drivers-contributing factors", pp. 345-360, *Annual Proceedings of the Association for the Advancement of Automotive Medicine,* No. 49, Association for the Advancement of Automotive Medicine.

(Accident Research Centre, Monash University, Clayton, Australia).

Some factors that may predict crash involvement were identified using data from (a) a self-administered survey of 673 older female drivers, and (b) a case-control study of 48 crash-involved and 44 non crash-involved older female drivers. Survey data included self-reported information on demographic characteristics, health status, travel patterns and driving practices.

Factors found to predict crash involvement included:

- driving characteristics such as being the main driver in the household,
- not highly confident of being a safe driver,
- experiencing difficulty driving in unfamiliar areas, and
- having problems with the driving style of other drivers.

In addition, crash involvement can also be predicted from low attention, cognitive and motor skills and presence of multiple medical conditions.

Walton JR, Barrett ML, Agent KR, 2007, "Evaluation of Methods to Limit the Time Taken to Investigate Crash Sites", *Accident Investigation Quarterly,* (46): 30-40, 48, Accident Reconstruction Journal.

A study was completed into the means of reducing the time required to investigate and clear crash scenes. This included a review of best practices, including a detailed examination of the use of photogrammetry for reconstruction. Findings suggest that the use of photogrammetry is declining due to the costs, labour intensity, steep learning curve and difficulty mapping and qualifying the data.

The authors recommend methods to reduce the time taken to investigate crash sites.

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