May 2010 Vol 21 No 2

Journal of the Australasian College of Road Safety

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Contents

Cover photo

Although beautiful for tourists taking a leisurely weekend drive, many country roads have features that can contribute to crashes, particularly when speed, poor weather or sub-standard road conditions are involved. This issue features 'Safer roads'.

Editorial policy

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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The Journal of the Australasian College of Road Safety

(published from 1988-2004 as 'RoadWise')

ISSN 1832-9497

Published quarterly by the Australasian College of Road Safety, PO Box 198, Mawson, ACT 2607, Australia

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Letters intended for publication should be sent to the Managing Editor. Published letters would normally show the name of the writer and their State or Territory of residence, unless anonymity is requested.

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The *Journal of the Australasian College of Roadsafety* publishes articles in all facets of the study of traffic safety. Articles are accepted from a variety of disciplines, such as medicine, health studies, road and automotive engineering, education, law, behavioural sciences, history, urban and traffic planning, and management. Interdisciplinary approaches are particularly welcome.

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Articles may be up to 5000 words in length and should be submitted in Microsoft Word format as email attachments to the Managing Editor at journaleditor@acrs.org.au. The email message should state whether or not peer review is requested. Articles should not be submitted if they have been published previously or are under consideration by other publishers.

By submitting an article, authors give their permission to the College to make minor editorial changes to conform to the College in-house style, to print the article in the *Journal of the Australasian College of Road Safety*, to send it for indexing to SafetyLit and Informit databases, and to make the full text of the article available online through the ACRS website and Informit. All photographs and diagrams for which the author or the author's employing organisation does not hold copyright must be accompanied by permission, as indicated above, from the copyright holder.

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From the President

Dear College Members,

There is some good news to report in my remarks for this issue. We should all be encouraged by the Australian Government's recent co-sponsorship of the proclamation at the United Nations General Assembly of the Decade of Action for Road Safety (2011-2020). The UN commitment to a 'goal to stabilize and then reduce the forecast level of road traffic fatalities around the world by increasing activities conducted at the national, regional and global levels' has to provide a positive umbrella for the College activities.

A recent UNESCAP report demonstrated road traffic injuries are the second most common cause of death of people between 5 and 29 years of age. Across the world, an estimated 3500 people die and 100 000 people are injured in road crashes every day. These tragedies are increasing dramatically, and without action, it is estimated that two thirds of the world's projected 2.4 million road deaths a year will occur in the Asia Pacific region by 2030.

WHO research indicates that by 2020, developing countries will be spending 25 per cent of their annual health budgets on road traffic casualties. Crashes are already estimated to cost the developing countries of the Asia Pacific region over US$80 billion per year.

Australia has the expertise and the resources to lead efforts to help reverse this trend. Australia's funding commitment to the World Bank Global Road Safety Facility has already supported efforts to prevent deaths and injuries in the region.

The challenge of the United Nations commitment to a Decade of Action is to promote early decisive action at a scale that will make a difference. Coordinated action will save many lives and reduce considerable permanent injury to the young and also the most productive people in each country.

Investment in road safety is a valuable and sustainable contribution to every country's economy. Road trauma affects every community, and in addition to the personal impacts and loss, the costs bear heavily on the economy, health, and transport and trade – and importantly, the achievement of the Millennium Development Goals.

At the end of March, the College welcomed the announcement by the Hon. David Campbell MP, NSW Minister for Transport and Roads, of a $170m program for a package of road safety measures. See more details on page 13. It was good to see a range of measures being introduced simultaneously.

As part of taking a new look at how to reduce road trauma, the South Australian Government has nominated Fred Wegman, the Managing Director of the Netherlands Institute of Road Safety Research, as their 'Thinker in Residence'. The Adelaide Chapter in conjunction with the AITPM is organising a seminar with Fred in May, which we will report on in the next issue.

At ANCAP we were pleased to report a major improvement in the crash test result for the recently introduced Great Wall Motors SUV over their utility we crashed last year. Research clearly shows the improvements in crashworthiness in many new models, an increasing number of new cars achieving a 5 star ANCAP rating. Research from MUARC has shown the importance of young drivers being in safer cars.

As you know, a Federal election is due this year. Road safety rarely gets any comprehensive mention in policy documents. At the last election the College did make a comprehensive set of proposals and I think we can claim some credit for the new road safety council from our work.

This month we would like to hear what you think the key issues are that the next Federal Government could do to improve road safety results. Email Linda at the office (eo@acrs.org.au) and we will collate these to send to all political parties.

Another area where you could help is helping us support the College. Your membership fees only provide about 25 per cent of the College revenue; the rest is from sponsorships or the small surpluses from events. Should you, or your company, be able to increase your support or identify others who could provide support, everyone would benefit. Again, please let Linda know if you can help.

Lauchlan McIntosh AM, FACRS

30 April 2010

RRSP profile - Senior Sergeant Steven Perry

Following the introduction of this feature in the May 2009 journal, we are continuing to profile in each issue an ACRS member who is on the ACRS Register of Road Safety Professionals. To be on the Register, applicants must satisfy stringent criteria. They must have relevant academic qualifications, have worked for at least five years at a senior level in their particular field of road safety, and be acknowledged as an expert by their peers. For details, visit www.acrs.org.au/professionalregister.

This issue focuses on Steven Perry. He is a Senior Sergeant with Victoria Police and is attached to the Office of the Assistant Commissioner Traffic and Transit Safety Department (TTSD).

Steven's extensive experience within the Victoria Police spans 28 years, including specialised duties at the Prosecutions Divisions, Traffic Camera Office, Strategic Policy and Road Safety Information Group and the Vehicle Impoundment Unit.

He has been involved in numerous projects, including the Victoria Police 'Tyre Deflation Device Project' and 'Operation Countdown Multi-Media Mobile Display Vehicle Project'. He was an organising committee member for the 2007 Australasian Road Safety, Research, Policing and Education Conference and an organising committee member for the Saferoads 2008 Conference. He has presented at a number of state and national conferences on a variety of road safety topics.

Steven holds a Post Graduate Diploma in Road Safety, issued from Queensland University of Technology (CARRS-Q), and also holds further qualifications in Training, Business Management and Emergency Management.

Steven's professional affiliations include the following: Member of the Australasian Institute of Traffic Planning and Management Inc., Associate Fellow and RRSP of the Australasian College of Road Safety, and Fellow of the Australasian Institute of Policing (AIPOL).

We asked Senior Sergeant Perry the following questions:

How long have you been a member of the College?

I have been a member for three years, having joined in 2007.

What do you value most about your membership?

Membership of the College provides me with a broad network of contacts in spheres of road safety, including engineering, academia and business. My participation in the Victorian sector executive group maintains my contemporary knowledge of road safety impacting multi specialist fields.

What is your particular expertise in road safety?

I have been recognised by the Australasian College of Road Safety as an expert in 'Enforcement'.

What is a typical working day for you?

A typical working day involves a mix of project management and corporate reporting functions. For example, this includes corporate reporting on Traffic and Transit Safety Department business performance, reporting Victoria Police performance against the Victorian road safety strategy Arrive Alive and against the Victoria Police Road Policing Strategy, and project management of the Vision 237 Victoria Police Road Policing Conference 2010.

At the time of this interview, Steven was informed that he has been selected for a 12-month secondment to the Australian and New Zealand Police Advisory Agency (ANZPAA) as the Road Policing Advisor. More information about ANZPAA is at www.anzpaa.org.au/.

Quarterly News

Welcome to our new sponsor: Brifen Australia

The ACRS would like to welcome Brifen Australia as a new sponsor for the *ACRS Journal* for the coming year. Brifen Australia (www.brifen.com.au) is the licensee of the patented Brifen Wire Rope Safety Fence system.

The Brifen wire rope safety fence is the original high tension cable barrier system developed by the UK Department of Transport in the 1960s; it was refined further in the 1980s to include interweaving ropes to increase the efficiency of energy absorption. Brifen first introduced tensioned wire rope safety barriers into Australia in 1991.

The Brifen fences are unique safety crash barriers, with all fences involving two or more ropes interwoven between the posts. The interaction of the ropes with the posts limits the flow of stretch in the ropes due to the friction of post on rope. This interaction controls the deflection performance of the fence, regardless of fence length.

College Chapters

Australian Capital Territory and Region

This has been another active year for the ACT and Region Chapter with a major seminar conducted on the Safe System approach.

The Chapter is pleased to note that latest available fatality data show that the ACT road death rate remains around 5.0 per 100,000 population – the lowest in the country and well below the national average of 7.0. The small data set for the ACT makes year on year comparisons somewhat difficult; however, the ACT road toll for 2009 was 12, two less than that recorded in the ACT for both 2007 and 2008.

ACT Chief Minister Jon Stanhope has taken a direct interest in road safety matters and has personally convened three roundtable discussion groups with key stakeholders. The College has been represented in these discussions by Chapter Treasurer Mr Robin Anderson. The Chapter has been providing feedback to the government about what the Chapter regards as key priorities and opportunities for linkages with the College. The roundtables are a heartening development.

In terms of the future, the Chapter is concerned about the small number of active members in the ACT and Region; the loss of some long-standing members through retirement and other circumstances, presents a number of difficulties. Recruitment of new members will be a priority for the Chapter.

(Stephen Jiggins, ACT and Region Chapter Representative on the ACRS Executive Committee)

New South Wales

The last seminar run by the Chapter was in December 2009. The topic was ‘Crunch time - National Road Safety Strategy towards 2020’. Harry Camkin chaired and moderated the meeting. Presentations were provided by Lauchlan McIntosh, David Healy, Barry Watson and by me. An article by Harry based on the meeting outcomes was published in the College journal and presented to the Federal National Road Safety Council for their consideration.

Also earlier this year saw Liz de Rome, Lori Mooren and me appointed as full members of TRB Committees (Motorcycle Safety, Truck and Bus Safety and Occupant Protection, respectively), which is an honour for Australian (i.e., non-US) transportation workers. This means five Sydney Chapter executive members now serve on current TRB Committees, including Teresa Senserrick (Operator Education and Regulation) and Ian Faulks (Occupant Protection).

Unfortunately, the College Chapter members’ work is never done until we reduce the deaths to zero. The number killed in 2009 rose alarmingly by an extra 106 deaths. The 2010 numbers so far appear to be similar to 2009. Some members of the committee attended a Road Toll Roundtable held in July last year by the Minister for Police and the Minister for Roads. It was concluded that speeding was a major factor as a result of the changes to the demerit points system, and that NSW was the only state not to have mobile and covert safety speed cameras. Fortunately, the new $170M program of countermeasures recently approved by the NSW government will include a rollout of mobile covert safety cameras. Let’s hope these cameras will have the same significant effect they did in Victoria when it rolled out its mobile safety speed camera program back in 1990 and 2002.

The Chapter is planning seminars on ‘Pedestrian safety’ in July, ‘Young drivers and driver monitoring systems’ in October and ‘Motorcycle safety and road side barriers’ in December. We hope to see a good turnout from NSW members.

(Prof. Raphael Grzebieta, NSW Chapter Chair and Representative on the ACRS Executive Committee)

Queensland

On 1 December the Queensland Chapter held its final seminar and Chapter meeting for 2009. The seminar ‘Exploring the psychosocial influences upon the risky behaviour of young drivers’ was presented by Ms Bridie Scott-Parker, PhD candidate at CARRS-Q.

The Queensland Chapter began 2010 with the quarterly meeting and a seminar on 2 March. The seminar was co-presented by Mr Ben Wilson, Manager, Bicycle Queensland, on ‘Bicycle Queensland: Improving safety by design and what’s possible in Queensland’ and by Professor Narelle Haworth, CARRS-Q, on ‘Bicycle Safety Research at CARRS-Q’.

Ms Nerida Leal was the inaugural winner of the Road Safety Sponsorship award. This award was for outstanding achievement to a graduating student in the Graduate Certificate or Graduate Diploma in Road Safety from QUT. The prize value is $500.

The Queensland Chapter will be calling for nominations for the June AGM. The next Queensland Chapter meeting, seminar and AGM is scheduled for Tuesday, 1 June 2010. Negotiations are currently taking place to set up a new ACRS Chapter in Cairns.

(Dr Kerry Armstrong, Queensland Chapter Representative on the ACRS Executive Committee)

South Australia

The South Australian Chapter held two lunchtime dialogues over the last quarter. The March dialogue, titled 'The road toll and what to do about it', was presented by Dr Robert Anderson of the Centre for Automotive Safety Research at the University of Adelaide. The dialogue provided a discussion of the past decade of road safety initiatives in South Australia and an opportunity for members to contribute ideas towards the next National Road Safety Strategy for 2011 to 2020. Outcomes will be submitted to the National Executive for submission to the newly created National Road Safety Council. There were 52 attendees.

The April dialogue on 'Hoon driving and car club culture' was presented by Inspector Phillip Newitt from the South Australian Police. It highlighted the enforcement response to an organised hoon driving culture that existed in Adelaide and the types of risks taken on the road by a select group of people. There were 43 attendees.

Next quarter Professor Fred Wegman will be in Adelaide as its next 'Thinker in Residence'. Professor Wegman is Managing Director of the Institute for Road Safety Research in the Netherlands (SWOV). The College will be involved in a series of 'Thinker in Residence' event. A major seminar is planned on 19 May in partnership with the Australian Institute of Traffic Planning and Management (ATIPM).

(Jeremy Woolley, South Australian Chapter Representative on the ACRS Executive Committee)

Victoria

The Victorian Chapter staged a successful seminar on the safety of older drivers on 15 March. The seminar capitalised on the presence of an American visitor, Eline Schold Davis, who is Project Coordinator of the American Occupational Therapy Association's Older Driver Initiative. Her visit was sponsored by the RACV in Victoria. Dr Judith Charltion of MUARC and Fiona Morris, Manager of Medical Review at VicRoads, also presented.

The next seminar on 'Motorcycle safety' is scheduled for 10 May. College executive members Raphael Grzebieta and Liz de Rome will present their work addressing motorcycle safety in terms of infrastructure design and protective clothing, respectively.

(David Healy, ACRS Co-Vice President and Victorian Chapter Representative on the ACRS Executive Committee)

Western Australia

A joint workshop with Main Roads WA, entitled 'Engineering towards zero: Practical road safety solutions', will be held on 4 June.

(Paul Roberts, Western Australian Chapter Chair and Representative on the ACRS Executive Committee)

Australia and New Zealand

Black spots to be fixed

On 20 and 21 April, Federal Infrastructure and Transport Minister Anthony Albanese announced funding for major black spot improvement works. Nationally, the program's funding has been doubled to half a billion dollars. All projects were recommended by a panel of independent road safety experts and will be delivered during the 2010-11 financial year. An independent evaluation of the program found it had prevented at least 32 fatalities and more than 1,500 serious injuries in its first three years. Nominations for black spot locations are invited from State and Territory government, local councils, community groups and associations, road user groups, industry and individuals. (*Source*: www.minister.infrastructure.gov.au/aa/releases/2010/April/index.htm)

ARRB turns 50

On 15 April, the Australian Road Research Board celebrated its 50th anniversary. ARRB was established in March 1960 by all Australian State and Territory road authorities to undertake research of national importance that the members could not justify carrying out individually. New Zealand and the Local Government Association have also joined. Major achievements include research that has led to two Chief Scientists being recognised with Clunies Ross Foundation Awards and the preparation of over 90 Austroads best practice guides.

Over the last 10 years, ARRB has successfully moved from a reliance on grant funding to a hybrid of grant funding and commercial operation. While doing so, it has maintained its research role and expertise and is recognised as one of the leading road transport research organisations in Australia and worldwide. During 2010, ARRB will continue to celebrate 50 years, with the 24th ARRB Conference to be held in Melbourne on 13-15 October.

State-of-the-art driving simulator

The Centre for Accident Research and Road Safety – Queensland (CARRS-Q) at the Queensland University of Technology is undertaking a $1.5 million project that allows drivers to step into a Holden Commodore and simulate driving at speed under different conditions. The simulator uses eight computers, projectors and a six degree of freedom motion platform. The simulator will be available to researchers through contract or collaborative arrangements. (*Source*: *Computerworld*, www.computerworld.com.au/article/ 340227/hi-tech_carrs-q_driving_simulator_advance_road _safety/?fp=2&fpid=1)

Safe alternative transport for young people

Youthsafe has conducted a study entitled 'Safe alternative transport options for young people: Scheme evaluation', available at www.youthsafe.org/alternative-safe-transport.html. Case studies include the Randwick City Council Pumpkin Bus and the Eurobodalla Shire Council taxi voucher scheme. The survey found that almost half the SAT scheme users had not planned their transport home that night and that the scheme helped the majority to obey passenger restriction laws, to avoid drink driving and not to get a lift with a drink driver. (*Source*: *yRED Youthsafe newsletter* no. 1, 2010)

Road safety campaigns

VicRoads' advertising campaign of nine short video clips targeting young people, each ending with the message 'Don't be a dickhead', has caused complaints to the Advertising Standards Bureau and the Human Rights Commission. The Victorian government defended the campaign aimed at getting the message across that mobile phone use while driving was socially unacceptable. A targeted social networking strategy is seeding the clips onto websites, forums and blogs that attract young people. (*Sources*: www.vicroads.vic.gov.au/Home/NewsRoom/News+Releases/OnlineCampaignTargetsYoungDriverBehaviour.htm and *The Age*, 31 March 2010, p. 7)

The Daily Telegraph has started a campaign for individuals to take responsibility for safe driving. The campaign is supported by the NSW government and the RTA. The campaign, which asks people to pledge to improve their driving behaviour, has targeted politicians, celebrities, and Woolworths' supermarket staff. (*Source*: www.dailytelegraph.com.au/ipromise)

The Centre for Automotive Safety Research at the University of Adelaide has published *Best practice in road safety mass media campaigns* to try to answer the question of what makes a campaign succesful. The report reviews the Australian and international road safety mass media literature from 2001 to 2009, focusing on what elements of road safety advertising are most effective and for which road user groups. (*Source*: casr.adelaide.edu.au/publications/list/?id=1165)

Community attitudes

The *Community Attitudes to Road Safety - 2009* survey report by Tina Petroulias documents the findings from the Department of Infrastructure, Transport, Regional Development and Local Government's 2009 survey of community attitudes to road safety. The 21st in a series of national surveys on community attitudes to road safety was conducted in March and April 2009. A total of 1615 interviews were conducted with persons aged 15 years and over. The issues examined include perceived causes of road crashes, exposure and attitudes to random breath testing, attitudes to speed, perceptions of police enforcement, mobile phone use while driving, reported usage of seat belts, involvement in road crashes and experience of fatigue while driving. Download at www.infrastructure.gov.au/roads/safety/publications/2010/pdf/community_att_09.pdf.

(*Reviewed by Colin Grigg*)

Drug use in road deaths

Professor Con Stough and Rebecca King from Swinburne University have undertaken an extensive review in the March 2010 *Prevention Research Quarterly* of the impact of alcohol and other drugs, including various pharmaceuticals, on road deaths and injuries. The review covers usage, prevention, detection and treatment. An interactive seminar on 15 April discussed the impact of drugs on the ability to drive safely and strategies for raising awareness of the risks. The presentations are available at www.druginfo.adf.org.au/toolkits/seminar_notes/drugs_and_driving_seminar1.html.

NZ crackdown on antisocial road users

Canterbury police are cracking down on antisocial road users, particularly young male racers, using intelligence, local bylaws, new legislation and community support. This has resulted in a substantial drop in the number of antisocial road user events, which have caused serious nuisance and posed a risk to other road users. (*Source*: Ten One, www.tenone.police.govt.nz/tenone/March10Heat.htm)

Worldwide

Northern Ireland road safety consultation

The Minister for the Environment, Edwin Poots, has announced a public consultation on road safety that will continue until 15 June. The vision is to position Northern Ireland among the safest countries in the world; it is now placed 6th of the 27 EU countries. The consultation paper was based on a Safe System approach. (*Source*: Ministerial Statement at 74.125.153.132/search?q=cache:pxLvyBrMRY0J:www.theyworkforyou.com/ni/%3Fid%3D2010-03-15.3.1+poots+road+ safety+ireland&hl=en&gl=au&strip=1)

US problems of vehicle recalls

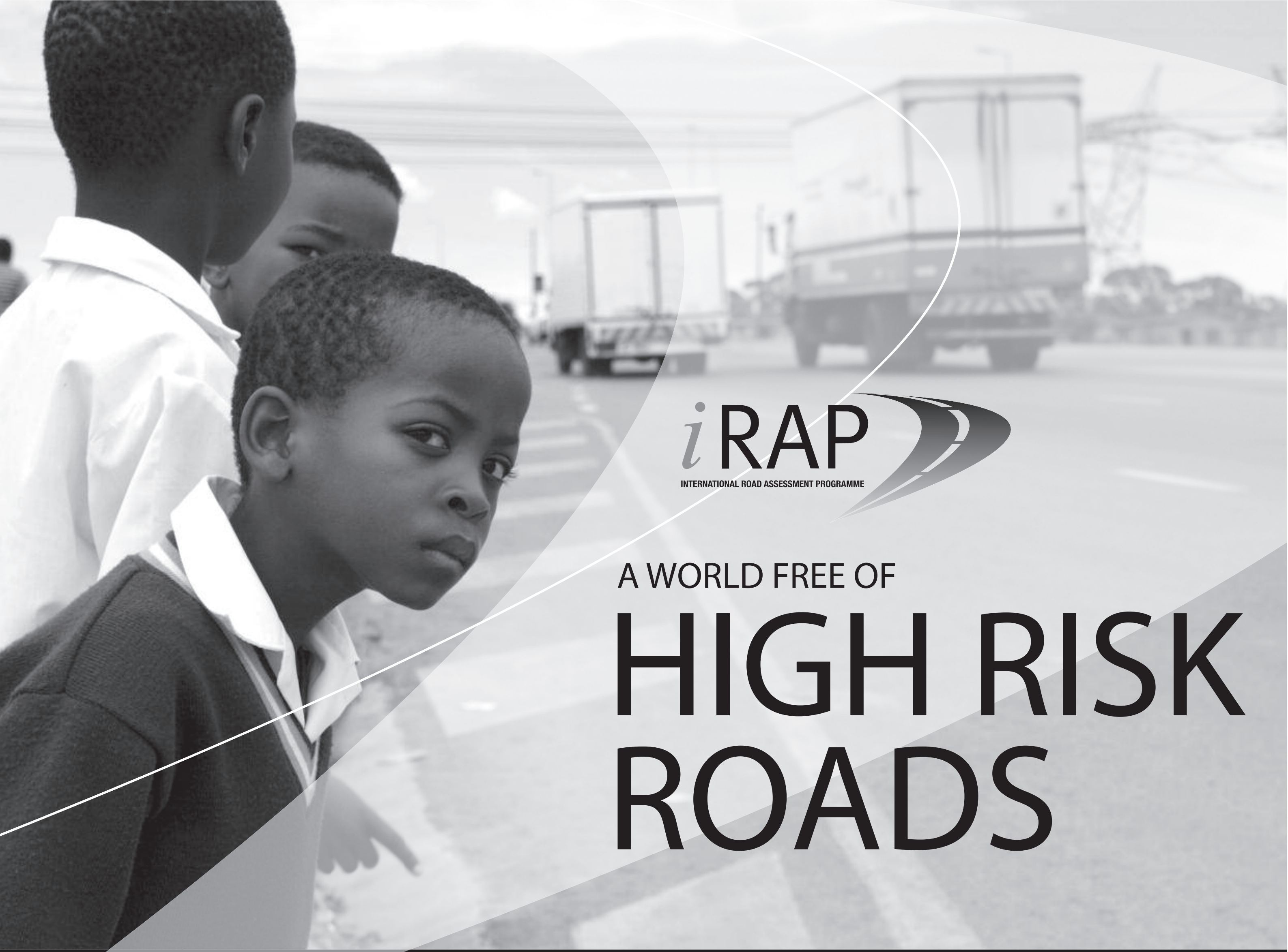
Toyota may have made recent headlines with vehicle safety recalls, but there are hundreds more recalls affecting millions of vehicles annually. The US government has estimated that 25 percent of owners do not get the problems fixed, resulting in about 37 million vehicles on the road that have safety problems. The vehicle history report company Carfax noted that last year at least 1.4 million cars that were recalled but not repaired changed hands. (*Source*: abcnews.go.com/GMA/ConsumerNews/cars-recalled-repaired/story?id=10362886)

Malaysia improves motorcycle lanes

A survey conducted over the past three years in Kuala Lumpur and Klang showed that traffic lanes that separate motorcycles from other vehicles can reduce fatalities among motorcyclists and pillion riders by up to 90 per cent, according to Road Safety Department Director-General Datuk Suret Singh. The department would continue monitoring the conditions of motorcycle lanes nationwide, trying to tackle problems of lanes that were infested with stray dogs, poorly lit or obstructed by trees. (*Source*: findarticles.com/p/news-articles/bernama-malaysian-national-news-agency/mi_8082/is_20100415/motorcycle-lane-reduce-fatalities-90/ai_n53240914/)

Abu Dhabi and Dubai safety campaigns

In response to a survey that found 10 per cent of respondents had been involved in a traffic accident in the previous 12 months, BMW Group Middle East has launched a 'Stay Alert Stay Alive' road safety initiative. The campaign is supported by the Health Authority of Abu Dhabi, the Road and Transport Authority of Dubai, Abu Dhabi Municipality and Dubai Municipality. (*Source*: Trade Arabia, www.tradearabia.com/news/newsdetails.asp?Sn=MTR&artid=176925)



Safe road infrastructure for all road users will be crucial in achieving the goals of the United Nations Decade of Action for Road Safety (2011-2012). Road Assessment Programmes (RAP) target roads where pedestrians, motorcyclists, vehicle occupants and bicyclists are killed and injured with brutal regularity. Together with safer behaviour, safer speeds and safer vehicles, RAPs can help make roads safe.

iRAP works at a global scale and is moving urgently to stop the growing road safety health crisis. We act on sound research and compelling evidence. We are prepared to take risks and challenge norms where it is necessary.

Internationally, RAPs are now active in 60 countries and have assessed almost 400,000km of roads. In Australia and New Zealand, AusRAP and KiwiRAP have assessed some 30,000km and 10,000km respectively.

With dedicated efforts, RAPs will help make wide-scale infrastructure safety assessment and road safety rating – critical elements of the UN Decade of Action and the recent global development banks' joint statement on road safety - a reality. In doing so, we will achieve our vision of a world free of high risk roads.

For more information, visit: www.irap.org

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Contributed Articles

Future issues of the journal will have special themes as follows:

August 2010 – Bicycle safety

November 2010 – Occupational health and safety related to road safety

February 2011 – Road safety in the Asian region

Members are invited to contribute articles related to these themes or on road safety more generally. Contact the Managing Editor (journaleditor@acrs.org.au) with respect to deadlines for receipt of articles.

Lost in translation: Translating injury research into effective interventions

By David A. Sleet, Ph.D. and Grant Baldwin, Ph.D., M.P.H., Division of Unintentional Injury Prevention, National Center for Injury Prevention and Control, Centers for Disease Control and Prevention (CDC), Atlanta, Georgia USA. dds6@cdc.gov; gfb3@cdc.gov

A version of this paper was delivered as a Plenary Address by David A. Sleet to the Australasian College of Road Safety Annual Conference, 5 November 2009, Perth, Western Australia. Portions of this paper were adapted, by permission from Sogolow, E, Sleet, DA, Saul, J. Dissemination, implementation, and widespread use of injury prevention interventions. In Doll, LS, Bonzo, SE, Mercy, JA, Sleet, DA (Eds.) Handbook of Injury and Violence Prevention (pp 493-510). New York: Springer, 2007.

Despite the existence of many effective interventions, more than 1.3 million people worldwide die from road traffic injuries. Another 20 to 50 million suffer serious injuries [1]. Many, if not most of these injuries are preventable. While effective interventions exist to prevent many traffic-related injuries [2], they are often not available or are simply not used to save lives. This is a problem of translation.

This situation is similar to developing a life-saving drug but not telling doctors about it, not packaging it for easy use by consumers, not giving it to pharmacists to dispense, and not helping people use it properly. This gap between research and practice, and between discovery and delivery, is large and continues to impede our progress in preventing and controlling injuries and violence [3]. For maximum impact, effective road safety interventions require widespread, sustained use by a large segment of the population. These issues are the focus of this paper.

The importance of translation in injury prevention

Diffusion is the process of moving an innovation – an idea, product, or practice – into widespread use. The process includes dissemination – spreading the word about a product, practice or idea; implementation – adopting and using it properly; and promotion – assuring its widespread use. The best interventions have little chance of achieving a public health impact if they do not end up in practice or are not translated into policy.

For many years, injury prevention researchers have assumed that an intervention deemed efficacious in an experimental setting will easily (or often automatically) be translated for use in the field of practice. Unfortunately, this is not the case. There is little empirical evidence from diffusion research on how to do translation most effectively. Oldenburg, Sallis, French, & Owen (1999) [4] reviewed 1210 articles in 12 public health journals and discovered that less than only 1 per cent were characterized as diffusion research and only 5 per cent as policy implementation research. Only 8 articles in the entire database were related to injury, and virtually none were focused on translational research.

A fundamental shift in the concept of intervention research is underway – a recognition that research does not end when a study demonstrates an intervention is effective [5-9]. The scientific language and intervention protocols used by the original research team must be translated into everyday terms for use by practitioners, and materials must be developed to help guide the end users (for example, health departments and community-based organizations) in adopting and implementing the intervention.

In this view, researchers remain essential to the process. They understand best what made the intervention effective, know the training and technical assistance provided to their staff, and can provide guidance on the range of modifications that would be appropriate (or inappropriate) in practice. Because translation activities can involve curriculum development and multimedia formats to support training and implementation, the original researchers may not be the best persons to undertake these translation tasks, but they can be important consultants to the process. This is why collaboration between researchers and policy makers, advocates, media experts, and social marketers is often necessary to achieve success in moving the science into practical use [10].

The complexity of translation

We acknowledge the complexity and effort involved in the process of taking interventions to scale. A new intervention may call for individuals, organizations and communities to change their own behaviours, policies or norms. It may be met with user resistance, or personal or organizational delay, and result in rejection. These barriers can occur whether you are introducing a new style of bicycle helmet, installing a roundabout, implementing random breath testing, or introducing a texting-while-driving ban. We need to anticipate the possible range of responses as we plan for activities associated with dissemination and widespread use of road safety interventions found to work.

We also need to recognize that new interventions may compete with existing programs for scarce resources. It is important to provide the rationale, materials and other information that administrators or other decision makers need as they contemplate how to manage the process. These 'gatekeepers' often decide whether and how an organization will adopt the new intervention and, if so, whether new staff is needed to integrate the intervention into existing programs and manage the implementation effort.

Activities to facilitate translation

Research on translation and diffusion builds a bridge between experimental research and everyday practice by providing knowledge about how ideas, products, and practices are most effectively translated and transmitted for use by individuals and communities. CDC's public health model identifies four stages in the progression from research to application, or from discovery to delivery: (a) defining the problem, (b) identifying risk factors, (c) developing and testing interventions, and (d) increasing widespread use (Figure 1). Although this model provides a logical sequence of events, the progression from defining the problem to widespread use is by no means automatic. Each stage must consist of its own planned and sequential activities, and in each stage, researchers and practitioners must be prepared to address external factors that may introduce barriers.

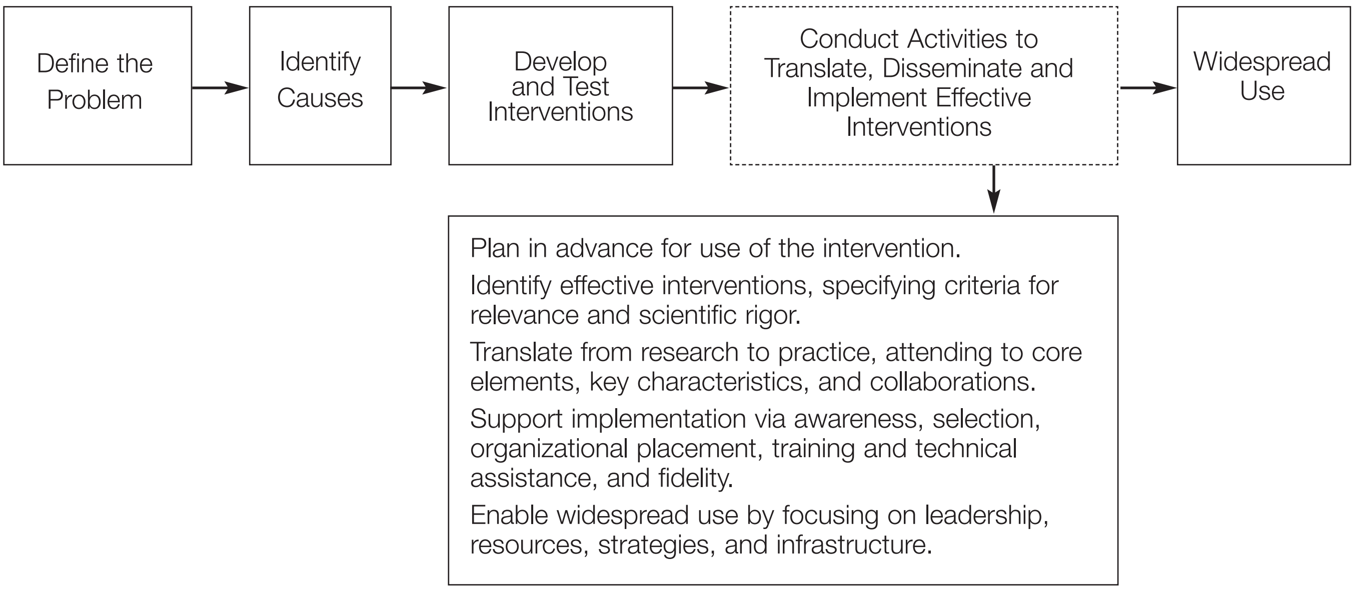
Once an intervention is successfully developed and tested, researchers may improve its perceived value and likelihood of adoption if they plan for translation by engaging in deliberate activities that fall within the public health model between 'developing and testing an intervention' and 'widespread use' as described in Figure 1.

Public health efforts in translation that have been successful

Research focused on how science-based interventions become prevalent in practice involves the study of processes that lead to improved translation. Whereas many interventions demonstrate effectiveness to prevent road traffic injuries, most have not been translated from research to lay language; tailored to be responsive to diverse cultural and societal norms; implemented in communities and evaluated for feasibility, fit with local needs; and delivered with fidelity. Consequently, they have not led to widespread acceptance or use.

In public health, after research has demonstrated the efficacy of a vaccine (for example, for diphtheria, tetanus, polio and smallpox), actions are immediately taken to translate those

Figure 1. Extending the public health model by interpolating translation activities



discoveries into prevention and delivery programs around the world [11]. When foods such as flour were found stripped of essential nutrients like thiamine, niacin and riboflavin, public health embarked on widespread nutrient fortification programs for all flour and white bread [12]. When bed nets were found effective in controlling malaria, public health delivered them to remote towns and villages.

Yet, when seat belts were found to reduce deaths and injuries by half, only some countries mandated their installation and use. Even today, 40 years after the seat belt 'vaccine' was discovered, the world is not protected by them. Road safety can bridge science and programs, but only if we make discoveries and then translate them into action and deliver them to those in need. Vietnam's recent helmet law that achieved nearly 100% use on motorized two-wheelers is an example of that principle in action.

New helmet laws enforced in Vietnam

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Translation barriers and possible facilitators

Translation in injury prevention is more difficult than it appears, and it is important to learn not only about possible facilitators for this process, but also about barriers [13]. One important barrier is lack of communication about what translation entails, why it is important, and how to do it. Traffic safety agencies and organizations need to consider ways to make key road safety research findings widely available to the public, but also to manufacturers and lawmakers.

The obvious successes we have achieved through the development of innovative road safety products (e.g., air bags, speed bumps and motorcycle helmets), programs (e.g., random breath testing, 'skipper' or safe rides, alcohol checkpoints) and policies (e.g., speed limits, alcohol use policies, traffic calming measures) have, nevertheless, not yielded the uptake necessary to save hundreds of thousands more lives. This raises the need to conduct research on how to ensure these life-saving interventions get used [14].

Many constraints on translation can be linked to the 'relative newness' of the intervention, inadequate preparation and planning for public acceptance, implementation failure or lack of adequate funding to take the intervention to scale. A fundamental barrier to removing these constraints is lack of scientific knowledge about the translation process. Road safety generally lacks a dedicated infrastructure to support dissemination and implementation. Wherever an investment is being made in the development and testing of interventions, a parallel investment needs to be made in translation and implementing the intervention in other settings and with other audiences.

Understanding the core elements and key characteristics of what made the intervention work will require guidance from the original researchers. Coalitions, advocacy groups, public interest groups, citizens and professional organizations have an important role to play in translation. They can be primary change agents, convening and leading stakeholders, using their own networks to promote dissemination and implementation activities, and serving as opinion leaders, influencing spread. Another key role is as 'linking agents', which may be enforcement personnel, facilitating the smooth implementation of programs by providing resources to help translate and disseminate effective interventions, developing and providing training, and troubleshooting adoption and maintenance problems [15].

Cost-benefit, cost-utility and cost-effectiveness research on translation is lacking. Knowledge about costs would inform the dissemination and implementation process and assist approaches to achieving nationwide use. Collecting or modelling implementation cost information would help practitioners and end users as well, as they contemplate adoption and use of new policies, practices or products. Those who fund road safety intervention effectiveness studies could include, at a minimum, collection and estimation of implementation cost data as a component of the study.

Many of these possible strategies for improving widespread use of effective interventions depend on system-level change [16, 17] – such as road building and maintenance systems, vehicle manufacturing systems, enforcement systems and legal frameworks. Such change is likely to be evolutionary and may encounter resistance along the way. Still, looking at the progress many fields have made already, such change appears to be ultimately welcomed and worthwhile in road safety. Some common barriers to translation of research are summarized in Figure 2.

POLITICAL WILL – Lack of political will in communities and by governments.

SYNTHESIS – Limited synthesis of road safety research findings.

COMPLEXITY – Road safety issues are muti-factoral and complex.

TAILORING – Translation efforts need to be tailored to different target groups, under different conditions, in different settings. They also need to be culturally appropriate.

EFFECTIVENESS – Road safety interventions need to be tested in real world conditions.

GOALS – Unrealistic goals for innovations in road safety and the timetable expected for adoption and implementation is too aggressive.

EVALUATION – There is limited information on the long term outcomes of translation research.

COMMUNICATION – There are differences between how road safety researchers, legislators, and practitioners communicate.

ROAD MAP – Researchers are not taught how to, nor do they plan for, widespread dissemination of their findings outside the road safety field.

RESOURCES – There are limited financial and human resources for widespread dissemination.

Figure 2. Barriers to the translation of research

Future directions

While many examples of successful translation abound in cancer prevention, HIV, heart disease, physical activity and smoking prevention [15, 18, 19], road safety has lagged behind. We may finally be able to address this opportunity by dedicating more resources into translation and implementation research.

Federal agencies and not-for-profit organizations like ACRS can and must be catalysts in initiating and sustaining these efforts, including translation research in road safety. This leadership may take the form of training injury researchers, providing annual prize for translation researchers, sponsoring interdisciplinary meetings, workshops, and conferences where researchers and practitioners—in road safety and other disciplines—can share their approaches to discovery and delivery of innovative road safety research.

Kok and Green [20] cite the findings from the Dutch Smoking Prevention Program for adolescents as an example of what can happen if we do not pay attention to these needs: 'After 4 years of careful and internationally respected research and development, deVries and co-workers presented their programme to be implemented nationwide. Now, almost 2 years later, absolutely nothing has happened.' Road safety can learn from this example of failure, and invest in specific activities to ensure the successful translation of effective traffic injury interventions of benefit to the public.

Acknowledgement

We acknowledge our CDC colleagues Ellen Sogolow, PhD, Janet Saul, PhD, and Rita Noonan, PhD, for ideas that contributed to this paper.

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Implementation of a Road Safety Package to address the NSW road toll

By Ralston Fernandes, Andrew Graham, Margaret Prendergast and Soames Job

After six consecutive years of reductions, the NSW road toll for 2009 increased by more than 20% on the previous year, although gains in NSW remain ahead of the slight downward trend for the rest of Australia (see Figure 1). In order to address this rise in road fatalities, a Road Safety Package was developed for implementation throughout NSW.

The Road Safety Package comprises a 5-year $170 million program of road safety measures developed to support the State Plan Objective to improve road safety and reduce fatalities on our roads, and includes many of the actions identified at the Road Safety Roundtable held in Sydney in July 2009.

The Road Safety Package was developed in accordance with the Safe System Partnership approach to road safety, which encapsulates the requirements that those responsible build and manage to deliver a safe road environment, safe vehicles and safe travel speeds.

The Road Safety Package includes the following initiatives underpinned by the Safe System Partnership approach:

- Highway safety reviews and improvement works for six major highways, including the Great Western, Mid Western, Mitchell, Oxley, Sturt and New England Highways (following the clear success of these reviews in NSW [1])
- Safety works for high crash areas – wire rope barriers [2], audio tactile lines and widening of road shoulders on roads with a history of head-on crashes or vehicles running off road
- Targeted safety works for local roads identified on the basis of crash risk
- Increased funding for public awareness and education campaigns
- Heavy vehicle safety initiatives, including trialling of electronic work diaries ('log books')
- Pedestrian safety measures, including pedestrian fencing
- Initiatives to target repeat offenders, primarily speeding offenders
- A motorcycle safety strategy.

Concurrently, an outsourced Mobile Speed Camera Program – accompanied by an extensive public awareness campaign – will be re-introduced to address speeding on NSW roads, along with a 5% increase in speeding fines and activation of speed enforcement function on all 200 new safety cameras (red light/speed). Speeding remains a key contributing factor in road crashes, and reducing speeding behaviour will be a major step towards achieving an overall reduction in the NSW road toll.

These initiatives will be comprehensively evaluated.

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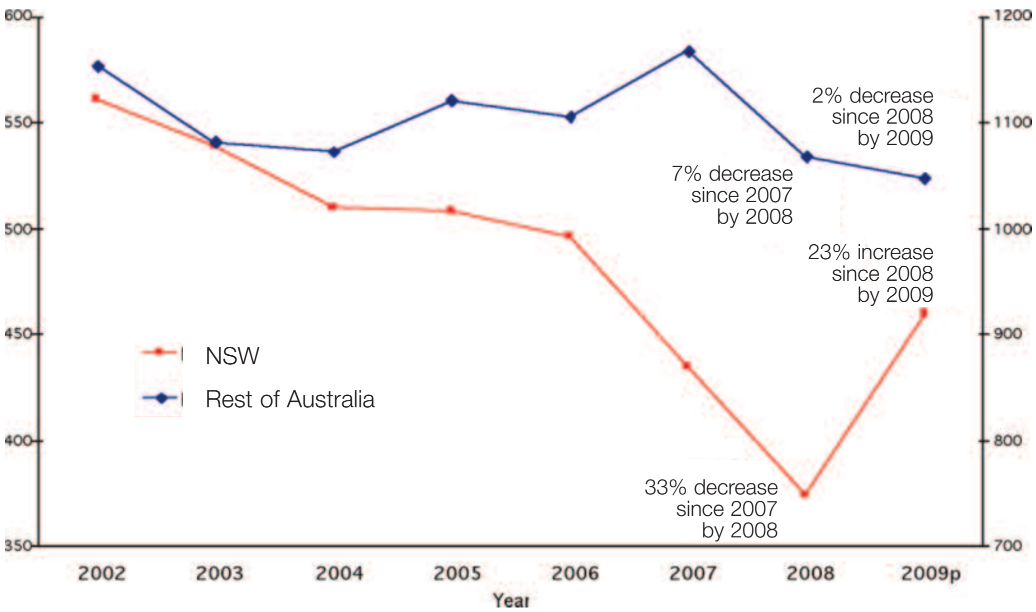

Figure 1. Recent trends in road fatalities in NSW and the rest of Australia

Speed limits in the Safe System context

By C. Jurewicz, ARRB Group Ltd, Melbourne, Victoria, chris.jurewicz@arrb.com.au

Abstract

This paper proposes a set of new principles for setting speed limits based on harm minimisation, the cornerstone of the Safe System approach. The Safe System approach seeks to develop and manage the road transport system so that death and serious injury are eliminated. Safer Roads and Safer Speeds are two of its main elements.

The new speed limit setting principles have been developed for Austroads by the Australian Road Research Board (ARRB) and road jurisdiction stakeholders. They follow the Safe System approach and have been based on recent research into the relationships between road features, speeds limits, driver speeds and crash outcomes. In the long term, application of these new principles will achieve harm minimisation through matching speed limits with the level of protection offered by the road infrastructure. As part of the new principles, a process is proposed to analyse the Safe System readiness of a road and identify the speed limit options and road improvement options required to achieve safe travel. It is recognised, however, that in the short and medium term, many of the Safe System road features may not be economically viable and not all speed limits would be immediately acceptable to the public. Thus, various harm reduction measures are proposed as interim steps towards the Safe System.

Introduction

The Safe System approach seeks to regulate driver speeds so that drivers respond to the level of protection offered by the road infrastructure. Under Safe System, speed limits should be set to maximise mobility consistent with safe travel – that is, to achieve safe mobility.

This paper proposes a set of new principles for setting speed limits based on the Safe System principle of harm minimisation, i.e., avoidance of death and serious injury due to road environment factors.[1] Various harm reduction measures are also proposed as interim steps towards the Safe System. This paper is based on the outcomes of a recent Austroads project conducted by ARRB described in detail in Jurewicz and Turner [1].

The traditional approach of speed limit setting is based on various road environment proxies for crash likelihood. These include accounting for such road features as roadside development level, number of access point and turning lanes, most of which relate to the risk of a crash event happening. The new principles propose a major evolution in a speed limit setting approach in the direction of the Safe System. They include both the likelihood and severity of crashes in consideration of speed limits. A broader range of road features is considered than previously. This way, death and serious injury due to road environment factors can be minimised over time.

Development process

In order to develop a deeper understanding of the subject, a thorough literature review was carried out, followed by road infrastructure and crash data analysis. Then, thorough consultation was undertaken with an expert panel of Austroads stakeholders drawn from road authorities' road safety managers to evaluate the new information and provide input into the new principles for setting speed limits. Finally, the new principles were formulated, presented to relevant Austroads task forces and subjected to further comments and review.

Speed limit setting principles

The prime objective of the new principles is harm minimisation while maintaining mobility appropriate to road class and function (that is, safe mobility). Thus, the principles involve a process of consideration of these two elements and the practical reconciliation of any gaps between them. The principles are as follows:

1. Mobility – what speed limit does the community expect for a given road class and function?
2. Harm minimisation – what are the safe speed limits for a given road given the existing conditions?
3. Gap analysis – Safe System Analysis evaluation of the existing level of protection offered by the road to identify speed limit and infrastructure improvement options.
4. Driver perception – management of the road environment and traffic speeds if necessary.

The consideration of each principle is a separate step in an iterative process. The result is one or more speed limit options, which may require changes to the infrastructure to provide safe travel at the recommended speed limit.

Mobility

The first principle (mobility) relates to community expectations about the travel speeds that are appropriate for different road class and function. There is a wide range of road classifications with different transport functions, intensity of traffic and mixes of road users. Many roads have more than one function. It is important to recognise this and select the mobility-based speed limit that matches expectations already held by the community. Table 1 provides a suggested hierarchy of road class and function-based speed limits recognising the current Australasian practice. Speed limits are generally set for homogeneous sections of road, so that one road class and function will fit the whole length of each section being considered.

Road class and function	Typical speed limit
Shared zones	10 km/h
Car parks, access driveways	20 km/h
Recreational areas/parks, car parks Local roads with traffic calming	30 km/h
Commercial streets with high pedestrian activity Urban local and collector roads	40 km/h
Default urban speed limit Urban undivided arterials with direct access	50 km/h
Urban fringe / rural living local access roads Urban undivided arterials with limited access	60 km/h
Urban divided arterials with direct access Urban divided arterials with controlled access Urban fringe undivided arterial and sub-arterial roads	70 km/h
Rural undivided roads of low design standard Urban freeways	80 km/h
Rural arterial and sub-arterial roads Rural freeways	100 km/h
Rural arterials of high design standard	110 km/h

Table 1. A proposed class and function speed limit hierarchy

Harm minimisation

The second principle (harm minimisation) involves determining the maximum speed that vehicles could travel on any road section under consideration without risking death or serious injury to any road user. The speed limits applied in the process are shown in Table 2. These limits were agreed by the Austroads expert group on the basis of primary research into survivability of crashes at different impact speeds. Universal application of harm minimisation speed limits coupled with a high degree of compliance on the part of road users would provide conditions under which death and serious injury would come close to being eradicated from the road system. Broad conditions were provided for applicability of these speed limits. Where more than one of the harm minimisation speed limits is applicable to a road link, the lowest harm minimisation speed limit applicable should be chosen.

Gap analysis

The third principle (gap analysis) concerns the gap between the road class and function speed limit and the harm minimisation speed limit. The Safe System Analysis (SSA) process was developed to identify options for bridging that gap with road improvements and adjusted speed limits. SSA is a risk assessment process that evaluates how the risk of death or serious injury for each applicable crash type from Table 2 can be minimised with existing or additional road features.

A selected harm minimisation speed limit may no longer be applicable if the effect of providing road safety features is estimated to raise safety to the level where the harm minimisation speed limit matches the mobility speed limit. Typically one primary or several targeted supporting road features would be required to minimise the risk of death or serious injury resulting from a given crash type.[2] In such a case, harm minimisation may be achieved at a higher speed limit – for example, the next higher applicable harm minimisation speed limit or a speed limit suggested by the road class and function. The SSA process should provide one or more speed limit options, some of which may call for road infrastructure improvements as a condition. The road authority then needs to weigh up the capital investment for improved road features (if any) against the loss of mobility due to a lower speed limit. Figure 1 illustrates the process schematically.

Driver perception

Finally, the fourth principle (driver perception) addresses any major discrepancies between the selected speed limit and the existing mean speeds. If the new speed limit is more than 10 km/h lower than the existing mean speed, it is likely to require additional measures, such as road narrowing, streetscaping or planting, education and publicity campaigns, and enforcement.

Example

Figure 2 provides an example of a suburban undivided arterial for which three speed limit and road improvement options could arise from application of the new principles. The example relates well to the process shown in Figure 1. In the example,

Crash type	Maximum impact speed tolerance	Harm minimisation speed limits	Applicability
Car/pedestrian, cyclist or motorcyclist	20-30 km/h	30 km/h	Where vulnerable road users are present in high numbers.
Car/tree or pole	30-40 km/h	40 km/h	Where unprotected road hazards exist within defined clear zone.
Car/car (side impact)	50 km/h	50 km/h	Where car / car side impact is possible at > 50 km/h (frequent T or cross-intersections or access points).
Car / car (head-on)	70 km/h	70 km/h	Where there is no separation between opposing traffic streams.

Table 2. Proposed harm minimisation speed limits and their general applicability

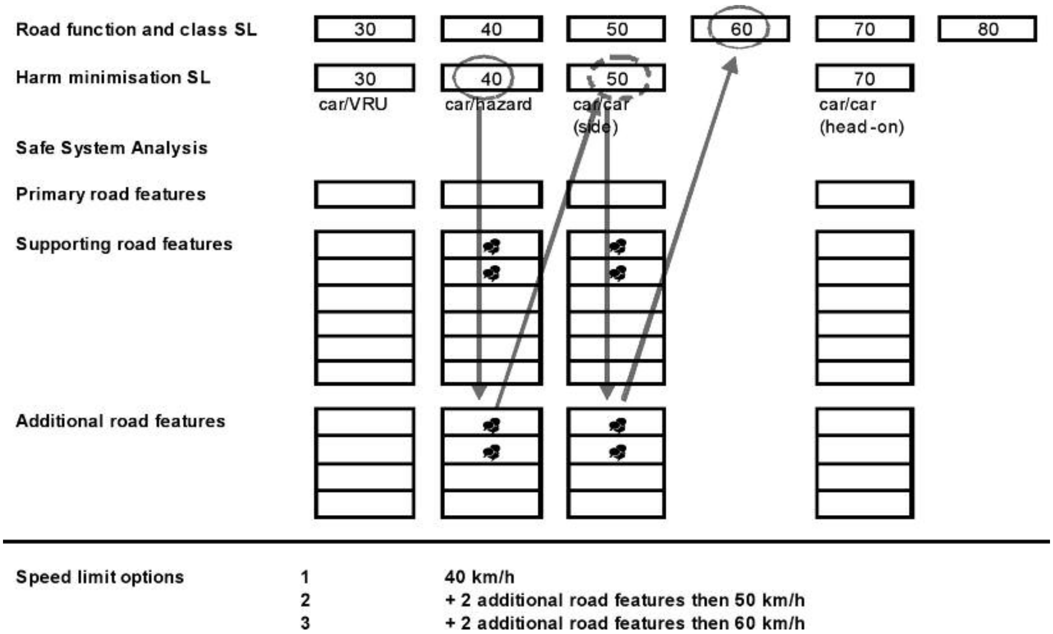

Figure 1: Schematic application of the Safe System Analysis process

the main sources of fatality and serious injury risk are roadside hazards, frequent access points and local road intersections (car/tree or pole and car/car side impacts). The mobility-based speed limit expected for such a road would be 60 km/h. The lowest harm minimisation speed limit, based on car/pole or tree survivable impact speed, would be 40 km/h (Option 1).

If the risk of death and serious injury from this crash type was addressed with relevant primary or additional supporting road features, the next highest harm minimisation speed limit would be 50 km/h based on car/car side maximum safe impact speed (Option 2). If fatalities and serious injuries from this crash type were also addressed, then the speed limit could be further increased to the mobility-based speed limit of 60 km/h (Option 3).

Safe System Analysis suggested several targeted road features that would substantially mitigate the severity and/or reduce the likelihood of both crash types. Increased clear zones to hazards by provision of well defined parking lanes would substantially reduce the risk of car/tree or pole fatalities and allow a 50 km/h speed limit to be applied. Further works, such as direct access restrictions and roundabouts at main intersections, would reduce the risk of car/car side impact fatalities and allow a 60 km/h speed limit to be reinstated.

Towards harm minimisation

In the short to medium term, the recommended road infrastructure features are not likely to be provided immediately on all roads in the system to achieve harm minimisation. Thus, a harm reduction approach may be applied while road authorities move towards the Safe System. Harm reduction involves adopting a speed limit somewhat lower than that suggested by the road class and function, but above the harm minimisation speed limit. Such speed limits would need to

Figure 2: Example of application of new principles on a suburban arterial

include driver warning/information telling motorists why the speed limit was reduced. Initially, only high risk locations should be targeted with harm reduction speed limits. In the above example, a harm reduction solution would be a reduction in speed limit to 50 km/h without any major capital works.

Further research work is required to better understand the role of supporting road features in Safe System implementation. It is particularly important to quantify the number and type of supporting treatments required for equivalence to one primary treatment in minimising deaths and serious injuries. This should be achieved through thorough empirical analysis.

In the medium to long term, a process should be established to assess the infrastructure investments needed to bring the entire network up to the standards where expected levels of mobility can be achieved safely. Restoration of speed limits lowered in the past to be in line with the road class and function should only occur once the road improvements are implemented. Medium- and long-term strategies should aim at gradual incorporation of Safe System road infrastructure in all areas of the road network, and the harm reduction approach should be abandoned in favour of harm minimisation.

The community expectation of speed limits on different types of roads may alter with time due to congestion management (for example, variable speed limits on freeways). This would reduce the gaps to be bridged through SSA.

Conclusions

Four new principles for setting speed limits in the Safe System context were presented. These principles represent an evolution of the traditional approach for speed limit setting by focussing the consideration on crash severity, crash likelihood and mobility expectations. The new principles recognise that travel should not result in death and serious injury.

It is recommended that the new principles be considered in future speed management policies. At the same time, it is recognised that implementation of speed limits fit for the Safe System will take considerable time and funding commitment. It is thus proposed that an interim harm reduction approach be applied to setting speed limits in the short and medium term.

Notes

1 The vision of zero deaths and serious injuries is based on integration of benefits of Safer Roads and Safer Speeds with Safer Vehicles and Safer Road Users. Grave harm due to human error is minimised due to road factors. It may still occur if road users choose not to comply with the road rules, for example.

2 In the Safe System context, a primary road feature alone minimises the risk of death and serious injury arising from such a crash. Examples include pedestrian overpass (car/pedestrian crash), roundabout (car/car side impact) or a median barrier (car/car head on). A supporting road feature simply reduces this risk – for example, curve delineation, audio-tactile edge lines or turn lanes. Typically, four to six targeted supporting road features should have a similar effect on a particular crash type as one primary feature.

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Local government and road safety

By Cr Geoff Lake, President, Australian Local Government Association

Road trauma is one of the major public health problems facing this country. Last year 1,509 people died on our roads.

The Bureau of Infrastructure Transport and Regional Economics (BITRE) report on the *Cost of Road Crashes in Australia 2006* [1] estimates that road crashes cost the community nearly $18 billion in 2006, equivalent to 1.7 per cent of GDP. There were an estimated 653 853 road crashes in 2006 involving 1.16 million vehicles resulting in the loss of 1602 lives.

These are shocking statistics, but what they do not reflect is the personal pain and injury experienced by the people directly involved and their families and friends.

The number of deaths on our roads is only part of the problem. The latest hospitalisation figures show that nearly 33,000 people were seriously injured in crashes during 2006-07. Many of these people are now living with severe and life-long injuries. Sadly, these figures have been trending upwards for several years.

Road trauma disproportionately affects young, healthy Australians. About 30% of those killed and 37% of those hospitalised in road crashes are under 25 years old. We have all seen the images in our papers and on our TV screens. The roadside memorials are a daily reminder. Indeed, it is sobering to think that school children today are unlikely to reach the age of 25 without at least one of their former classmates being killed or seriously injured on our roads.

Much good work has been achieved over the last 40 years to make our roads safer. According to BITRE, annual road deaths have dropped from a peak of 3798 in 1970 to an average of around 1640 between 2000 and 2008, even though the number of vehicles on Australian roads has more than tripled in that time.

Tougher laws and better policing targeting speeding and drink driving, improved driver training, better road design, extensive education campaigns and new vehicle technologies have all contributed to a large reduction in the frequency, severity and economic cost of road crashes over recent decades.

Driver attitudes also need to change. According to the most recent annual survey of Community Attitudes to Road Safety undertaken by the Federal Government [2]:

- 61 per cent of respondents said they use their mobile phone while driving
- 25 per cent consider it acceptable to speed 'if you are driving safely'

- 16 per cent of respondents had fallen asleep at the wheel, with 43 per cent having done so more than once
- 6 per cent of respondents – and 11 per cent of those younger than 25 – 'always, nearly always or mostly' drive at least 10 km/h over the speed limit.

On a more positive note, the same survey found that most people are well-informed about road safety matters and support the efforts of police to catch and punish those who break the law.

Ten years ago State and Federal Transport Ministers, through the Australian Transport Council (on which I represent local government today), agreed on the current National Road Safety Strategy, 2001-2010. The strategy set a target of reducing the rate of road deaths by 40 per cent over that period, from 9.3 to 5.6 deaths per 100,000 people. To date we have achieved a 26 per cent reduction, but it is very unlikely that we will meet the 40 per cent target in the final year of the strategy.

One of the major policy challenges that the Australian Transport Council will be grappling with this year is the next National Road Safety Strategy to operate for the period 2011-2020. The new strategy will need to:

- have a national commitment to achieving ambitious reductions in deaths and serious injuries on Australian roads over the next 10 years and beyond
- present high-level goals and specific policy objectives in areas such as acceptable road speeds, road infrastructure, vehicle safety, road user behaviour and institutional management
- identify agreed actions, timelines, responsibilities and performance indicators.

Role of local government

The BITRE reports do not show what proportion of crashes and deaths occur on local roads controlled by councils. However, we can be certain it is a significant number, as councils are collectively responsible for over 650,000 kilometres or 80 per cent of all roads in Australia. In most cases, it is local roads where there will be the greatest interaction between vehicles and pedestrians.

Roads are local government's biggest asset by some margin. Nationally, local government spends about 25 per cent of its funds on roads, although in rural councils this figure is typically more than 50 per cent. This means that the maintenance of the local road system is one of local government's major tasks, and in the case of almost every council, the largest single item of annual expenditure.

Safety is a key consideration in the design, building and maintenance of roads and is a key factor in prioritising works. Local government also has a major role in the delivery of the Federal Government's Road Safety Black Spot Program, which targets locations that have identified poor road safety history.

One of the strengths of local government is its ability to tailor services to local needs. In different councils and different States, local government is tackling road safety in a variety of different ways, each designed to achieve the best outcomes. I would like to focus on three specific local government initiatives that are helping to respond to the road safety challenge:

- Moreton Bay Road Safety Partnership Project
- Community transport
- RoadWise.

Moreton Bay Road Safety Partnership Project

Morton Bay Regional Council (MBRC) to the north of Brisbane includes road safety in its corporate plan. In 2007 the Council established the Moreton Bay Road Safety Partnership Project (RSPP) with other road safety stakeholders in the region to work collaboratively to establish road safety as a priority and to develop frameworks to reduce road trauma.

The project involved establishing a Steering Committee with representatives from the Council, the Local Government Association of Queensland, the Department of Transport and Main Roads, the Queensland Police Service, Queensland Health and the Institute of Public Works Engineering Australia Queensland. The collaborative nature of the Steering Committee has led to a coordinated approach to road crash and asset data collection and management which, along with community feedback, has helped to identify and prioritise hazardous sites for funding.

The Steering Committee has developed a *Road Safety Strategic Plan and Action Plan* for the Moreton Bay Regional Council area, which provides a framework and direction for an integrated approach by Council and other agencies to improve road safety. The *Road Safety Strategic Plan and Action Plan* identifies the priority road safety issues for the Moreton region and describes both behavioural and engineering actions that are likely to mitigate the problem.

Community transport

The provision of community transport by councils, although not primarily a road safety measure, gives the often vulnerable group of disabled and frail and aged members of the community an alternative to driving when they need to access care and services.

Older members of our community face unique road safety challenges, and statistics show that the highest fatality rates after younger drivers are for those aged over 70 years. Offering alternatives to private motor vehicle travel, such as community-run shuttle bus services, provides an opportunity to improve road safety outcomes for older Australians.

As the population ages, the demand for community transport will grow. For example, the Australian Bureau of Statistics data show that almost 20 per cent of people aged over 60 in Victoria need assistance with transport, a figure that rises to 33 per cent for those aged 80 to 84 and 43 per cent for those aged 85 to 89.

In Victoria, 45 per cent of councils provide transport services for people who are transport disadvantaged. A report prepared by the Victorian Council of Social Service in 2008 examined six community transport services and found that they provided more than 78 000 passenger trips, travelled over 778 000 kilometres and utilised over 13 800 volunteer hours each year. This is the largely hidden, but rapidly emerging, public transportation of the future, and it is being run out of local government.

RoadWise

The Western Australian Local Government Association (WALGA) has developed road safety programs on a State-wide basis to actively engage and involve local government and the community in implementing specific initiatives of Towards zero, the Western Australian road safety strategy [3].

RoadWise Road Safety Committees are the formal structures and extend across 11 regions encompassing metropolitan, regional and remote areas of Western Australia. This network of committees offers an ongoing mechanism for engaging and involving communities in the dissemination and sharing of information and knowledge.

The committees provide a regular forum where road safety is considered and strategies are developed and tailored to address road safety issues at the community level. They represent local partnerships that enable collaboration and coordination with lead agencies.

More than half of the councils in WA have a formal local road safety committee. Action plans have also been developed by most committees to focus on and monitor local safety activity in their area.

One element of the WALGA RoadWise program has been to establish a network of Type 1 Child Car Restraint Fitters to help parents install child car seats correctly.

Conclusion

The deaths on our roads of more than 1,500 people annually is a major economic cost, but of far more pressing concern is the immeasurable personal anguish for the families and friends of those killed.

More can and should be done to improve our roads, vehicles and also our attitudes to road safety. Local government, as owner and manager of more than 80 per cent of the total road system, has a critical role to play in road safety at the local level

Local government must ensure that its roads are built and maintained to a safe standard by working with the community to identify black spots, by providing transport alternatives for the transport disadvantaged and vulnerable where possible, and by playing a part in changing the attitudes of communities to road safety.

Safety on our roads is something that all three levels of government have a direct interest and a serious stake in.

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New Zealand's new road safety strategy

By David Eyre, Policy Project Manager, New Zealand Ministry of Transport - Te Manatu Waka

In March this year, Transport Minister Steven Joyce launched a new strategy for reducing the impact of road crashes over the next decade. *Safer journeys: New Zealand's road safety strategy 2010-2020* (available at www.transport.govt.nz/saferjourneys/Pages/default.aspx) proposes significant changes to help improve New Zealand's road safety. These include raising the driving age from 15 to 16, introducing a zero drink drive limit for under 20s, changing the give way rules for turning traffic and reconsidering the adult drink drive limit.

The initiatives in *Safer journeys* are underpinned by a Safe System approach to road safety, which focuses on actions across the entire road system: roads and roadsides, speeds, vehicles and road use. The strategy also aims to address a number of road safety priorities, such as the safety of young drivers and the impact of drugs and alcohol on road safety.

The strategy was developed by the National Road Safety Committee (NRSC). The NRSC is led by the Ministry of Transport and includes the New Zealand Police, the NZ Transport Agency, the Accident Compensation Corporation and Local Government New Zealand.

From the start, public consultation has been a key part of the strategy. We have aimed to strike a balance between feedback received, resources available to implement change, and the evidence and research. This recognises the importance of both research and public support for road safety actions.

Development of *Safer journeys*

Although New Zealand has made significant road safety progress in the last 30 years, since 2002 this progress has slowed and our number of annual road deaths has fluctuated between a high of 461 and a low of 366. The challenge for *Safer journeys* was to ensure New Zealand continues to improve in road safety, and that the rates of deaths and injuries on our roads reduce.

In the early stages of developing the strategy, we looked to identify the key road safety issues and the existing measures used to address them. We also looked to research and experience in other countries to find new initiatives that could make a difference in New Zealand.

The development of *Safer journeys* involved two stages of consultation. We held an initial round with key road safety stakeholders and partners to discuss road safety issues and possible actions for addressing them. The feedback we gathered was used in the development of a *Safe journeys* discussion document.

The discussion document presented road safety priorities (e.g., improving the safety of younger drivers, reducing the impact of alcohol/drug impaired driving) and potential actions, as well a summary of the Safe System approach, information on New Zealand's road safety progress and a proposed vision for road safety. The discussion document and a summary version were released for public consultation on 18 August 2009 and consultation ran until 2 October.

During this time, New Zealanders had the opportunity to rank their preferred actions in the discussion document as well as make submissions. A discussion forum on the *Safer Journeys* website gave people the opportunity to discuss their views with others before making a submission. In addition, we worked with the Ministry of Youth Development to ensure young people had their say. A youth version of the *Safer journeys* discussion document was developed and youth focus groups were held.

We know road safety actions are much more effective when they have 'buy in' from road users, and so giving the public the chance to have their say has been an important part of the strategy. While evidence and research were essential in selecting the initiatives in the strategy, we also carefully considered public feedback. More than 1500 submissions were received on the discussion document and more than 1200 New Zealanders ranked their preferred submissions. These views were taken into account in the development of the final strategy.

Safer journeys goals

Safer journeys sets a vision for 'a safe road system increasingly free of death and serious injury', and the Safe System approach supports this vision. As outlined earlier, a Safe System means working across all elements of the road system to help achieve the strategy's aims for safe roads and roadsides, safe speeds, safe vehicles and safe road use. This is a world best practice approach, but a first for New Zealand's road safety.

Safer journeys also seeks to address a number of road safety priorities. Areas identified as being of high concern are:

- Reducing alcohol/drug impaired driving
- Increasing the safety of young drivers
- Safe roads and roadsides
- Safe speeds
- Increasing the safety of motorcycling

The strategy also sets areas of medium concern, including safe walking and cycling and addressing distraction, as well as areas of continued and emerging focus.

Implementing *Safer journeys*

We have set New Zealand's direction for road safety through *Safer journeys*, but its actions will still need to go through the parliamentary process before they can be introduced. This process will include further consultation and the approval of Parliament. Actions that require funding changes will need to satisfy the funding requirements of the National Land Transport Programme.

Over the life of the strategy we will be developing action plans that set out the actions that will be taken, as well as the timing and detail for implementing them. Action plans will also identify any emerging issues in road safety.

The first action plan will be released later this year. Before this, the Minister of Transport is taking packages of first initiatives aimed at young driver safety and drink driving to Cabinet to discuss and finalise any policy changes.

Safer roads

We know that New Zealand's roads are not as safe as those in other countries. Our road network is variable, and much of it was built when we had fewer vehicles, which were travelling at lower speeds. A low population base and challenging geography mean it is hard to get the same benefits as the best performing road safety nations. For these reasons, roads and roadsides are a high priority for *Safer journeys*. They are also an important element of its Safe System approach. The strategy sets the following actions for safer roads:

- Develop a classification system for the road network
- Focus safety improvement programmes on high risk rural roads
- Focus safety improvement programmes at high risk urban intersections
- Change the give way rules for turning traffic
- Implement targeted treatments on popular motorcycle routes
- Develop and support new approaches to safety on mixed-use urban arterials
- Strengthen techniques to integrate safety into land-use planning.

Safer journeys aims for a road system where roads have a set of self explaining features such as signage, lane width and road markings that make them predictable for drivers and encourage appropriate travel speeds. It also seeks to make our roads forgiving – to reduce the consequences of crashes that do occur.

Conclusion

Safer journeys sets a new direction for New Zealand's road safety with its vision and Safe System approach for reducing the number of deaths and injuries on our roads. Its approach to the safety of our roads, focusing on forgiving and predictable roads, is also a first for New Zealand. Research and evidence have been crucial to the strategy. At the same time, consultation has been important to ensure actions are appropriate to New Zealand and acceptable to New Zealanders. We hope that giving road users the chance to have their say in the creation of *Safer journeys* encourages them to support its actions and share the responsibility for making our roads safer.

Loads off roads: Shifting freight to rail creates a shift in road safety

By Peter MacKenzie, Independent Transport and Road Safety Researcher, Westbury, Tasmania. Email petermac1984@hotmail.com

Australia is not meeting national road safety targets [1], national progress in reducing road trauma over recent years has been much slower than was originally projected [2], and we face a challenging future in which it will become increasingly more difficult to achieve reductions in road trauma without significant investment in the road network [3].

Trucks are over-represented in road fatalities [4], and destructive crashes involving trucks occur across Australia far too often to be considered acceptable in either road safety, public health or the on-road transport workplace systems that it represents.

Yet with political will, coupled to industry and community support and co-operation, we can choose to begin saving more lives quite quickly through compulsory shifting of more freight from road to rail, beginning with specifically targeted routes and freight type – particularly fuel products and other dangerous goods.

It is probable that many truck-related deaths and serious injuries would be prevented if the roads used by trucks were upgraded to meet the Safe System approach adopted by Australian jurisdictions. John Wikman, Executive Manager Traffic and Safety, Royal Automobile Club of Queensland (RACQ), quotes the Australian Transport Council as saying: 'Improving the safety of roads is the single most significant achievable factor in reducing road trauma.' [5]

However, while safety upgrades to roads (including roadsides) are considered a core component of the Safe System, the major impediment ahead of us is that many thousands of kilometres of highways and roads across the nation lack the safety features required for Safe System approaches; it will take decades and tens of billions of dollars to even part complete that work. Infrastructure Australia indicates that $42 billion would be required to bring the National Highway to four star safety rating. The RACQ notes that '…nine years on from the original [2001-2010 National Road Safety Strategy] not enough has been done to improve the safety of roads and roadside environments themselves'. [6]

While the Australian Trucking Association echoes the need for safer road environments, they also place much emphasis on introducing longer and heavier vehicles to reduce exposure to risk of crashes, something repeated by the National Transport Commission. [7]

Thousands of larger, Higher Mass Limit or HML trucks have been introduced in an effort to gain efficiency savings for the road transport industry and to gain safety benefits from reduced exposure to risk during massive growth in the freight task. But much of this is on roads that are very inadequate in safety terms. Professor Ian Johnston, Deputy Chairman from the National Transport Commission (NTC), said in 2008: 'Yet 50% of the road network is more than 20 years old and designed for wheelbarrow sized trucks.' [8]

Professor Johnston also noted that these HML vehicles are supposed to be limited to 'better' (that is, safer) roads [9], but my investigations across several States show too many examples of heavier vehicles being approved access to roads that have numerous safety deficiencies that would not anywhere meet Safe System requirements, nor modern occupational health and safety (on-road) workplace practices. (This is not to say that access approvals do not always meet outdated processes and requirements). I suspect the problem is far more widespread, and warrants an urgent national safety audit, perhaps through a Senate enquiry.

This mismatch of unsafe road environments and introduction of heavier freight vehicles results in an outdated, one-dimensional approach to freight transport and road safety, not a Safe System.

While two reputedly safer B-Doubles can replace three semi-trailers, their numbers have increased from 700 in 1997 to more than 6000 across Australia. There are now more than 500,000 trucks overall, including numerous less-safe older semis, still operating. [10]

There are also serious concerns within the rail industry about the ability of increasingly HML trucks to derail trains in level crossing crashes. (Somewhat ironically, the greatest threat to rail safety is from road users at level crossings.)

A simple shift to rail of the 15 per cent of road freight said to be transferable (or contestable) could save up to 45 lives annually (calculated on the basis of roughly three deaths for every 1 per cent of freight hauled). It could also save 275 or more people from paraplegia, quadriplegia, brain damage and other serious long-term disability (because ratios of fatalities to injuries in truck-related deaths are not the same as for overall motor vehicle deaths/injuries, and estimates vary greatly, a mid-range estimate was used). That is equivalent to reducing the annual average road deaths to zero in Tasmania or the Northern Territory, and significantly reducing the serious injury levels.

During the next decade, up to 450 Australian men, woman and children could be saved from death, 2750 from serious injury, and thousands more family and friends not grieving. That is near 3 per cent reduction in road deaths alone. It would include a significant reduction in numbers of dead or traumatized truck drivers, and less occupational health and safety burden on employers, as well as substantial savings to the hospital and health services.

Much of the potential saving of more than $1 billion dollars in crash costs could be invested in the massive backlog of urgently needed safety works on roads and highways where there is no rail alternative to truck use, thus preventing more deaths and further reducing serious injuries.

While the imperative is strong, the ability to shift freight from road to rail has been seriously impeded by continuing rail line closures, train service suspension and lack of upgrades due to under-funding.

In NSW in recent months, a combination of government policy and corporate profit motives have resulted in the end of rail haulage of petroleum products, despite all the risks involved in road haulage. This concern about too many trucks on inadequate roads and with a very incomplete safety system was raised by the Privy Council members in the landmark 1954 Hughes and Vale transport case, and obviously continues today. It is a very clear non-alignment of policies, stakeholder budgets and safety.

While two B-Doubles can replace three semis, one train can replace up to 150 semis. This results in significantly greater safety gains, as well as reductions in emissions and fuel usage, while substantially reducing costly road damage.

The safety priority would need to target the greatest potential gains, which would include those freight tasks where the roads have safety deficiencies. Trucks would still be needed for part of many haulage tasks, linking to rail using various modern coordinated intermodal technologies. The linking roads where trucks would be used would require assessment for Safe System upgrades, to ensure 'seamless' safety across both modes.

This change will not cost truck drivers jobs due to the massive growth in the freight task (doubling by 2020) and the impending shortfall in truck driver numbers. The consequent safety implications of having inexperienced or inadequately regulated imported drivers is raising serious concerns within the trucking industry, but also needs to be on the radar of developing issues within the road safety domain.

Unfortunately, while the aim of modal shift from road to rail is agreed to by most if not all Australian jurisdictions, it has not been matched by strategically dedicated targeting, timeframes or resourcing. For example, the 2001-2010 National Road Safety Strategy includes 'Encouraging alternatives to motor vehicle use', but that does not translate into any specific actions in the National Road Safety Action Plans for the period.

Modal road to rail shift would also have substantial benefits in reduction of emissions and imported petroleum fuels, while reducing urban congestion (expected to be in excess of $20 billion per annum by 2020) [11], and unsafe traffic overload in regional towns and cities.

Sweden's Vision Zero approach to road safety is underpinned by an ethic whereby deaths and serious injury is not acceptable in road use. We in Australia now need to develop an ethic that puts prevention of serious road trauma before corporate and competition policy priorities in the freight haulage domain.

However, as noted by Lydon: '…major infrastructure improvements are still overwhelmingly aimed at improved mobility, rather than safety.… A national strategy is an opportunity to change the balance in decision making to give the protection of life and health a higher priority than faster travel.' [12] I would add: Or than cheapest, fastest freight movement.

In that light, it is concerning that while the President of the Australasian Council of Road Safety rightly talks of international calls for a 'Decade of Road Safety' to 2020, the Federal Government is clearly focusing on 'Making 2011 the year of freight' [13,14]. I suspect that will continue to be the priority focus beyond 2011 unless there is strong advocacy to make safety 'Transport Priority # 1' from an alliance of those working for road safety.

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Research initiatives to improve the visibility and hence safety of road workers at night-time

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Introduction

Collisions between vehicles and pedestrians represent a significant road safety problem and are overrepresented at night-time, with pedestrians being up to seven times more likely to be involved in a fatal collision at night than in the day [1]. This is particularly relevant at road work sites, which place road workers in a potentially vulnerable position with respect to oncoming traffic. Over the 1995 to 2002 period, 844 US workers were killed while working at a road construction site, and in over half of these fatalities the road worker was struck by a vehicle or moving equipment [2]. Fatal crash data also demonstrate that night-time construction is five times more hazardous than daytime construction [3]. Visibility and conspicuity issues may be key causative factors; analyses of crash databases have shown that the increased incidence of crashes involving pedestrians at night is primarily a consequence of reduced illumination rather than other factors that might vary between day and night, such as driver fatigue and alcohol use [1, 4]. This suggests that at night, drivers are often unable to recognize and respond to pedestrians from a safe distance [5].

Research approaches

While a variety of approaches have been used to make pedestrians more conspicuous to drivers at night (including vehicle and roadway lighting technologies and night vision enhancement systems), emerging research by our group and others has demonstrated that clothing incorporating retroreflective markers can provide highly significant improvements in pedestrian visibility in reduced illumination. Importantly, retroreflective markers are most effective when positioned on the moveable joints creating a sensation of "biological motion". Based only on the motion of points on the moveable joints of an otherwise invisible body, observers can quickly recognize a walking human form, and even correctly judge characteristics such as gender and weight (see Blake and Shiffrar [6] for a review of the literature).

When reflective strips are positioned in the full biomotion pattern (ankles, knees, shoulders, waist, elbows, wrists) they provide substantial advantages for improving pedestrian visibility over and above that of reflective material positioned on the torso, such as reflective vests [7-14]. In the study by Wood et al. [14], for example, drivers using low beam headlights on a closed road recognised a pedestrian walking while wearing biomotion markers at a distance that was 3.4 times greater than when the same pedestrian wore a vest that included an equal amount of reflective material (148m compared to 43m). Importantly, it is the configuration and not the amount of reflective material that determines pedestrian conspicuity. We have also shown that the visibility advantages of biomotion configurations are robust to the effects of driver age [14, 15], visual impairment and headlight glare [16] and visual clutter surrounding the pedestrian [13].

In collaboration with the Queensland Department of Transport and Main Roads, we recently conducted a field study in order to establish whether biomotion reflective markings are also effective in increasing the conspicuity of road workers under in-traffic conditions at two road work sites (one suburban and one freeway) [17]. We evaluated the value of strategically adding reflective markings to those already present in standard vests by determining drivers' subjective ratings of the relative conspicuity of road workers wearing a standard road worker night vest a) alone, or with additional reflective strips on b) thighs, c) ankles and knees, or d) on eight moveable joints (a convenient subset of biomotion).

Participants, seated in stationary vehicles at three different distances (80 m, 160 m, 240 m), rated the relative conspicuity of the four road workers using a standardized scale. Road worker conspicuity was maximized by the full biomotion configuration at all distances and at both sites. The addition of ankle and knee markings also provided significant benefits relative to the standard vest alone. Collectively, these data provide the first evidence that the conspicuity benefits of biomotion markings generalize to open-road work zones. It is important, however, to be aware that these data describe judgments of relative conspicuity (not response distances) and it is imperative that this study be followed up by future studies of the behaviour of unalerted drivers as they approach work zones.

Future studies

In future studies planned in collaboration with Transport and Main Roads, we will further explore the factors affecting road worker visibility and determine optimum configurations that confer visibility benefits that are practical in occupational environments. We will also promote the use of these visibility solutions through educational change, specifically the development of targeted programs to road workers to facilitate awareness of the limitations of driver ability to see both occupational and recreational road workers at night and to promote the use of these optimized visibility clothing configurations.

In previous research we revealed that a key element of the pedestrian visibility problem is that pedestrians fail to appreciate the magnitude of the problem and overestimate their visibility to oncoming drivers [18]. In the only known study that sought to alter pedestrians' visibility estimates, Tyrrell et al [19] discovered that a lecture-based delivery of information on night-time visibility to a 'captive' audience effectively changed subsequent judgments of visibility by pedestrians in an on-road situation. This research provides reason for optimism about translating the findings from our research into safety benefits for road workers over and above the benefits gained by using biomotion.

Future research will develop and test an educational intervention aimed at road workers, demonstrating the need to be aware of difficulties drivers, particularly older drivers and those with visual impairment, have in seeing them at night-time, and the utility and value of biomotion markings in relation to other clothing configurations. The intervention will be developed in consultation with Transport and Main Roads, and will be evaluated in terms of changes to both knowledge and behaviour. It is anticipated that the outcome will be an intervention which is effective and easily implementable by organizations employing road workers.

Conclusions

The adoption of reflective markers in a biomotion configuration has the potential to be an affordable and convenient way to provide a sizeable safety benefit. It does not involve modifications to vehicles, drivers, or infrastructure. Instead, adding biomotion markings to standard vests can enhance the night-time conspicuity of roadway workers by capitalizing on perceptual capabilities that have already been well documented.

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Alcohol and the teenage brain: Safest to keep them apart

By Professor Ian Hickie AM, MD, FRANZCP, FASSA, Executive Director, Brain & Mind Research Institute (BMRI), University of Sydney

Recently College President Lauchlan McIntosh met with DrinkWise Australia to discuss areas of mutual interest and a potential partnership. DrinkWise is a not-for-profit research and social change agency that is dedicated to building a culture in Australia where intoxication or 'drinking to get drunk' is considered unacceptable. As road safety authorities are well aware, the individual and social harms associated with this culture are significant and borne by everyone in the community.

The President was made aware of research commissioned by DrinkWise, which summarizes the current literature in relation to alcohol and the teenage brain. The paper [1], a summary of which appears below, provides strong support for actions by licensing authorities to separate novice drivers from drinking and driving.

DrinkWise advises parents that delaying drinking for as long as possible is still the best message for teenagers. Research is clear that the younger the age children are introduced to alcohol, the more likely they are to develop a range of problems, including dependence later in life. The DrinkWise website at www.drinkwise.com.au provides practical advice for parents in dealing with the issue.

The full article, along with related research about alcohol consumption, cultural drivers and community attitude, can also be found on the DrinkWise website.

What do we know about alcohol and the teenage brain?

Traditionally, the major components of brain development were believed to occur before birth and in early childhood. Consequently, there has always been a strong view that exposure to alcohol and other substances that are toxic to brain cells should be minimized during these periods. The most recent National Health and Medical Research Council guidelines (2009) [2] have significantly reinforced this perspective.

Most cultures have recognized that, with the onset of puberty, individuals move rapidly towards sexual maturity and associated adult responsibilities. Consistent with that major change in social roles, and its associated rites of passage, consumption of alcohol and other substances is encouraged or at least widely tolerated.

Following the discovery of new highly sensitive brain imaging techniques in the 1990s, as well as key findings about the ways in which nerve cell connections are radically reshaped in the post-pubertal period, these traditional views are now undergoing significant re-evaluation. At this time, it is rapidly becoming clearer that alcohol and the teenage brain don't mix and that exposure to alcohol should be postponed and preferably avoided at least until the late adolescent or early adult years.

Much of the clinical, neuroimaging and neuropsychological literature demonstrating the adverse effects of alcohol on the brain is based on adult rather than teenage subjects. The inferences concerning the likely toxic effects of alcohol on the adolescent brain also rely strongly on findings in developing animals rather direct observations in human studies. Those animal studies have tended to emphasize the long-term adverse cognitive and behavioural effects of alcohol and other drug exposures during the relevant 'adolescent' periods of brain development.

Traditionally, the more conservative academic position has highlighted the lack of a large number of long-term human studies and, hence, concluded that the potential adverse effects of early exposure to alcohol amongst teenagers and young adults should not be overstated. While this perspective is understandable, it needs to be balanced first by the emerging findings in human neuropsychological and neuroimaging studies. On balance, the available studies suggest that the adolescent brain is particularly sensitive to the negative effects of excessive or prolonged alcohol exposure, including the adverse effects of binge drinking.

Additionally, one needs to consider the large body of evidence of the degree of direct harm due to injury (including significant head injuries) that results from excessive risk-taking in young people who consume alcohol. This degree of risk-taking while intoxicated is likely to reflect the combination of the disinhibitory effects of alcohol (which are present at all ages due to dampening down of frontal lobe function) and the relative lack of development of the frontal lobes in adolescents. From this perspective, the risk of accidental injury due to excessive risk-taking and poor impulse control is particularly likely to be evident in younger teenagers who use alcohol.

If one weighs up the available evidence concerning direct risks to brain development, short- and long-term effects on cognitive and emotional development, and risks of associated injury due to poor judgment and lack of inhibition, on balance, two conclusions now appear to be justified:

- Alcohol should not be consumed by teenagers under the age of 18 years
- Alcohol use is best postponed for as long as possible in the late teenage and early adult years.

What is the scientific support for this view?

The key emerging scientific issues that support this view are as follows:

1. The frontal lobes of the brain underpin those major adult functions related to complex thought and decision, and inhibition of more child-like or impulsive behaviours. These parts of the brain undergo their final critical phase of development throughout adolescence and the early adult period. While there is considerable individual variation in this

process, it appears to continue well into the third decade of life (age 22-25 years) and may be particularly prolonged in young men.

2. Key parts of the temporal lobe, including the amygdala and hippocampus, continue to undergo development during the adolescent period. The amygdala underpins the normal fear response, while the hippocampus is an essential part of normal memory function.
3. The final phase of frontal lobe development occurs at the same time as the onset of all of the common and serious mental health problems. Seventy-five per cent of adult-type anxiety, depressive, psychotic and substance abuse related disorders commence before the age of 25 years.
4. Alcohol has significant toxic effects on the cells of the central nervous system, and depending on dose and duration of exposure, is likely to result in serious short-term and long-term harm. Those harmful effects are most likely to be evident in areas in which the brain is still undergoing rapid development (i.e., frontal and temporal lobe structures).
5. Alcohol, even in small doses, is associated with reduction in activity of the normal inhibitory brain processes. Given that such processes are less developed in teenagers and young adults, alcohol use is likely to be associated with greater levels of risk-taking behaviour than that seen in adults.
6. Alcohol normally results in sedative effects as the level of consumption rises. It appears that teenagers and young adults are less sensitive to these sedating effects (due to higher levels of arousal) and are, therefore, likely to continue with risk-taking behaviours. As they also experience loss of control of fine motor skills, the chances of sustaining serious injuries (including head injuries) are increased.
7. Exposure to significant levels of alcohol during the early and mid-adolescent period appears to be associated with increased rates of alcohol-related problems as an adult, as well as a higher rate of common mental health problems such as anxiety and depression.
8. Young people with first lifetime episodes of anxiety, depression or psychotic disorders who also consume significant amounts of alcohol are at increased risk of self-harm, attempted suicide and accidental injury, as well as persistence or recurrence of their primary mental health problem.

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Road Safety Literature

AP-T149/10: Road safety engineering risk assessment - Part 4: treatment life for road safety measures

This Austroads report considers the length of time a road safety treatment is expected to remain in place and be of a sufficient standard to continue providing a safety benefit.

Download at www.onlinepublications.austroads.com.au/Script/Details.asp?override=1&SAID=9000&UpdID=494&SID=306447&DocN=AUSTROADS31248.

AP-T157/10: Reviewing ITS technologies and road safety opportunities

This review estimates the potential crash avoidance and injury reduction benefits of different types of Intelligent Transport Systems (ITS) technologies for Australia and New Zealand. Download at www.onlinepublications.austroads.com.au/Script/Details.asp?override=1&SAID=9000&UpdID=494&SID=306447&DocN=AUSTROADS05613.

CASR066 - Vehicle speeds in South Australia 2008

CN Kloeden and JE Woolley assess the effects of speed reduction countermeasures in South Australia. All but one road type showed reductions in speed measurements from 2007 to 2008.

Download at casr.adelaide.edu.au/publications/list/?id=1162.

The effects of Electronic Stability Control interventions on rural road crashes in Australia: Simulation of real world crashes

About 60 per cent of all fatal road crashes in Australia occur on rural roads. Electronic Stability Control (ESC) is an active safety system that has shown potential in preventing crashes on high speed rural roads. The ESC system can detect when a vehicle is about to skid and apply braking interventions to individual wheels to prevent the skid from occurring. Previous studies have shown that vehicles equipped with ESC have a significantly reduced crash rate compared with vehicles not equipped with ESC.

However, the way that the ESC system intervenes to prevent or lower the severity of crashes on rural roads has not been elucidated. Twenty crash scenarios were developed based on actual rural road crashes obtained from an in-depth crash database. With the assistance of Robert Bosch (Australia) Pty. Ltd., 12 of the scenarios were simulated using a vehicle model with and without ESC fitted.

The simulations produced detailed plots that displayed the timing and magnitude of the ESC systems interventions. For the 12 successful simulations, ESC was found to prevent a collision in 10 cases and reduce the severity of a collision in the other two.

Download at http://www.infrastructure.gov.au/roads/safety/publications/2009/RSRG_2009005.aspx.

(*Reviewed by Colin Grigg*)

Peer Reviewed Papers

Driver behaviour and crash profiles at Seagull T-junctions on high speed rural roads

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This paper was adapted from a paper presented at the November 2009 Road Safety Research, Policing and Education Conference in Sydney.

Abstract

The aim of this paper is to evaluate the safety performances of unsignalised Seagull T-junction configuration on high speed rural roads in NSW. The findings were that two types of crashes, Right Near and Right Through, were predominant among all the crashes, and those that result in casualties. Driver impairment, speeding behaviour and road environment conditions were a factor in a small percentage of these crashes.

Of the deemed to be at-fault male drivers, almost two-thirds were at and above the age of 67. However, for each of the other age groups below this, there was a higher incidence of female drivers than male drivers involved in Right Near crashes. The former is consistent with other studies on older male drivers.

Consistent with the New South Wales Roads and Traffic Authority (RTA) Safe System approach, key solutions include substantially reduced speeds for through traffic and removal of critical side impact crash types. This may require further investigation prior to implementation.

Keywords

Seagull intersection / junction, T-junction, Road safety, Driver behaviour, Driver age, Driver gender, Crash profiles

Introduction

Rural T-junctions commonly connect a high speed rural road with a minor road that may be controlled by ‘Stop’ or ‘Give Way’ signs. Road crashes that occur on rural roads have a greater tendency to result in serious injuries and fatalities, due to the existence of a higher speed environment, remoteness, side impacts and poorer access to emergency services.

In New South Wales, more than 400 crashes occur at rural T-junctions every year. To reduce the road toll, a better understanding of the relationship between road environments and crash patterns is required, and from these findings, recommendations can be made for a better design of T-junctions.

A major road safety study on rural T-junctions is being conducted by the New South Wales Centre for Road Safety. The aim of this study is to quantify the road safety performance of common T-junction configurations. The four T-junction configurations selected for this study are: Basic Right Turn (BAR), Auxiliary Lane Right Turn (AUR), Channelised Right Turn (CHR) and Seagull junction. This outcome of the study will provide measures of the relative crash frequencies and severities at these four T-junction types.

This paper will present findings on Seagull T-junctions only. Findings on other T-junction configurations will be published at a later stage of the project.

What is a Seagull junction?

A Seagull junction is a common ‘at grade’ treatment for three legged T-junctions. It consists of a channelised deceleration lane for vehicles turning right into the minor road and a protected acceleration lane for vehicles turning right out of the minor road. These two lanes form the ‘wings’ of the Seagull when viewed from the air.

An advantage of the Seagull layout is the separation of conflicting vehicle paths. Motorists turning right from the stem of the T-junction need to worry about traffic from one direction only at any time. A typical Seagull layout diagram is in Figure 1.

Methodology

Site identification

The first step in the study was to identify the locations of Seagull junctions on the road network. Fifteen state highways known to have high speed rural sections were investigated based on the following criteria:

- Seagull junctions
- on rural undivided roads

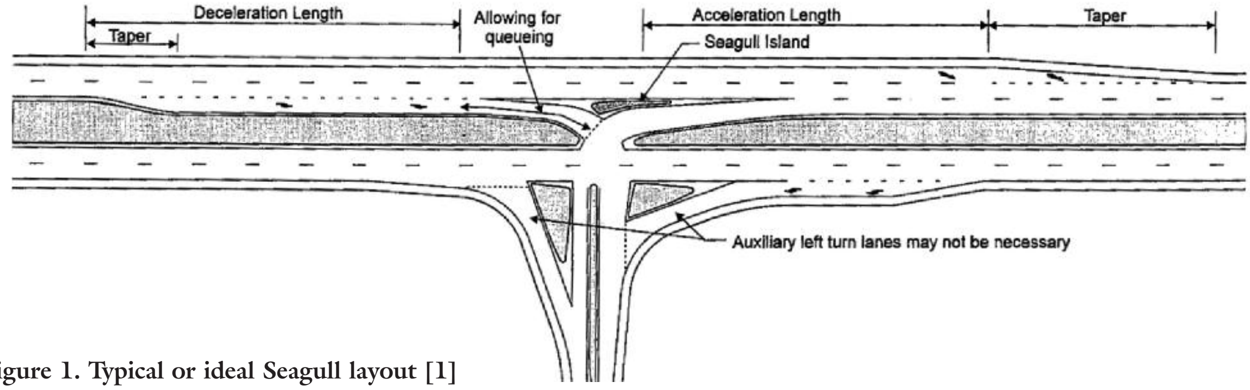

Figure 1. Typical or ideal Seagull layout [1]

- with speed limit 90 km/h or above
- having significant traffic volume.

The RTA's Gipsicam[1] system, which allows the investigator to view the intersections from the driver's perspective in various directions, was used to identify these locations. Visual clues used include the following:

- regulatory signs showing speed limit of 90 km/h or above
- presence of a tourist sign, directional sign or other destination signage, which is an indication of a significant traffic volume.

After the Seagull junctions along the highways were identified, the sites for the study were selected. The sites selected were sites where the Seagull junction was in operation for a reasonable length of time and where crashes had occurred. Twenty-three Seagull T-junction sites were identified by using this method.

An added complication is that the configuration of the intersections changes over time and it was difficult to identify the exact installation date for all the sample sites. Some sites may have also been upgraded to their current state from a different configuration.

Hence, in the investigations stage, there was a need to identify the operation period of the configuration at each site and to disregard any crash data that is not applicable to the specific configuration. Historical Gipsicam images were used to determine the definite operation period of the Seagull junction.

For example, Figure 2 shows three Gipsicam images of the same location taken in different years. By comparing the three images, it can be confirmed that

- a Seagull junction was operating by 3 December 2006
- Channelised Right Turn (CHR) treatment operated between 23 February 2001 and 18 February 2004.

In such cases, often the exact date of operation of the Seagull junction could not be ascertained, but for the purpose of this study, only crash data occurring after the date shown on the images showing a Seagull junction was considered for the analysis.

Crash data analysis

For this study, crash data were extracted from the Roads and Traffic Authority's Crashlink database, which contain records of all road crashes that occurred on the New South Wales classified roads and local roads network from 1996 onwards.

The data include information on crash location, time of day, surface and lighting conditions, speed limit, road user movements, number of vehicles involved and directions of travel for all reported fatal, injury and tow-away (property damage) crashes. The data used in the study were crashes that occurred between the years 1996 and 2008.

To make the data appropriate for the purpose of this study, the raw crash data were filtered using the following criteria:

Figure 2. Gipsicam images of the same junction over a period of years

- Only crashes occurring within 100 metres from the node on any of the three legs of the Seagull junction were included in the analysis.
- Crashes that were not within the operation period of the Seagull junction (described in the previous section) were excluded from the analysis because these crashes were unlikely to be affected by the Seagull junction.
- Only intersection-related crashes were included. Other crashes such as Off Road on Straight, Off Road on Curve and Hit Animal were excluded, as they are unrelated to the presence of the Seagull junctions.

The selected crashes were analysed in terms of crash severity, crash types, behavioural factors, road environment factors and road user factors. During the analysis, it was noted that some of the crashes were coded as Cross Traffic crashes. This was considered to be in error, as Cross Traffic crashes cannot occur at T-junctions. These crashes were re-coded as Right Near crashes, which were nearest equivalent crash type to a Cross Traffic crash.

Results

These results are based on an analysis of all intersection related crashes that occurred at the 23 chosen Seagull junctions within the period of study as defined in the methodology.

A total of 153 reported crashes were analysed. Table 1 summarises these crashes by the degree of crash severity. There were 4 fatal crashes (4 fatalities), 82 injury crashes (154 injuries) and 67 tow away crashes. More than half of the crashes (57%) were casualty crashes, involving at least one person being killed or injured.

Degree of crashes	**Number of crashes**	
Fatal	4	3%
Injury	82	54%
Tow away	67	44%
TOTAL	153	

Table 1. Number and degree of crashes

Behavioural factors

Behavioural factors such as driver fatigue, alcohol usage and excessive speeding were also assessed. None of the crashes involved were identified as driver fatigue crashes. 6 crashes (4%) were known to involve alcohol and only 4 (3%) of the crashes had speeding identified as a factor. The low rate of identification of speed may have occurred because the errors are apparent in crashes at Seagull intersections (especially failure to give way), yet clear evidence of speed is difficult to obtain.

	Behavioural Factors		
	Fatigue identified	Known alcohol	Speeding identified
Yes	0	6	4
No / Unknown	153	147	149
TOTAL (all crashes)	**153**	**153**	**153**

Table 2. Behavioural factors involved in analysis of 153 crashes

Road environment factors

Of the total number of crashes, 73% occurred during daylight with dry surface conditions, 15% during daylight with wet conditions, 9% during darkness with dry conditions and 3% during darkness in wet conditions. Despite 18% of the crashes occurring in the wet surface, only 14 motor vehicles out of 315 (4%) involved skidding and sliding.

	Surface condition	**Dry**		**Wet**	
Natural lighting	Darkness	14	9%	5	3%
	Daylight	111	73%	23	15%
TOTAL (all crashes)				**153**	

Table 3. Road environment factors involved in analysis of 153 crashes

Crash types

Table 4 summarises the number of crashes by crash type. The predominant crash types were Right Near, Right Through and Rear End which account for 45%, 27% and 14% respectively. Right Near and Right Through movements were more severe with 48% and 31% of the crashes being casualty crashes. Rear End crashes were less severe, with only 7% resulting in casualties.

A majority of the crashes (121) occurred as a result of poor gap selection by the driver in the key vehicle, which means that the driver was unable to select a safe gap to clear the intersection. Of the crashes, Right Far (RUM 11), Right Near (RUM 13), Two R Turning (RUM 14), Left Near (RUM 16), Right Through

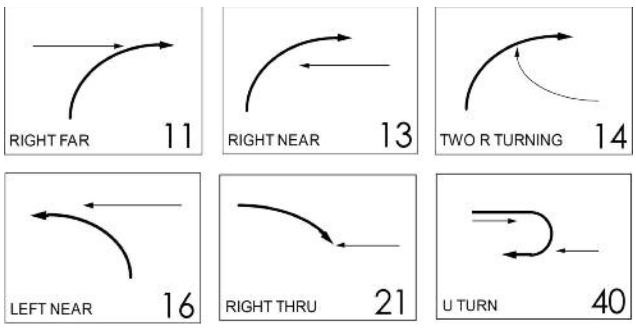

Figure 3. Vehicle path diagrams for poor gap selection crashes

Road User Movement (RUM code)	Fatal	Injury	Tow away	Total	% Total	% of casualty crashes
Adjacent - Right Near (13)	3	38	28	69	45%	48%
Right Through (21)	1	26	14	41	27%	31%
Rear End (30-32)	0	6	15	21	14%	7%
Adjacent - Other (11; 12; 14 - 19)	0	4	7	11	7%	5%
Lane Change (33-35)	0	3	2	5	3%	3%
Off End of T-Junction (75)	0	2	1	3	2%	2%
U-Turn (40)	0	1	0	1	1%	1%
Parallel Lanes Turning (36 - 37)	0	1	0	1	1%	1%
Vehicle Accessing Road (42; 47 - 49)	0	1	0	1	1%	1%
TOTAL	**4**	**82**	**67**	**153**		

Table 4. Crashes by Road User Movement (RUM) groups

(RUM 21) and U-turn (RUM 40) were considered to be related to poor gap selection. They account for 79% of the total number of crashes.

The crash type diagrams detailing vehicle travel paths of the key and second vehicles for each of these crashes are shown in Figure 3.

Vehicle type

Further analysis was carried out to identify the vehicle type of the deemed to be at fault vehicle[2], and the second vehicle, for the 121 crashes that were a result of poor gap selection. As shown in Figure 4 below, the distribution of vehicle types for the key and the second vehicle is almost identical, with a majority of the traffic units being motor cars.

Time of day

The incident time of the 121 poor gap selection crashes were also analysed. Of the crashes, 105 occurred between 8am and 6pm, which accounts for 87% of the poor gap selection crashes. The crashes that occurring in the two-hour time groups of 8am-10am, 10am-12pm, and 12pm-2pm were consistently at 12-13%. However, the number of crashes that occurred in the afternoon periods of 2pm-4pm and 4pm 6pm come to 24%, which is double the number of crashes during the morning and mid-day periods.

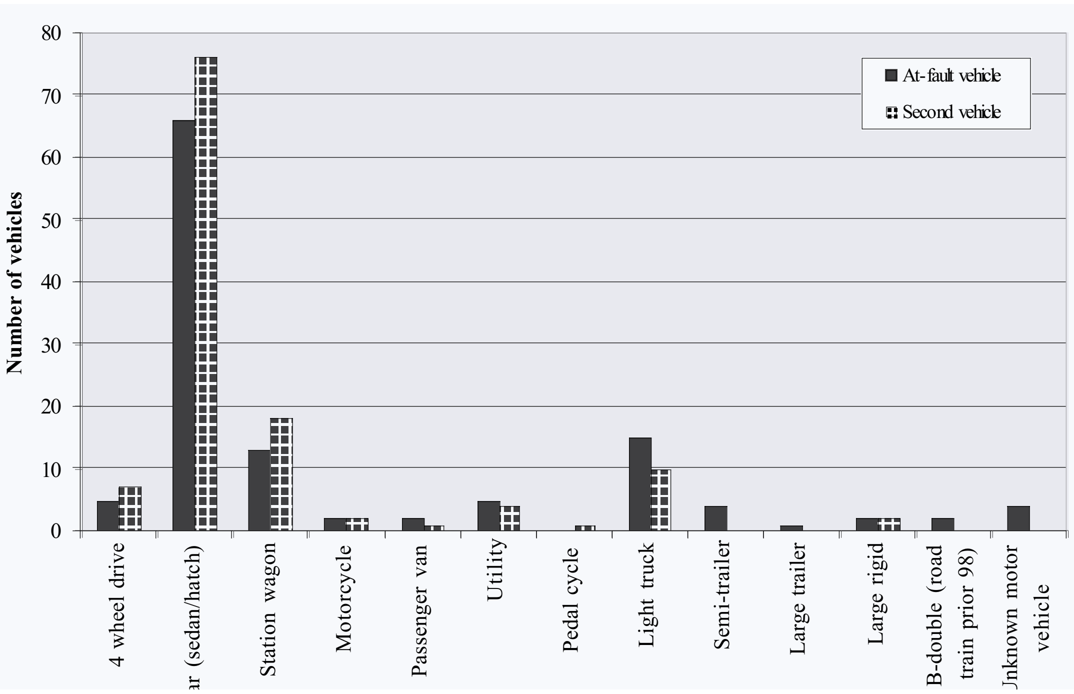

Figure 4. Vehicle types of key and second vehicle involved in poor gap selection crashes

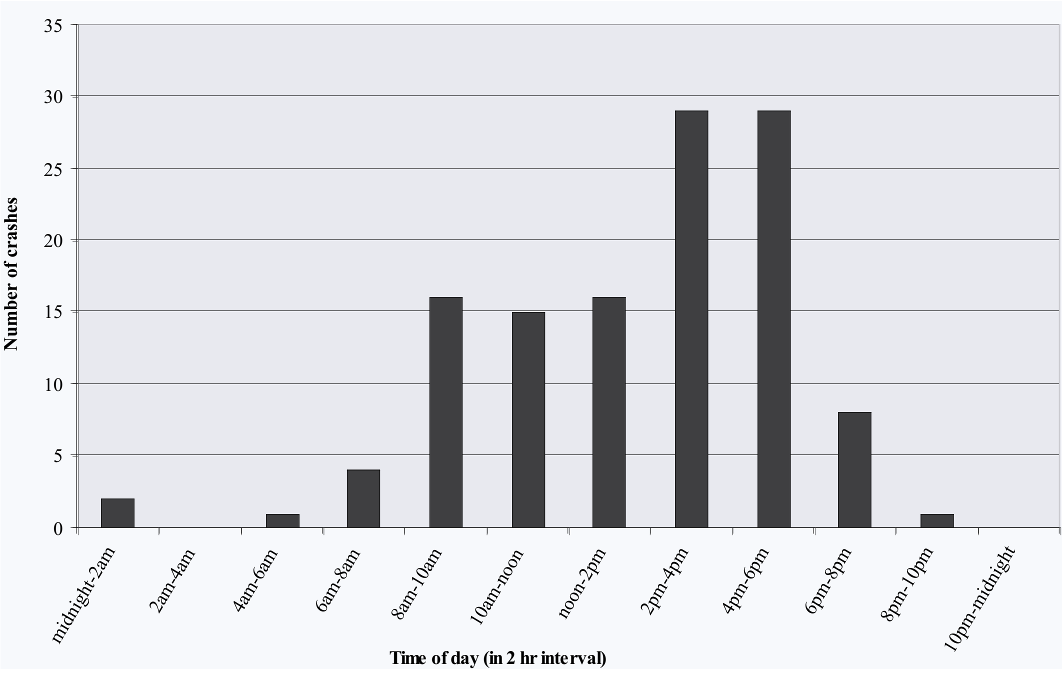

Figure 5. Crashes related to poor gap selection in 2-hour intervals

Age group, gender and time of day

The gender and age groups of the deemed to be at-fault drivers[3] (those unable to select a sufficient safe gap) of the 121 poor gap selection crashes were identified. The two most severe crash types (Right Near and Right Through) were analysed separately.

Right Near crashes are those that occurred as a vehicle turned right out of the minor road and collided with the vehicle from the right. The at-fault driver who is performing the right turn manoeuvre is only required to observe the safe gap from the adjacent vehicles, as a fully protected acceleration lane is available once the right turning vehicle is on the 'wing' of the Seagull junction.

There were 69 Right Near crashes, with almost an equal split on the total number of female (34) and male (35) key vehicle at-fault drivers, as shown in Figure 6. The distribution of female at-fault drivers is consistent across all ages, with the number of crashes fluctuating between 4 and 6. Male drivers appear to perform relatively better than female drivers in Right Near crashes at or under the age of 66. However, in the age group from 67 to 96, the proportion of male at-fault drivers increases substantially. Approximately 60% of male at-fault Right Near crashes are within this group.

From Figure 7, the distribution of male at-fault drivers shows a steady increase with time of the day, with the peak at 2pm-4pm followed by a gradual decrease after the peak. In contrast, the distribution of crashes with female at-fault drivers has two peaks, one at 8am-10am and a second peak at 4pm-6pm.

Right Through crashes occurred when the driver travelling from the main through road performed a right turn into the minor road and collided with an opposing vehicle. The at-fault driver performing the right turn is required to observe the safe gap from an oncoming vehicle.

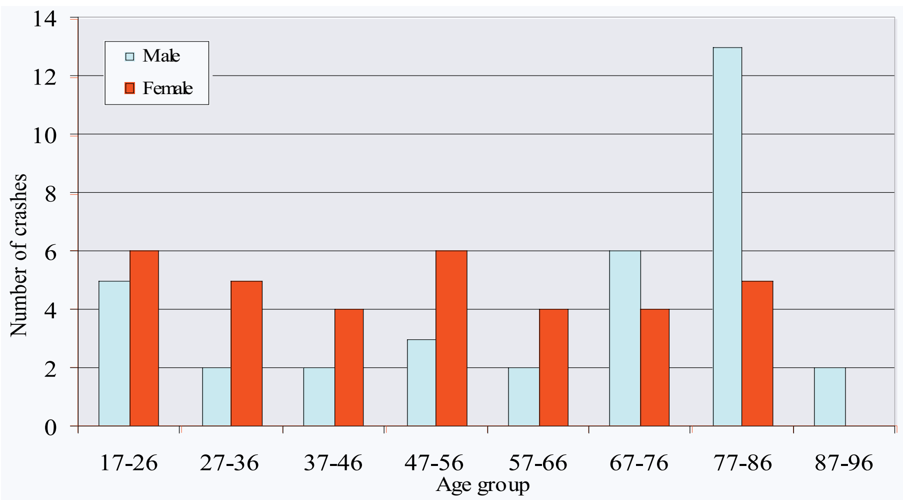

Figure 6. Distribution of Right Near Crashes (RUM 13) in age and gender group

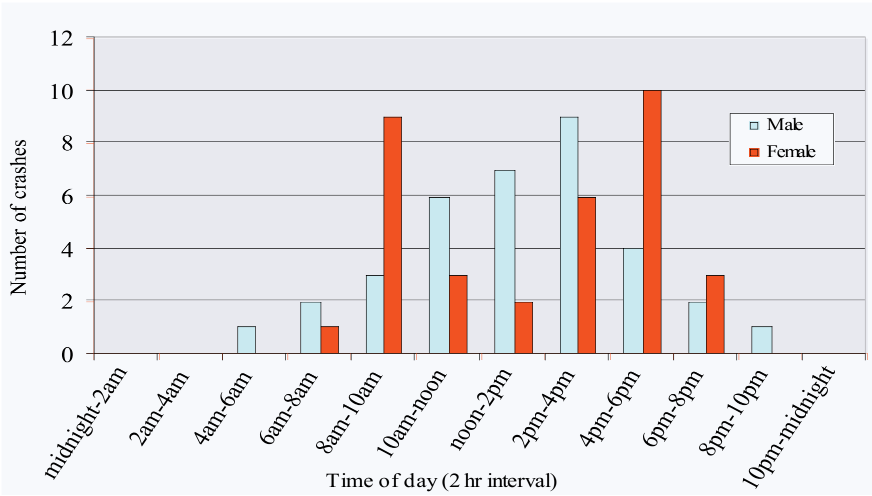

Figure 7. Distribution of Right Near crashes (RUM 13) in 2-hour intervals and gender group

(Note: Time of day may reflect traffic volume and should not be interpreted to indicate more problem behaviour.)

There were 41 Right Through crashes involving 20 female and 21 male at-fault drivers. The dataset may not be large enough to show a significant difference in different age groups and time intervals for this crash type, as indicated in Figures 8 and 9, respectively. However, it gives an indication that a majority of the at-fault drivers for Right Through crashes were in the lower age groups. Unlike the case of Right Near crashes, older male drivers are not so significant in terms of crash frequencies. Similarly, a majority of the crashes occur at the afternoon hours between 2pm-4pm and 4pm-6pm.

Discussion

There were 153 reported crashes at the 23 Seagull T-junction sites, of which 57% of the crashes were casualty crashes. A majority of the crashes occurred with dry surface conditions and during daylight hours and in light motor vehicles. Although 18% of the crashes occurred with wet surface conditions, this is not considered to be a significant factor as only 4% of the vehicles involved in a crash had skidding or sliding as an error factor.

This is consistent with studies by Arndt [2] that found that the majority of the high frequency intersection crashes occurred during clear conditions and in daylight. The study also suggested that it is possible that, because traffic volumes and delays are greater during the hours of daylight, drivers accept smaller traffic gaps, thereby taking greater risk and increasing their likelihood of being involved in a crash.

The predominant crash types are Right Near (45%), Right Through (27%) and Rear End (14%). Right Near and Right Through crashes contribute 48% and 31% of the casualty crashes. Rear End account for only 4% of the casualty crashes. Of the total crashes, 87% were due to the result of poor gap selection by the deemed to be at-fault driver.

The crash frequencies of older male drivers in Right Near crashes were substantially higher than younger age groups. Approximately 60% of the male deemed to be at-fault drivers involved in Right Near crashes were at or above the age of 67. In general, the crash occurrences of Right Near (adjacent traffic gap) crashes of female drivers at or under the age of 66 were higher than male drivers in the equivalent age group. With the 56% of female driver deemed to be at-fault Right Near crashes occurring at 8am-10am and 4pm-6pm, 73% of these female drivers were at or under the age of 66.

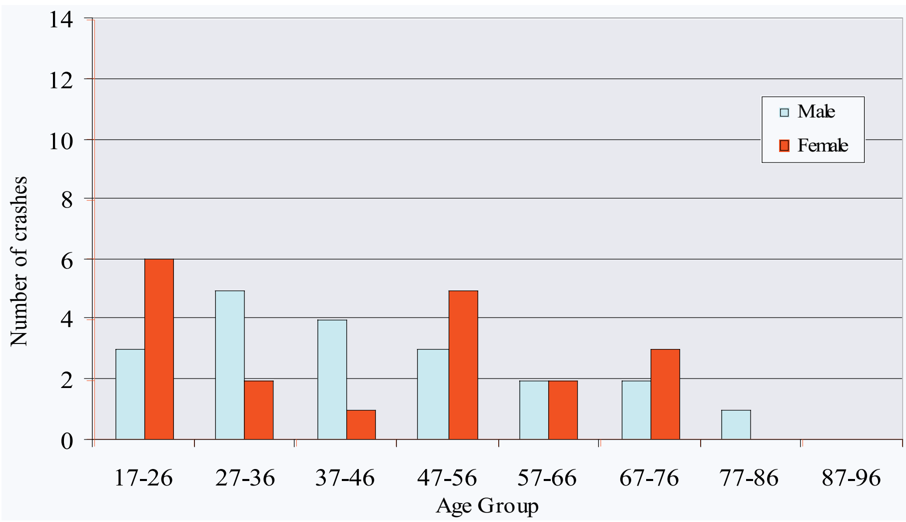

Figure 8. Distribution of Right Through Crashes (RUM 21) in age and gender group

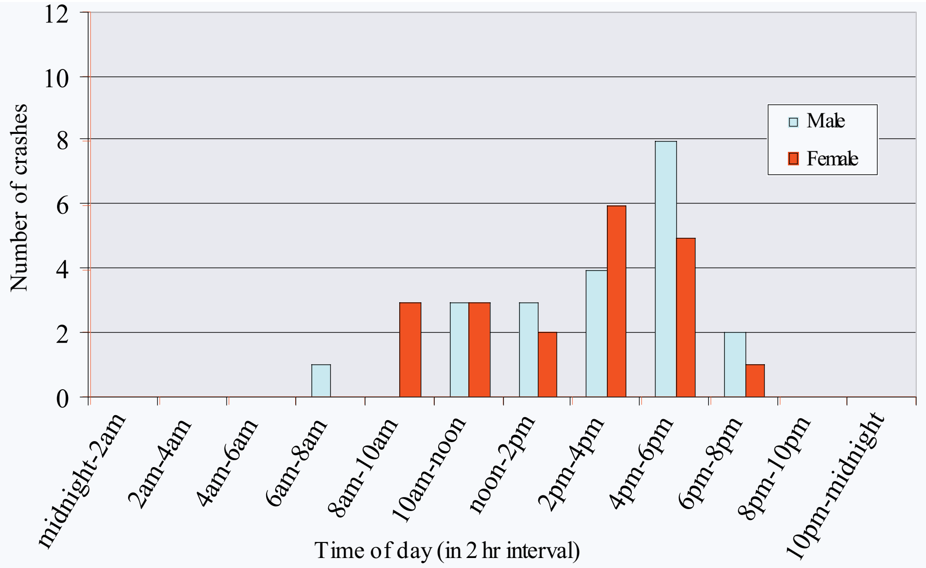

Figure 9. Distribution of Right Through Crashes (RUM 21) in 2-hour interval and gender group

A study by King [3] found that older drivers were more likely to be involved and responsible for intersection crashes. Similarly, Ryan, Legge and Rosman [4] also found that older drivers over the age of 60 had more direct and indirect right angle crashes. Another study by Oxley, Fildes, Corben and Langford [5] found that older drivers had problems in determining safe gaps and turning across oncoming traffic. Job [6] also found that older males are more overconfident about their driving ability.

Yan, Radwan and Guo [7] suggested older drivers rely primarily on perceived distance to perform gap selection judgements. There is also work suggesting that older drivers may have difficulty selecting safe gaps in traffic while the principles of gap identification and ability to judge speed and safe distance can apply to drivers as well. For example, an experimental study by Oxley, Ihsen, Fildes, Charlton and Day [8] in a simulated environment showed that a high proportion of older pedestrians selected unsafe gaps to cross the virtual road. This experiment followed an RTA-funded real world observation of the same pattern of gap acceptance and age [9].

The above studies are consistent with the findings in this study that older drivers have a higher probability of involvement in right angle crashes. It is possible that this may be due to the deterioration in their cognitive ability, resulting in a delayed reaction time and difficulty in selecting safe gaps.

The reasons for the uneven gender split of deemed to be at-fault drivers in Right Near crashes in the age of 67 or above are at this stage unclear. However, in general, there are fewer older female drivers on the roads [10], and hence may be less represented in the crash statistics. Hakamies-Blomqvist [11] also found that older female drivers drive less than male drivers.

The observation that younger female drivers are over-represented in Right Near crashes could be because female drivers are more responsive to pressure from higher traffic volumes. It may also be due to other factors that are not captured in the crash database. Further research is required to identify the influencing factors.

As Right Through crashes involve substantially lower numbers of older drivers, it is conjectured that the right turn manoeuvre only requires drivers to look forward to judge the speeds and distances of opposing vehicle (apparently head on) which falls within their peripheral limit. There is no significant pattern in terms of age band and gender group to suggest possible reasons for the crash. The crash data demonstrated a vast majority of these crashes had no influence of alcohol, driver fatigue and excessive speeding. There may be a broad range of reasons why these crashes are occurring, however, no obvious ones were identified other than that of a diminishing cognitive ability to select gaps due to age.

Conclusion

This paper provides empirical evidence of the crash frequencies and patterns of reported crashes occurring at rural Seagull T-junctions. It also produced identification of crash profiles for further analysis. The findings from this study will still be applicable even though the demographics in other locations may be different.

Future studies will place emphasis on identifying crash trends at Seagull junctions as compared with other T-junction configurations. A full report, which will assist road safety practitioners in selecting T-junction treatments, will be compiled once the other T-junction configurations have been analysed.

The crash data indicates two groups of drivers that have a higher risk of crashes at rural Seagull T-junctions, namely young female drivers and older (at or above 67 years of age) male drivers.

The Seagull treatment separates out conflict points and thereby reduces the conflict complexity. The Seagull treatment provides relatively safe positions for drivers to stop before turning as demonstrated by the relatively few rear end crashes. However, the Seagull treatment, like other rural intersection treatment, does not affect the speeds of through traffic, and other means to reduce the speeds of through traffic requires further consideration and research.

Consistent with the RTA's Safe System approach, which acknowledges the inevitability of human errors, the feasibility of reducing the entering speeds of the through traffic into the T-junction and other measures to minimise conflict points may be considered for the junctions where crashes have occurred.

Notes

1 Gipsicam is a mobile mapping system that records photo images of RTA's State road network. It also provides accurate Geographic Positioning System (GPS) coordinates for the photo location. The roads are re-surveyed every two to three years, and the survey date is clearly marked on the image. It enables users to view images of the State road network in 10-metre intervals for both directions.

2 At-fault vehicle is defined as the key and second vehicle involved in the turning movement based on the vehicle travel directions provided in the crash data. Second vehicle is defined as the next vehicle that collided with the at-fault vehicle.

3 At-fault driver is defined as the driver controlling the at-fault vehicle who made the gap selection decision for the turning movement – that is, the driver who failed to give way.

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Evaluation of narrow median wire rope barrier installation on Centennial Highway, New Zealand

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Abstract

This paper reports on the performance of a wire rope barrier on a narrow median installation on Centennial Highway, New Zealand. Since the time the speed limit was reduced from 100km/h to 80km/h and the wire rope median barrier was installed, no fatalities or serious injuries have occurred. The median barrier was introduced in two stages and has been very successful in reducing road trauma. Prior to stage one the average annual social cost of crashes on Centennial Highway was $5,796,889.[1] This has since reduced to an average social cost of $65,400 per year.

Surveillance of the Centennial Highway median barrier showed that vehicles generally sustained relatively little damage when they struck the barrier and were often observed to drive away after the impact. Drivers also tended to travel more centrally within their lane with the barrier in place.

While the narrow median on Centennial Highway has resulted in an increase in maintenance costs due to impacts on the wire rope barrier, this cost has been significantly offset by reductions in trauma costs. This paper presents a number of challenges that needed to be overcome to construct the narrow median wire rope barrier and evaluates the success of the barrier in reducing road trauma along this section of state highway.

Keywords

Head-on crashes, Wire rope, Median barriers

Introduction

Coast Road, also known as Centennial Highway, is a picturesque stretch of State Highway 1 that extends along the New Zealand coastline around 30km north of Wellington and serves as the main access route to the nation's capital city. Road closures and delays caused by crashes result in significant disruption, often impacting significantly on commercial carriers.

By the late 1990s, the reputation of this section of two-lane, two-way highway as a scenic travel route had become overshadowed by a notoriety for serious road crashes. While Centennial Highway did not feature unduly as having a high crash rate, the crashes that occurred were generally severe and often involved fatalities.

A number of fatal crashes in the late 1990s fuelled public concern. The New Zealand Transport Agency (then Transit New Zealand) responded with a series of measures, including enhanced road marking and signage. These measures had seemingly been successful in eliminating serious injury crashes for two years.

Then in 2004, the incidence of two fatal head-on crashes reignited the community's concern. A strong public call for action was fuelled by intensive media focus. This time the response was stepped up by reducing the speed limit to 80km/h and installing a median barrier to reduce the likelihood of high severity head-on crashes.

This paper presents a number of challenges that needed to be overcome to construct the narrow median wire rope barrier and evaluates the success of the barrier in reducing road trauma along this section of state highway.

Background

Public concern about the safety of Centennial Highway peaked in the late 1990s following a number of serious road crashes. In the five years from 1996 to 2000 there were 14 head-on crashes along the 3.5km stretch of Centennial Highway that winds its way along the coastline between the two townships of Pukerua Bay and Paekakariki.

Implementing physical changes to this section of highway presented a significant challenge. The road extends through a narrow corridor carved between a rocky coastline and a steep hill range. This physical constraint is compounded even further by a parallel railway line running along the hillside. The traffic volume along this section of highway is around 22,000 vehicles per day [1].

In 2000 a package of safety improvements was implemented to address the incidence of high severity crashes without confronting the physical constraints of the road and its boundaries. The measures included:

- removal of a southbound passing lane
- signs advising of speed and entry to a high accident area
- passing and parking restrictions
- extra wide and profiled (tactile) double yellow centre lines
- red-coloured, raised reflectorised pavement markers on the edge lines.

Additionally, roadside vegetation was trimmed to improve visibility and the adjacent seawall was painted to more clearly mark its presence. In 2001, further improvements were carried out to correct the shape of one of the curves and to install a section of roadside guardrail.

From 2001 to 2004, the measures appeared to have had the desired effect of reducing crashes; the number of high-severity crashes had reduced significantly. However, public concern was reignited in the middle of 2004 following the quick succession of two head-on crashes that resulted in fatalities.

As a result, the speed limit was dropped from 100km/h to 80km/h on 23 August 2004 and the challenge of installing a median barrier in this difficult environment began. Around three months later a wire rope median barrier was in place, separating north and southbound traffic over a length of around 700m where the most recent fatalities had occurred. Physical works on the median barrier began on 26 October 2004 and on 22 November 2004 the NZ$1 million project was completed.

The safety improvement afforded by the median barrier became well established over the following two years and calls continued to have the barrier extended over the remainder of the length of road. Works to complete the remaining 2.8km along this section began in September 2006 and were completed in October 2007 at a cost of $14.5 million.

Finding an innovative solution

The typical standard width for a road of this type with a median barrier is shown in Figure 1. However, because of the physical constraints along this road corridor it was not going to be possible to provide a desirable standard width median treatment without huge cost. These physical constraints include a coastline and seawall on one side of the road and a steep rocky hillside on the other.

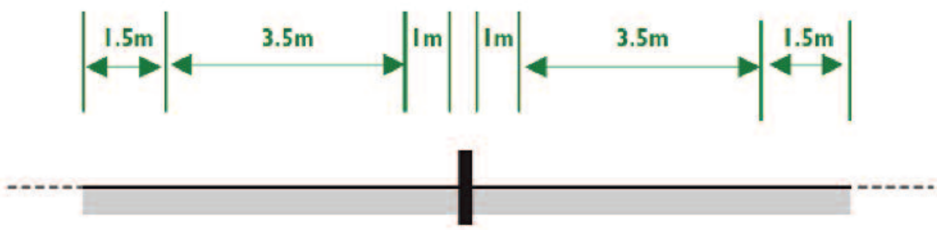

Figure 1. Typical median treatment

Wire rope *Steel w-beam* *Concrete*

Figure 2. Different median barrier types

A feasibility study was carried out to investigate the potential use of a wire rope barrier, a semi-rigid steel w-beam barrier and a solid concrete barrier (Figure 2). The solution needed to improve safety while allowing access for emergency vehicles in the event of an incident. If a semi-rigid or solid barrier was installed and a crash caused one lane to be closed, the ability for emergency vehicles to reach the incident would be hampered. In addition, the barrier solution needed to allow flexibility to carry out maintenance activities on the road.

A wire rope barrier was considered the most appropriate solution for this location. The capital investment required was significantly less than that for a solid concrete barrier, which was a significant factor in this instance to enable a solution to be implemented quickly. In addition, it was considered that a semi-rigid w-beam barrier would cause greater delays during repairs and, with a narrow median, an impact could potentially result in permanent deflection of the barrier encroaching into the opposing lane until such time that repairs could be carried out.

A wire rope barrier could be dropped quickly if there was an incident to facilitate emergency service access and, with a number of reasonably tight (200 to 300m radius) curves along this section of road, a wire rope barrier was considered to have the least impact on forward visibility. A wire rope barrier was also considered to be the least visually intrusive on this scenic stretch of State highway.

The chosen option proposed a 1.5m wide wire rope median with a slightly reduced lane width (from 3.5m to 3.25m), providing a minimum overall road width of 10 metres (Figure 3). The solution needed to ensure a minimum width for each lane of at least 5m to enable two vehicles to pass each other in the event of a breakdown.

Wire rope median barriers are used extensively on Sweden's 'collision free' roads [2]. These roads are generally 2+1 or 2+2 highways and expressways that have been treated with median barriers to separate the opposing traffic directions. The 2+1 roads are three lane roads with two lanes in one direction and one lane in the other, alternating every few kilometres and separated with a median barrier, usually a wire rope barrier (Figure 4). Around 1800 kilometres of collision-free roads have been constructed and opened to traffic as at 1 January 2008.

A study by the Swedish National Road and Transport Research Institute (VTI) to evaluate the in-service performance of roads treated with wire rope medians showed that this barrier system significantly reduces road trauma. The study compared normal 13 metre wide roads and expressways to MML and MLV collision-free roads. MML expressways have interchanges with access provided via entry and exit lanes. MLV highways have at-grade intersections with breaks in the median barrier.

MML expressways with posted speed limits of 110km/h and 90km/h showed an overall reduction in fatalities and serious injuries (FSI) of 57% and 62%, respectively. MLV highways with posted speed limits of 110km/h and 90km/h showed a FSI reduction of 39% and 63%, respectively [2]. These reductions represent the overall performance for links plus junctions.

New Zealand has a number of road sections treated with narrow medians similar to Sweden's 2+1 roads. However, the Centennial Highway installation was the first use of a median barrier on a two-lane, two-way (1+1) road in New Zealand. Part of the consultation process involved working with the emergency services to demonstrate the level of accessibility that could be maintained in the event of an incident blocking one of

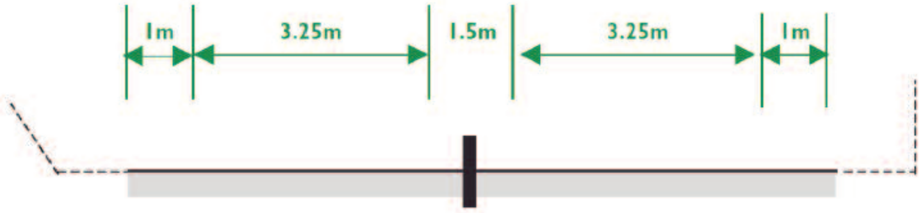

Figure 3. Selected median treatment

Figure 4. Swedish 2+1 road

the lanes. A demonstration was carried out to show how easily the wire ropes could be lifted and the posts removed.

The wire rope barrier system used on the first 700m stage had been tested to international standards with a test level 3 (TL3) design deflection [3] of 1.9m at a post spacing of 2.0m and a design deflection of 2.5m at a post spacing of 3.0m [4]. With an offset of 0.75m between the median barrier and the centerline, this meant that deflection upon impact was likely to extend into the opposing traffic lane. To minimise the amount of deflection, the post spacing was reduced to 1m. For the remaining 2.8km extension, the wire rope barrier post spacing was selected to achieve a maximum TL3 design deflection of 1.5m.

Surveillance of the barrier in operation, as described later in this paper, has captured a number of incidents involving a vehicle hitting the wire rope barrier in close proximity to vehicles travelling in the opposing traffic lane. There has been no evidence of problems associated with potential deflection into the opposing lane from crash records or from observations of performance during an impact. Figure 5 shows the final Centennial Highway cross section incorporating a wire rope barrier on a narrow median reserve.

Figure 5. Narrow median wire rope barrier installation on Centennial Highway

Safety and operational performance

Review of crash data

Historical crash data has been obtained from the New Zealand Crash Analysis System (CAS), which includes records of all vehicle crashes that are reported to the police in New Zealand [5]. Any crash on a public road in New Zealand that results in injury is required by law to be reported to a police officer, although it is acknowledged that not all injury crashes are reported, particularly the less severe crashes.

The attending police officer completes a traffic crash report and codes injuries as fatal, serious or minor. A fatal crash involves injuries that result in death within 30 days of the crash. A serious crash involves an injury such as a fracture, concussion, severe cuts or other injury that requires medical treatment or removal to and retention in hospital. A minor injury crash involves injuries of a minor nature such as sprains and bruises that are typically treated onsite.

Table 1 provides a summary of crashes on Centennial Highway between 1996 and 2009. This represents all crashes reported along the 3.5km coastal section of Centennial Highway that has been treated with a wire rope median barrier. All social costs are based on 2008 figures published by the New Zealand Ministry of Transport: Fatal crash $4,039,000, Serious $717,000, Minor $84,000, Non-Inj $2500 [6].

Prior to construction of the first 700m length of median barrier in 2004 there were 12 fatal crashes and 4 serious injury crashes in nine years. Of these, 8 of the fatal crashes and all of the serious injury crashes were head-on crashes. There have been no fatal or serious crashes, nor any head-on crashes, since 2004.

Prior to the safety improvements in 2000, the average annual social cost of crashes on Centennial Highway was $6,877,300 (average for 1996 to 2000 inclusive). The average annual social cost of crashes then reduced slightly to $4,446,375 per year up to 2004 (average for 2001 to 2004 inclusive), when the first 700m section of median barrier was installed and the speed limit over the entire 3.5km length was dropped to 80km/h. Since 2004 the average annual social cost of crashes has reduced to $65,400 per year (average for 2005 to 2009 inclusive).

Year	Fatal	Serious	Minor	Non-Inj	Social Cost	Head-on % of all crashes	Head-on % of F & S crashes
1996	1	0	0	3	$4,046,500	25%	100%
1997	1	0	0	5	$4,051,500	50%	100%
1998	1	1	3	3	$5,015,500	25%	50%
1999	2	0	1	6	$8,177,000	56%	100%
2000	3	1	3	4	$13,096,000	27%	50%
2001	1	1	1	4	$4,850,000	14%	50%
2002	0	1	0	2	$722,000	33%	100%
2003	0	0	0	3	$7,500	33%	0%
2004	3	0	1	2	$12,206,000	67%	100%
2005	0	0	2	3	$175,500	0%	0%
2006	0	0	0	4	$10,000	0%	0%
2007	0	0	1	7	$101,500	0%	0%
2008	0	0	0	7	$17,500	0%	0%
2009	0	0	0	9	$22,500	0%	0%

Table 1. Centennial Highway crash history (social cost of crashes)

The crash data confirm that the level of trauma has been significantly reduced on Centennial Highway as a result of the median barrier, although it is acknowledged that a proportion of these gains may also be due to other measures such as the lowered speed limit. Even though the speed limit on Centennial Highway was also dropped from 100km/h to 80km/h in 2004, there has been a notable increase in the number of non-injury crashes. Many of these crashes involve impacts on the wire rope median barrier although, as outlined later in this paper, the number of barrier impacts appears to be under-reported in CAS.

Perceptual measures such as the narrowed lane width and the presence of the median barrier are also likely to have had some impact on the improved safety performance. However, the authors consider that the elimination of head-on crashes since 2004 is predominately due to the installation of the wire rope median barrier and that this is supported by continued strikes on the median barrier.

Surveillance monitoring

Because a wire rope barrier had not previously been constructed in New Zealand on a 1+1 road with such a narrow median and high traffic volume, a video camera surveillance system was installed to monitor driver behaviours and to record any hits on the barrier.

The surveillance system comprised three CCTV cameras installed at different points along the initial 700m length of wire rope barrier. Three days were selected to represent a 'before installation' scenario (19 October 2004), an 'immediately after installation' scenario (30 November 2004), and a 'some time after installation' scenario (27 January 2005).

The lateral positioning of vehicles relative to the centreline was assessed by viewing five-minute segments of footage from the morning and evening peaks.

Because the camera footage was not sufficiently clear it was not possible to reliably obtain detailed measurements of the lateral position of vehicles onscreen. Instead, vehicle positions were described in general terms according to three different zones – 'Left', 'Centre' and 'Right' – relative to the edgeline and centreline. Any subtle changes between the 'immediately after installation' and 'some time after installation' scenarios were difficult to detect and were therefore combined into a general 'after installation' scenario.

Comparison of footage from before and after the median barrier installation showed that drivers tended to travel more centrally within their lane with the median barrier in place (Figure 6). On the inside of a left hand bend, however, the proportion of drivers tracking to the left of their lane was generally higher, with a small increase in the number of vehicles cutting the left edgeline.

Drivers tend to react to objects placed close to the edge of a traffic lane by slowing or steering away [7]. The results indicate that the median barrier placed close to the edge of the traffic lane, potentially in combination with other perceptual measures such as the narrowed lane widths, has created a tendency for drivers to track further away from the centreline.

Lane position observations from Camera 3 are summarised in Table 2. An example view from Camera 3 is shown on the left of Figure 6. Vehicles shown on the right side of the double yellow centreline are travelling northbound and vehicles on the left side are travelling southbound.

Southbound observations	
Before installation	**After installation**
• Majority of vehicles tracking along the centre of the lane (83%) • Some vehicles tracking to the right side of the lane (17%) • No vehicles tracking to the left side of the lane, cutting the edgeline, or cutting the centreline.	• Proportion of vehicles tracking along the centre of the lane largely unchanged (84%) • Slight decrease in vehicles tracking to the right side of the lane (10%) • Vehicles tracking to the left side of the lane increased (6%) • 2% of vehicles cutting the left edgeline, no vehicles cutting the median centreline
Northbound observations	
Before installation	**After installation**
• Majority of vehicles tracking along the centre of the lane (71%) • Some vehicles tracking to the left side of the lane (28%) • 1% of vehicles tracking to the right • No vehicles cutting the left edgeline or the centreline.	• Some vehicles tracking along the centre of the lane (17%) • Majority of vehicles tracking to the left side of the lane (83%) • No vehicles tracking to the right side of the lane or cutting the median centreline • 5% of vehicles cutting the left edgeline

Table 2. Lane position observations from Camera 3

Figure 6. Lane position before and after installation

The southbound results indicated a shift from a distribution skewed slightly to the right of the lane before installation to a distribution skewed slightly to the left of the lane after installation. The northbound results showed a significant shift towards the left, i.e., vehicles tended to cut towards the inside of the left bend. However, this shift may not actually be as pronounced as the results suggest because the majority of vehicles classed as 'Centre' in the 'before installation' scenario were offset slightly to the left. Therefore, any small shift to the left in the 'after installation' scenario would be enough to change the classification from 'Centre' to 'Left' [8].

For the first 18 months following the initial 700m installation, particular attention was paid to any incidents involving vehicles hitting the wire rope median barrier. Footage from a number of these incidents was obtained from the CCTV recorded images for evaluation.

Generally, vehicles that hit the barrier sustained relatively little damage and were observed to drive away. By way of example, one sunny afternoon a northbound motorist momentarily fell asleep at the wheel and drifted towards the centre of the road. On contact with the barrier the driver awoke and continued the journey without incident. Without the barrier the driver would have veered into oncoming traffic.

A second incident involved a heavy vehicle drifting into the median barrier. Again, without the barrier, the driver would have veered into oncoming traffic. Both of these examples are illustrated by the surveillance footage shown in Figure 7. In summary, the surveillance footage further confirms the improved level of safety along this stretch of highway.

Figure 7. Two separate incidents involving vehicles hitting the median barrier

Barrier strike rate and maintenance costs

One of the advantages of a wire rope system compared to a semi-rigid w-beam alternative is the ability to carry out repairs quickly following an impact. Often the network maintenance contractor is able to carry wire rope barrier posts to the site and carry out repairs while onsite by placing the new posts into the existing sockets. These repairs can often be carried out in a matter of minutes with minimal disruption to traffic. By comparison, a w-beam barrier requires the damaged posts to be removed and replaced, which will often involve either driving the new posts or boring new holes.

Because this installation had generated such attention amongst the public, the network maintenance contractor was asked to keep records of strikes on the barrier. Latest records to the end of February 2010 indicate that there have been a total of 61 recorded strikes on the barrier since 2004.

The first 700m section was hit 11 times between November 2004, when the first 700m section was completed, and September 2006, when works commenced to extend the barrier. This is assumed to represent an operational period of 22 months without construction. The extension was completed in October 2007, providing median barrier protection over a total length of 3.5km. An operational period of 28 months has been assumed, since construction was completed to February 2010. During this period, the median barrier was struck 46 times. There were a further four strikes that occurred during the construction period for the extension.

Traffic volumes have been obtained from a permanent telemetry site located around 500m north of this section of State Highway with an annual average daily traffic (AADT) volume of 21,958 recorded in 2004 and 22,382 in 2008 [1]. From the maintenance records it is possible to determine the frequency of strikes on the median barrier as summarised in Table 3.

There were 8.6 recorded impacts per kilometre per year, or one crash per 0.9 million vehicle kilometres of travel (vkt) on the initial 700m length of median barrier. The complete 3.5km length has a crash rate of 5.6 recorded impacts per km per year, or 1 crash per 1.5 million vehicle km. This compares with impact frequencies experienced on Swedish and New Zealand 2+1 roads.

Beca Carter Hollings and Ferner Ltd [9] was commissioned to determine if the Swedish 2+1 cable barrier system [2] was an appropriate interim solution for a section of State Highway 1 in New Zealand located between Longswamp and Rangiriri. Beca reported that ‘information from the Swedish experience was used to estimate the frequency of barrier impacts and their costs. The Swedish predicted one barrier impact per 1-2 million vehicle kilometres of travel. The initial observed rate was around one per 1 million but appears to be dropping (Bergh, 1999). In our analysis we [Beca] have assumed the barrier will be hit once every 1.5 million vehicle kms … The adopted barrier impact rate would see the barrier hit on average once every 10 days’.

Opus International Consultants Ltd [10] has since reported 86 impacts on the Rangiriri 2+1 wire rope median barrier during 2006 and 2007. This was found to represent an average of one impact every 8.48 days or approximately 1.13 impacts per 1.5 million vehicle km. From more recent monitoring, this hit rate appears to be dropping. Opus also determined that the average impact on the Rangiriri installation resulted in 15 damaged posts at an average cost of NZ$2579 per repair, or NZ$12,295 per km per year.

	Total length	Traffic volume	Number of impacts	Period (years)	Frequency (per km per year)	Frequency (1 crash per x million vkt)
Initial installation	0.7km	21,958	11	1.83	8.6	0.9
Extension	3.5km	22,382	46	2.33	5.6	1.5

Table 3. Frequency of vehicle impacts on the median barrier

The average impact along Centennial Highway resulted in 12 damaged posts at a repair cost of $1356. This represents an average cost of $11,644 per km per year for the initial 700m section and an average cost of $7649 per km per year for the extended 3.5km section. The maximum recorded repair cost was $6345, which resulted in damage to 56 posts. For 90% of impacts the damage was limited to 24 posts or less at a cost of $2394 or less. All costs include traffic management.

The Centennial Highway experience was similar to that of Sweden and Rangiriri with regard to increased maintenance cost associated with impacts on the wire rope median barrier. The use of a narrow median has proven to significantly reduce crash severity and is considered an appropriate solution when retrofitting existing roads, particularly in constrained environments. However, it is recommended that wider medians are adopted wherever possible to minimise the associated maintenance costs. Ideally, the median width should provide at least sufficient space to fully accommodate the design deflection of the selected barrier system.

Lane markings were supplemented on Centennial Highway with yellow reflective strips attached to the wire rope barrier posts and yellow raised retroreflective pavement markers placed along the centre edgelines to heighten the level of delineation at night. These reflective elements were installed at 10 to 12m spacing which is now the standard adopted in New Zealand [11].

Experience from narrow median wire rope barrier installations in New Zealand suggests that there may be merit in applying audio tactile profiled (ATP) line markings (rumble strips) on the centrelines to reduce the likelihood of strikes on the barrier. Further research is recommended to determine the likely reduction of median barrier strikes with the installation of ATP centreline markings. This would enable a benefit cost evaluation to be carried out to determine whether the installation of ATP markings is likely to offset the maintenance costs associated with barrier impacts on new and existing installations.

Conclusions and recommendations

This paper reports on the performance of a wire rope barrier on a narrow median installation on Centennial Highway, New Zealand. The median barrier was introduced in two stages and has been very successful in reducing road trauma. Prior to stage one, the average annual social cost of crashes on Centennial Highway was $5,796,889. This has since reduced to an average social cost of $65,400 per year.

Surveillance of the Centennial Highway median barrier showed that vehicles generally sustained relatively little damage when they struck the barrier and were often observed to drive away after the impact. Drivers also tended to travel more centrally within their lane with the barrier in place.

The use of a narrow median wire rope barrier has proven to significantly reduce crash severity and is considered an appropriate solution when retrofitting existing roads, particularly in constrained environments. However, it is recommended that wider medians be adopted wherever possible to minimise the associated maintenance costs. Ideally, the median width should provide at least sufficient space to fully accommodate the design deflection of the selected barrier system.

Further research is recommended to determine the likely reduction of median barrier strikes with the installation of ATP centreline markings. This would enable a benefit cost evaluation to be carried out to determine whether the installation of ATP markings is likely to offset the maintenance costs associated with barrier impacts on new and existing installations.

Acknowledgments

The authors would like to thank Fulton Hogan, the Wellington Network Maintenance Contractor, for their efforts in obtaining and collating maintenance records pertaining to vehicle impacts on the Centennial Highway wire rope median barrier. The authors would especially like to thank Andrew Smith and Kate MacKenzie for their contributions.

Notes

1. All dollar values are in New Zealand dollars

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The effect of traffic lane widths on the safety of cyclists in urban areas

by A Schramm, and A Rakotonirainy, Centre for Accident Research and Road Safety-Queensland (CARRS-Q)

Abstract

This literature review examines the relationship between traffic lane widths on the safety of road users. It focuses on the impacts of lane widths on motor vehicle behaviour and cyclists' safety. The review commenced with a search of available databases. Peer reviewed articles and road authority reports were reviewed, as well as current engineering guidelines. Research shows that traffic lane width influences drivers' perceived difficulty of the task, risk perception and possibly speed choices. Total roadway width, and the presence of on-road cycling facilities, influence cyclists' positioning on the road. Lateral displacement between bicycles and vehicles is smallest when a marked bicycle facility is present. Reduced motor vehicle speeds can significantly improve the safety of vulnerable road users, particularly pedestrians and cyclists. It has been shown that if road lane widths on urban roads were reduced, through various mechanisms, it could result in a safety environment for all road users.

Keywords

Urban, Geometric design, Cyclist

Introduction

This review will explore the relationship between lane width and the safety of cyclists on urban roads. Research into roadway design and cyclist safety has been limited. What research has been conducted in diverse fields of roadway design and safety has not been collated and summarised, and lacks substantive discussion of the various factors and principles that could be used to improve cyclists' safety on urban roads. Road design impacts on all road users, and it is therefore essential to investigate the effects of modifications in road design on each road user group.

Once the impact of road design on each road user group is understood, it is important to understand how the design factors influence the interactions between road user groups. The initial section of this paper will outline the methodology and scope of the review. The requirements of separate road user groups will be examined, and relevant road engineering guidelines will be highlighted. The review will then examine the effect of lane width on driver (motor vehicle) behaviour and then on cyclist behaviour and safety. The final section will summarise the findings of the available literature.

Methodology

A thorough search was conducted across available online databases. Multiple searches were undertaken using a variety of search strategies. Searches of individual journals *(Transportation research record, Accident analysis and prevention, Ergonomics, Safety science, Journal of transportation engineering, ITE journal), electronic databases* (Web of Science, Science Direct, and Australian Transport Index), and the internet were conducted. All papers identified through the search procedures (approximately 100 research papers, not including engineering and design guidelines) were scanned for relevancy.

Relevant papers were defined as those that evaluated the safety of road geometric designs for urban environments, excluding high-speed roads (freeways and motorways, where cyclists are usually prohibited from travelling). Through the review process, 71 of the papers were excluded. Papers exploring geometric design were excluded for the following reasons: research was conducted in rural locations, lane width was examined at roadwork locations, only a specific crash type was investigated, or research explored the effect of geometric design excluding lane width (landscaping, or median strip types). Research into cycling safety is limited, and as such, the exclusion criteria were less strict. No geographical restrictions were implement, however there was a preference for auto-centric locations (USA, UK, New Zealand, Canada or Australia). Only peer reviewed articles and reports by road authorities (local, state or national) were reviewed.

Research methodologies in the included papers were varied, which makes comparisons between findings difficult. Investigations into cycling safety included observational and modelling research methods. The majority of studies examining the effects of lane widths on driver behaviour were simulator based.

Selection of studies for inclusion

The scope of this review is purposely focused on general traffic lane widths on urban roads. Several other issues were perceived to be important enough to be investigated independently. These issues include:

- The effects of lane narrowing as a traffic calming measure
- Road shoulders, which were considered a separate issue in geometric design
- Lane width requirements at intersections (roundabouts, signalised intersections, uncontrolled intersections, turn lanes etc.)
- Other intersection measures, such as advanced stop lines and traffic signal sequences
- Other conflict points, such as lane merging and lane splitting.

As a result, these issues were not examined in this review. This review is limited to urban road segments without notable features (intersections, traffic calming and other features). Early research into geometric design parameters and their impact on safety has focussed on rural roads. Later research has moved the focus to urban roads. The majority of research has only examined the safety of these geometric design parameters on the safety of motor vehicle occupants. This paper investigates the implications of narrow lane widths for cyclists and for road users with whom cyclists have the greatest level of conflict. While research does show that the majority of crashes involving bicycles occur at intersections (54%), a large number occur on mid-block road segments devoid of road features (46%) [1]. Future research could examine the effect of lane widths on cyclist safety at intersections and other conflict points.

Vehicle requirements and engineering considerations

Vehicles, whether stationary or moving, occupy a defined space on the roadway. When vehicles are travelling, the space required by each vehicle is dependent on functional width and operational/dynamic width. The capabilities of all vehicles using a road should be considered when evaluating geometric design features, particularly with respect to lane width and road user safety. This review focuses on the requirements of three vehicle types – bicycles, as well as heavy vehicles and passenger vehicles – as these place the most pressure on cyclists' safety through size and likelihood of crash involvement.

Heavy vehicles

Heavy vehicles, due to their size and operating capabilities, have specific design requirements. One aspect that requires careful consideration, particularly when examining traffic lane widths, is the tracking ability of heavy vehicles. In the context of heavy vehicles, tracking ability refers to ability of the attached trailing unit to follow the same path as the lead unit. The lateral displacement the trailer undergoes when travelling at speed, in addition to the vehicle width, is the swept width. Swept width is dependent on the configuration of the vehicle, road factors and environment factors [2].

Comprehensive testing across various road surface environments (roughness and cross-slope measures) of various heavy vehicle configurations during straight path travel has been conducted on rural roads [3]. Swept width, or physical width requirements, of heavy vehicles increased as speed increased for all heavy vehicle combinations.

Modelling demonstrated that the majority of heavy vehicle configurations had a lane width requirement of 3.1m when travelling at 60km/h, increasing to 3.2m when travelling at 90km/h. Prime-movers and semi-trailer configurations were shown to have the smallest width requirements, estimated at 2.8m when travelling at 60km/h. At speeds of 60km/h, rigid +3 combinations (a rigid truck combined with a dog trailer) required 3.4m to avoid lane excursions. This increased to 3.85m when speed increased to 90km/h.

Passenger vehicles

Current road design standards are determined by the operational characteristics of passenger vehicles. The operating speeds of passenger vehicles are often the critical input used by engineers to determine the safety of a road [4]. It is assumed that passenger vehicles would be able to operate well within the boundaries discussed above for heavy vehicles.

Bicycles

There has been little research into the operating space requirements of bicycles. Almost all bicycles have a functional width of 0.65m, measured as the width of the handlebars [5]. Disturbing factors may impact on the ability of the cyclist to maintain a steady course. Common disturbing factors include removing a hand from the handlebar to signal a turn or looking over the shoulder to check for traffic when attempting a right turn. Cyclists' ability to hold a steady course was also impacted by road surface unevenness and side-wind disturbances, particularly at low speeds [6].

Allowing for slight movements in travel path due to operator control, associated with operating a single-track vehicle, a minimum operating space requirement of 0.75m is proposed [5]. However, research suggests that the space requirements of bicycles may be greater than this, and will be dependent on several factors. When cyclists can maintain sufficient speed on

	Netherlands[a]	Germany[a]	Sweden[a]	Norway[a]	USA[b]	UK[c]	NZ[d]	Australia[e]
Recommended bicycle lane width (m)	1.0	1.0	1.2	1.6	1.2 1.5*	1.5 2.0^	1.5† 1.9‡	1.5

[a] Allen et al, 1998 [5]
[b] American Association of State Highway Transportation Officials (AASHTO) Guide [7]
[c] Department of Transport [8]
[d] Transit New Zealand [9]
[e] Austroads [10]

* recommended minimum with an increase in bus and/or truck volume
^ recommended minimum with higher speeds (≥65km/h)
† desirable minimum when vehicle speed is ≤50km/h
‡ desirable minimum when vehicle speed is ≥70km/h

Table 1. Recommended bicycle lane widths: selected international locations

straight paths or gentle curves, they require at least 1m of lateral space. If interfering factors are present, or the cyclist has a lower travel speed, additional space may be required [6]. The skill of the bicycle operator may also impact on the lateral space requirement.

International road design standards do not provide consistent recommended widths for on-road bicycle lanes (see Table 1). This may reflect the range of attitudes towards bicycling by governments and/or other road users. It may also reflect the broad spectrum of motor vehicle travel speeds permitted in urban environments.

Current road engineering guidelines

In the current Australian guidelines, 3.5m traffic lane widths are considered standard [10]. This recommendation places Australian guidelines towards the upper end of lane width recommendations for arterial roads compared with international guidelines (see Table 2). In the Australian context, traffic lane width is measured from the kerb face to the centre of the marked line. This includes the gutter pan (from 500mm) and half of the lane marking (50mm of painted line, as general traffic markings are 100mm wide). This impacts on usable surface width for bicycles.

Country	Roadway classification		
	Freeway	Arterial	Minor/Local
Brazil	3.75	3.75	3.0
Canada		3.0	3.0 - 3.3
China	3.5 - 3.75	3.75	3.5
Denmark	3.5	3.0	3.0 - 3.25
France	3.5	3.5	3.5
Germany	3.5 - 3.75	3.25 - 3.5	2.75 - 3.25
Japan	3.5 - 3.75	3.25 - 3.5	3.0 - 3.25
Poland	3.5 - 3.75	3.0 - 3.5	2.5 - 3.0
UK	3.65	3.65	3.0 - 3.65
USA	3.6	3.3 - 3.6	2.7 - 3.6

Table 2. Urban road widths (in metres): Selected international locations [8]

There are provisions for considerations for wider traffic lanes, although this is limited to horizontal curves and is primarily for heavy vehicles. Several factors may allow for the provision of narrower traffic lanes of 3.3m. Situations where narrow traffic lanes may be permitted include a limited road reserve, low speed traffic environments, very low heavy vehicle traffic and satisfactory safety records [10].

Shoulder width is considered as part of the geometric design of roadways. Shoulders provide several functions, with one of them being 'space for cyclists' [10]. Drivers are required to drive completely in a marked lane, which does not include the road shoulder [12]. As bicycles are considered vehicles under the current road rules, this seems to suggest that bicycles should not be riding on road shoulders.

Bicycle amenity is considered in a separate section of the design guidelines. There are seven bicycle facilities outlined, and they are listed in order of safety and priority: off-road exclusive bicycle path within the road corridor; on-road segregated bicycle lane; on-road exclusive bicycle lane; on-road peak period exclusive bicycle lane; on-road bicycle/car parking lane; wide kerbside lane; and narrow kerbside lane. Facilities are considered unnecessary on local streets, due to lower traffic speeds, but are considered necessary on arterial roads and collector streets. These on-road facilities can be dedicated bicycle lanes, road shoulders, widened lanes for joint use by bicycles and moving/parked vehicles, and separated bicycle lanes.

Bicycles are given no special consideration for vertical and horizontal alignment. Consideration is given for vertical gradients; the guidelines state that 'bicycle riders prefer to avoid hills wherever possible' and will select the flattest alternative route [10]. This contradicts research conducted into cyclists' route preferences, which has found that cyclists do not necessarily avoid hills, and prefer to select the most direct route [13].

Due to the specific considerations of bicycles as single-track vehicles with narrow tyres, it is important to consider the functional width rather than the measured width [14]. Design guidelines (see Table 3) suggest that consideration should be given to the kerb clearance of cyclists. On roadways with kerbs, cyclists allow 0.5m clearance from the kerb [14], although this decreases when the road is not kerbed. Cyclists will avoid surface hazards and temporary obstructions that may present stability issues.

Considering that 4.1% of all bicycle-motor vehicle crashes are a result of a car door being opened into the path of a cyclist [15], and almost 6% of mid-block crashes in Queensland [16] it may be necessary to consider whether additional space is required when parked cars are present. In shared bicycle/car parking lanes, the required space may include the parked vehicle, the width of the car door, as well as the cyclist envelope.

How lane widths affect motor vehicle driver behaviour

The following section will review research investigating how lane widths may influence driver behaviour. The focus of this section will be research into the effect lane widths have on speed choices, the difficulty of the driving task, and the perceived danger of narrower travel lanes.

The implications for narrow lane widths on self-selected driving speed have been examined in various situations. Low speed suburban environments have been investigated for curved sections of road. Results from this research have been dichotomous. Observed speed was found to decrease when lane widths were reduced, most noticeably at the mid-point of curves [17]. However, other results found no significant reduction in operating speed through horizontal curves [18].

	Desirable			Acceptable range		
	60km/h	80km/h	100km/h	60km/h	80km/h	100km/h
Exclusive bicycle lane	1.5m	2.0m	2.5m	1.2-2.5m	1.8-2.7m	2.0-3.0m
Bicycle/car parking lane	4.0m	4.5m		3.7-4.5m	4.0-4.7m	
Wide kerbside lane	4.2m	4.5m		3.7-4.5m	4.3-5.0m	

Table 3. Guidelines for bicycle facility widths for on-road facilities [7]

This research was conducted on low-speed urban roads and suburban streets. Further research would be required to determine what, if any, effects reduced lane widths had on roads with higher speeds.

The effect of lane widths has been invested on straight road sections. Research on low-speed urban roads suggests that lane width has a significant effect on self-selected speed on straight road sections. In real road situations, an increase in lane width by 1m was predicted to result in an increase in speed by 15km/h [18]. Simulator-based research supports these results. The influence of lane width on self-selected speed was found to be non-linear, but narrower lane widths did result in reduced travel speeds. Compared with 3.0m, 2.5m traffic lanes resulted in a 2.23km/h reduction in mean speed. However, there was no significant difference in mean speeds between 3.0m and 3.6m wide lanes.

Research is required to establish if a reduction in traffic lane widths increases the difficulty of the driving task or the perception of risk by drivers. Initial work in driving simulators found that especially narrow lanes (2.5m) were perceived to present a higher level of risk, although there was no significant difference in the ratings between lane widths (2.5-3.6m). Caution should be used when looking at these results. While the scale was designed specifically for the study, it has not been independently validated [19].

The same study also investigated the effect of lane width on the perceived difficulty of the driving task. Using the NASA Task Load Index, the mental, physical and temporal demand of the driving task was measured. Driver performance, effort and frustration level were also assessed for various roadway configurations. Subjective assessments by drivers found that difficulty ratings decreased when lane widths increased. Further research is required to establish the relationship between the subjective rating of task difficulty and safety.

It is important not just to consider the effect of single traffic lane widths on driver behaviour, but also the whole roadway environment. Research has shown that the total number of lanes (whole roadway width) also influences drivers' self-selected travel speed. As the road width or the number of traffic lanes increases, driver travel speed increases [20, 21]. This suggests that total roadway width can also be important in determining driver speed choices, independent of the width of the traffic lanes. Further research is required to determine if this relationship is true if the additional road space is dedicated to bicycle facilities.

The flow-on effects of lower speed choices by drivers increase the safety of all road users. Research has shown that a reduction in mean driving speed results in decreased speed variability [22]. Greater levels of speed variability have been shown to be associated with increased crash risk. As a result of these findings, it is hypothesised that a reduction in lane width that results in reduced self-selected speed would result in a reduced crash risk. The ability of a driver to control a vehicle is also affected by travel speed. Research in traffic safety has shown that increased travel speeds result in greater variability of vehicle positioning within lanes [23].

This review of the research has found that narrower lane widths result in reduced self-selected travel speed. Lower travel speeds are associated with an increase in perceived safety [20]. Research into the effects of reduced travel speed indicates that narrower lane widths would be beneficial to the safety of vehicle occupants and vulnerable road users. Narrow lane widths did not increase the perceived risk of the road environment, but were found to increase the perceived difficulty of the task. It is possible that the increase in task difficulty could have possible, as yet undetermined, implications for road safety. It is important to note that the research reviewed did not explicitly correlated speed with safety.

How lane widths affect cyclist behaviour and safety

The purpose of this section is to explore the implications on bicycle safety of roadway geometric design factors. Research has been conducted regarding the safety of traffic lane widths for vehicles. This has primarily focused on the safety of heavy vehicles and passenger cars. As far as we are aware, no such body of research exists in the area of safety of lane widths for bicycle safety.

Several factors have been found to influence a cyclist's route selection. Some of the findings may seem counter-intuitive to the non-cyclist. The primary body of evidence in this area is based in the United States, with the focus on commuter cyclists. Several facility and route factors have been identified as critical to cyclists, including shorter travel times, continuous facilities, smooth riding surface, flat to moderately hilly terrain, on-road bicycle facility in preference to a separate path, low traffic volumes and an absence of parked cars [14].

Despite experiencing collisions or falls while cycling, serious leisure cyclists were likely to rate traffic (including abuse, near misses or threats from aggressive motorists) and the ongoing risk of injury as low to moderate barriers to cycling [24]. It is important to remember that cyclists are not a homogenous group, and there a variety of trip purposes for cycling trips (recreation, leisure, commuting or training). Research suggests that off-road bicycle facilities should be considered recreational facilities rather than commuter facilities [25].

To account for the limited research between crashes and geometric design for bicycles, the concept of safety has been considered in three separate ways:

- Actual safety, typically measured through crash data
- Perceived safety, a subjective measure express by the road user
- Inferred safety, an indirect measure of safeness.

If a direct measure of safety is unavailable, it may be appropriate to evaluate safety of geometric designs by inferred measures. Measures that may be indicative of cyclists' safety may include vehicle speed when passing cyclists or the position of the motor vehicle in relation to the bicycle [26]. It could be hazardous to rely on cyclists' perceptions about safety when implementing safety interventions. Research has shown that cyclists are unable to accurately judge the speed of passing motor vehicles [27]. It is also possible that cyclists are unable to accurately assess the passing distance of motor vehicles.

It is important to also consider the road environment as a whole with regard to cyclist safety. Being single track vehicles, bicycles have inherently less stability than dual track vehicles (e.g., cars). Road surfaces and road markings have been found to present hazards to cyclists [28]. The only marking materials that did not cause significant hazards to cyclists were 2mm thermoplastic lines (no beads or calcite), waterborne paints lines (0.2mm and 0.5mm in height), and 0.2mm chlorinated rubber lines. There are several common road items that create hazards for cyclists, and these include rough ground, round utility access cover, loose gravel, domes, several thermoplastic lines (4.5mm dropon, 3.5mm, 3.5mm large beads, 7mm, 3mm dropon, and profiled thermoplastic), and RRPMs (reflective raised pavement markers) [28].

As a result of an increase in popularity of cycling in Australia (bicycle sales have increased by 140 % since 2001) [29], road authorities have considered design measures to improve cyclist safety. Initial research has found that the presence of bicycle lanes influences both driver and bicycle behaviour.

A cyclist's choice of travel path on a roadway is impacted by several roadway factors. The presence of an on-road bicycle lane results in cyclists' being less likely to demonstrate unpredictable behaviours and more likely to maintain a more consistent travel path [30]. On-road bicycle lanes also influence the positioning of bicyclists in relation to the kerb. When cycle lanes are present, there is an increase in the distance between the cyclists and road edge [29, 30].

The level of facility magnifies this trend. Lower level facilities, those marked with a single white line, result in less displacement between cyclist and kerb compared with higher level facilities (marked green bicycle lanes) [30]. Without the presence of a bicycle lane, total roadway width influences the bicycle's positioning on the road. The distance between kerb and bicycle increases as total roadway width increases [31]. The signed speed limit of the road, the number of traffic lanes and the presence of a motor vehicle also influences a bicycle's lateral positioning. Further information regarding the impact of these factors was not presented [31].

Initial research has found that the separation distance between bicycle and motor vehicle (an inferred measure of safety) during a passing manoeuvre depends primarily on the available travel space. In this context, travel space is the distance between the road marking (traffic lane demarcation, or the centreline) and the bicycle. The lateral displacement between bicycle and motor vehicle increases as travel space increases [32, 31].

The type of bicycle facility present on a roadway also impacts on the separation between bicycle and motor vehicle. Wide kerb lanes result in greater displacement between bicycle and passing motor vehicles compared with roadways where bicycle lanes are present [26, 30, 31, 33]. The presence of multiple motor vehicles during a passing manoeuvre reduces the lateral displacement between motor vehicle and bicycle [31].

As previously outlined, bicycle lanes result in bicycles behaving in a more predictable manner. Bicycle lanes also result in motor vehicles behaving in a more consistent manner, with fewer wide swerves or close passes [32]. Several other factors influence the position of vehicles in the relation to bicycles. These factors include urbanisation and the existence of a gutter pan [33].

Research has examined bicycle safety at roundabouts, bicycle crossings, intersections, road surfaces, sidewalks, street lighting, roads/paths design, and road design characteristics [31]. The primary focus of research has been the effectiveness of on-road bicycle facilities, with only one research paper investigating the effect of roadway width. There is little research identified that investigates the impact of on-road bicycle lanes on bicycle safety. Several early studies from the United States have examined the effect of bicycle lanes on cyclist safety. This research has shown that on-road bicycle lanes reduce injury rates, collision frequency or crash rates [34-37]. These papers were reviewed as part of a meta-analysis examining the effect of transportation infrastructure on bicyclist safety [39]. Research from New Zealand found that crash frequencies decreased over time in locations where bicycle facilities were not present [26]. This research was based on a single intervention site, where there was low exposure to bicycles. If bicycle facilities were implemented in nearby locations, it is possible that bicycle traffic itself decreased.

Initial research has been conducted into the effect of short-term road narrowings on cyclists. While not the primary stress of the cyclists interviewed, temporary narrowings were a source of concern. Cyclists implement various strategies to cope, including riding on footpaths and using alternative routes. Road narrowing had negative effects on driver behaviour, increasing risky behaviour. These included motorists passing closer to cyclists, and attempting to overtake the cyclists prior to the narrow point [39]. Further research is required to determine if these behaviours are observed on sections of narrower roads, rather than solely at 'squeeze points'.

The impact of various road design factors on bicycle crash severity has been examined through modelling. Two roadway design factors found to influence bicycle safety are total roadway width and road classification level (freeway, arterial or local) [40]. Other factors that influence bicycle safety include traffic volume, truck volume, population density, and commercial activity.

The results may seem counter-intuitive. Serious injury crashes were more likely to occur on wider roads, and with lower traffic volumes. Greater levels of injury severity with lower traffic volumes may be explained through possibly higher motor vehicle speeds. The relationship between roadway width and road classification level was not explored, although this may explain why wider roads resulted in serious injury crashes. A decrease in cyclists' safety when heavy vehicle density increases may be a result of the increased road width requirements of heavy vehicles.

Conclusions

It is difficult to come to definitive conclusions regarding the effect of a reduction in traffic lane widths on the safety of all road users. True experimental protocols are difficult to implement in the area of road geometry. The research in this area has employed diverse methods, making it difficult to integrate the research and make comparisons. There are differences in research design and statistical approaches, with variations in road types, traffic volume and other road factors.

It is also difficult to make conclusions about cycling safety research. Skill levels and confidence may impact on individuals' route choice, introducing bias when examining the safety of on-road facilities compared with unmarked roads. More research is required in the area of geometric design on cyclist safety. Additional research in the area of bicycle safety interventions such as bicycle lanes, especially in the Australian context, is also required, to establish their effectiveness in improving cyclist safety on urban roads.

A reduction in traffic lane width could reduce the financial and spatial burden of new roadways, and also allow for the retrofitting of marked bicycle lanes or wide kerbside lanes. The current body of research into the impact of reduced lane widths indicates that the resultant changes in driver behaviour could improve the safety of cyclists. Narrower lane widths result in drivers reducing self-selected travel speed in free flow traffic environments. A reduction in travel speed has a number of flow-on benefits, including a reduction in speed variability and improvements in vehicle handling ability. These benefits increase the safety not only of cyclists, but also pedestrians, vehicle occupants and other road users. Reduced vehicle speeds improve the outcome for cyclists and pedestrians in the event of a collision [33,41].

Preliminary research suggests that a reduction in lane width does result in an increase in the perceived difficulty of the driving task. As yet, the safety implications of the increased demand of the task have not been investigated. The increase in task difficulty may be offset by the decrease in travel speed, resulting in no effect on the safety of vehicle occupants. The perceived risk of driving has not been found to increase when lane widths are reduced. Lower travel speeds associated with reduced lane widths may explain the absence of significant difference in perceived risk.

It would be important to consider the typical vehicle types present on the roadway if reduced lane widths were to be implemented. Reducing lane widths on roadways with higher proportions of heavy vehicles may be impractical, and reduce safety, if heavy vehicles are subsequently unable to avoid lane incursions. As urban roads, with a speed limit of 70km/h and a low density of extreme heavy vehicles (A-Triples or Rigid +3), this may not be an important consideration. As an alternative for roads with high volumes of heavy traffic, it may be beneficial to create wider heavy vehicle lanes to accommodate larger vehicles to ensure the safety of all road users.

There is very little research into the effect of road geometric design factors and cycling safety. It is acknowledged that additional research is required to clearly define the implications of traffic lane widths on cyclist safety. Bicycle lanes are frequently implemented to improve the safety of cyclists travelling on roads. Further research is needed to clarify if on-road bicycle lanes have the desired effect on cycling safety.

Research suggests that narrowing traffic lane widths would result in safety improvements, such as reduced vehicle speed, but this may be lost if total roadway width is not reduced. Further research into this phenomenon is required with respect to the impact on cycling safety, particularly if marked bicycle lanes are introduced to the road environment through retro-fitting or more accommodating wider new roads. Australian guidelines still recommend traffic lane widths of 3.5m on urban roads (regardless of the provision of bicycle facilities).

While bicycle lanes have been shown to improve the interaction between bicycles and motor vehicles by making behaviour more consistent, several factors indicate they might not improve actual safety, with research being sparse and contradictory. Where a bicycle lane exists, the lateral clearance between bicycle and motor vehicles is reduced. This may suggest that recommendations of bicycle lane widths are insufficient, or a single white line is not sufficient to induce appropriate separation between bicycles and motor vehicles.

While bicycle lanes may improve perceived safety, research has shown that cyclists themselves are poor judges of the speed and position of vehicles during a passing manoeuvre. Bicycle lanes also reduce the freedom of the cyclist to assess the road and make context-appropriate judgements on position. It has been suggested that it is important for cyclists to have the 'freedom to manoeuvre', and bicycle lanes compel a cyclist to stay in the narrow bicycle lane (through traffic laws, or through motorist coercion). The absence of a bicycle lane allows the cyclists to choose how much lane to use based on the operational context, with the cyclist able to consider road conditions and other factors.

Early research has shown that marked bicycle lanes can improve cyclist safety; however, further research is required in this area to understand the mechanisms for reductions in crash rates and other measures. It is also pertinent to consider the appropriateness of shared bicycle/car parking lanes with respect to improving cyclists' safety. Further refinement of crash data is required for Queensland to evaluate the effectiveness of bicycle facilities, as the presence of marked facilities is not currently recorded in crash reports.

At present, the research suggests that reduced lane widths could improve the safety of all road users through various mechanisms. Further research is required in the area of geometric design to reach a definitive conclusion regarding the impact of narrow road lanes on cyclist safety in urban areas. Further research is required to understand the complex interactions between traffic lane width and total lane width impact on driver behaviour and cyclist behaviour, and ultimately on road user safety.

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Driver compliance with, and understanding of, level crossing controls

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Abstract

Since the early 1970s, in an effort to improve road safety, Australian railway authorities have made a concerted effort to reduce the number of level road-rail crossings, particularly those controlled by passive devices such as 'give way' or 'stop' signs. Despite this effort, approximately 1400 passive-controlled level crossings in Victoria remain in operation. To improve this situation, passive level crossings are often 'upgraded' with active traffic controls devices. Consequently, the question arises as to which of the available options represents the most effective active traffic control device at level crossings.

The main objective of the present study was to compare the efficacy, and drivers' subjective perception, of different traffic control devices at level crossings. Twenty-five fully-licensed drivers aged between 20 and 50 years participated in a high fidelity driving simulator study that compared three level crossing traffic control devices. A stop sign-controlled level crossing served as the passive referent, while two different active level crossing traffic control devices were also assessed: flashing lights and standard traffic lights.

Because traffic lights are believed to be more recognisable and to convey more salient information to drivers than flashing lights, it was hypothesised that drivers would report a preference for traffic lights over flashing lights at level crossings, and that this preference would correlate with safer driving behaviour. In fact, however, the majority (56%) of drivers reported preferring flashing lights to traffic lights, and were less likely to commit a crossing violation at one equipped with flashing lights than one with traffic lights.

Forty per cent of participants made violations at the stop sign-controlled level crossing. Collectively, results indicate that the installation of traffic lights at real-world level crossings may not offer safety benefits over and above those provided by flashing lights. Furthermore, the high rate of violations at passively controlled crossings strongly supports the continued practice of upgrading level crossings with active traffic control devices.

Keywords

Driving simulator, Driver behaviour, Subjective data, Road safety

Introduction

Road-rail level crossings exist within all road categories and can be either of two types: those controlled by active devices (i.e., that provide a signal to vehicle drivers of an approaching train), or those that are controlled by passive devices (referred to as 'passive' level crossings). The latter are characterised by signage only (usually a 'give-way' or 'stop' sign) and, as their name suggests, do not provide any active indication to drivers of the presence or absence of oncoming trains.

While the overall number of level crossings in Victoria has decreased by about 30% from the early 1970s to the year 2000, there has been, in the same period, a much larger reduction of 73% in the number of collisions and an even larger reduction of 85% in the number of deaths at railway level crossings [1]. This is likely due, at least in part, to the upgrading of many level crossings from passive, to active, controls. For example, while there was a 48% decrease in the number of passive level crossings from 1969-1974 to 1996-2000, there was a corollary increase of 46% in the number of crossings controlled by flashing lights, and a 295% increase in the number controlled by flashing lights with boom barriers [1]. Despite these changes, however, safety at railway level crossings remains one of the top concerns amongst road and rail authorities.

Understanding why drivers cross against active level crossing controls is important in order to devise appropriate countermeasures. An investigation of 87 fatal level crossing crashes by the Australian body responsible for investigating fatal transport accidents [2] found that unintentional error was a more common causal factor in level crossing crashes than in other fatal road crashes. It is likely that the saliency, or conspicuity, of a level crossing control is strongly implicated in this unintentional driver error. Although typical level crossing controls may be designed to be physically obvious to users, they do not always convey the intended urgency. In fact, Green [3] noted that level crossing control design is not typically based on human factors knowledge regarding the most effective means of conveying information to the driver.

In an effort to make them more conspicuous, current railway level crossing controls such as flashing lights were intentionally designed to be dissimilar to common road warnings [4]. It is possible that this design philosophy may have inadvertently reduced the controls' effectiveness by making them more difficult for drivers to understand. Using standard traffic lights at level crossings instead of red flashing lights may improve drivers' decision making ability and improve the level of warning compliance.

The rationale behind this proposal involves the hypothesis that drivers will be more likely to comply with traffic lights because they represent stimuli associated with a well-learned response, i.e., a sequence of behaviours that ultimately concludes with the driver bringing his or her vehicle to a full stop. In addition, failing to stop at a traffic light is a well-known, prosecutable offence, while failing to stop at a level crossing equipped with active flashing lights may not be regarded as seriously. In addition, the use of standard traffic lights at railway level crossings will provide an additional warning phase (the amber phase) that may allow drivers to make safer judgements regarding whether to stop or to continue through a level crossing.

To date, only one published evaluation of traffic lights at level crossings has been conducted [5]. Two months of data were collected before and after the installation of traffic lights at a level crossing previously equipped with flashing lights. Compared to the number of vehicles crossing when the flashing lights were active, the number of vehicles crossing during the red traffic light phase was lower by 80 per cent.

The present study assessed driver compliance to, and subjective perceptions of, two active level railway crossing controls: Flashing lights vs. traffic lights. It was hypothesised that drivers would report a preference for traffic lights over flashing lights at level crossings and that this preference would correlate with safer driving behaviour in terms of fewer level crossing violations.

Methods

Twenty-five fully licensed drivers (19 males, 6 females) aged 20-50 years (mean = 33.7 [SD = 9.2]) took part in the study. Participants were recruited by means of notices posted within the local community, the MUARC potential participant database and advertisements in a local community newspaper, and were compensated $20 for their participation. The study was approved by the Monash University human ethics committee. A within-subjects design with level crossing control (three levels) as a factor was used for both groups.

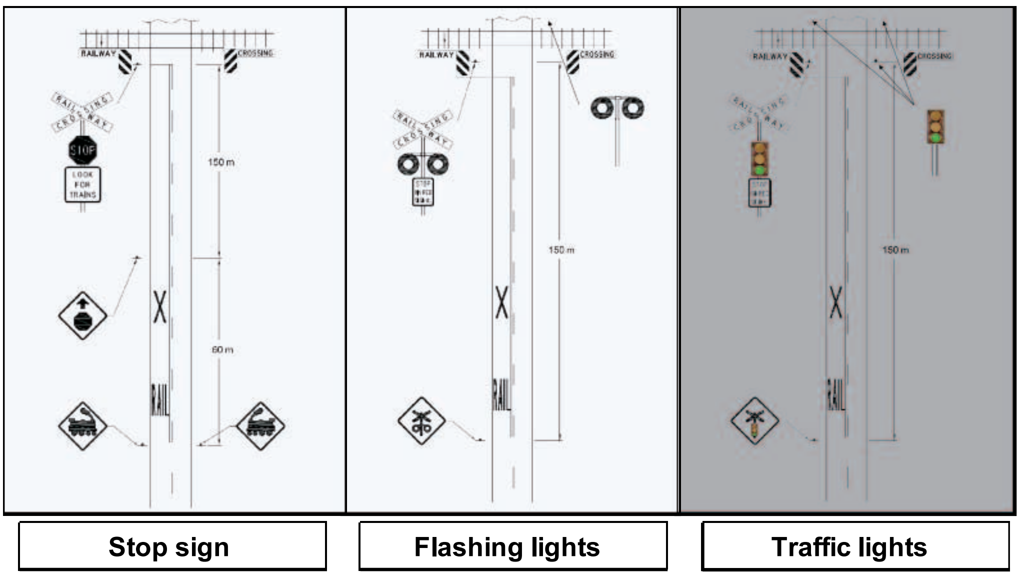

Figure 1. Schematic diagrams of simulated level crossing conditions

Equipment

Driver testing was carried out using the MUARC advanced driving simulator, which consists of a GM Holden VE Commodore sedan mounted on a three degrees-of-freedom motion base and a curved projection screen (located in front of the vehicle) that provides a 180° horizontal and 40° vertical field of view. Forward vision was produced by three image generators using seamless blended projection onto a cylindrical screen, while rear vision was provided by a separate projection screen at the rear of the vehicle. An experimenter controlled all driving simulations remotely from a control room.

Design of the simulated level crossing conditions was informed by examination of level crossing data provided to the investigators by VicTrack, as well as the relevant Australian standards. Figure 1 presents schematic diagrams of the three simulated level crossing conditions.

In relation to the subject vehicle, an approaching train was programmed to arrive at each level crossing at the same time (i.e., approximately 20 seconds after the arrival of the subject vehicle). This was done to ensure that a participant's decision to stop safely or to proceed through the crossing was based upon the crossing characteristics and not confounded by potential detection of the oncoming train itself. In all conditions, a train horn sounded just prior to the train arriving at a level crossing.

When activated, the Flashing light-controlled level crossing (Figure 1, centre panel) showed red lights flashing alternately at a rate of 45 per minute, accompanied by audible warning bells (60 dB) ringing at a rate of 60 bells per minute. Activation of the flashing light controls was dependent on the speed of the subject vehicle and occurred at the same relative time point across participants. The lights would continue to flash and the bells would continue to ring until approximately three seconds after the train cleared the level crossing. The entire sequence took 37 seconds.

In accordance with instructions from VicRoads signal engineers and Victrack, the Traffic light-controlled level crossing (Figure 1, right panel) comprised two primary sets of traffic lights on the left and right hand sides of the road on the approach side of the level crossing, and two additional sets of traffic lights on both sides of the departure side of the crossing. When activated, the traffic lights cycled from green to amber for a duration of 4.5 seconds, and then to red. Audible warning bells (60dB) accompanied the amber and red traffic lights. Like the Flashing light-controlled level crossing condition, activation of the traffic light controls was dependent on the speed of the subject vehicle and occurred at the same relative time point across participants. The traffic light would remain red and the bells would continue to ring until approximately three seconds after the train cleared the level crossing, at which point the traffic light changed to green. The entire sequence took 37 seconds.

Procedure

Upon their arrival at the simulator laboratory, participants signed an informed consent form and filled out demographics and general driving questionnaires. Participants were told that the study 'was looking at how people respond to traffic controls, such as road signs, signals and road markings', but were not informed that the focus of the study was level crossing controls. The first exposure to the driving simulator was a 10-minute *familiarisation drive*. This drive allowed participants to experience the virtual driving environment and the control dynamics of the simulated vehicle. Participants were instructed to practise accelerating and braking gently, and to practise driving at a consistent speed of 80 km/h.

After the *familiarisation drive*, the simulator was configured for the first of two 15-minute test drives. Each *test drive* consisted of a two-lane highway with gentle curves and dips. Scenario road geometry was designed according to the VicRoads Traffic Engineering Manual [6] as well as from video data of typical Victorian roads. Each participant encountered a total of four level crossing scenarios during the test trial, two in each *test drive*. The final level crossing encountered had an activated warning device (either flashing lights or traffic lights), but was not associated with the arrival of a train (i.e., the level crossing was in 'failure' mode). Data from that level crossing exposure are not described in this report.

The order of presentation of the level crossings, with the exception of the failure mode crossing, was counterbalanced across participants to limit any potential confounding due to order effects. Each level crossing type was presented first, second or third within the experimental trial, an equal number of times across drivers. On average, participants encountered a level crossing approximately every 7.5 minutes. In addition, drivers encountered three other road-road intersections during each *test drive* – one controlled by traffic lights, and two with stop signs on the secondary road. Oncoming traffic (approximately 3-4 vehicles per km, on average) was present during each *test drive*, but was not present at any of the level crossings. In between the two *test drives*, participants were given the opportunity to take a short break.

Upon completion of the second *test drive*, the experimenter brought participants to the simulator control room where they completed a face-to-face *post-drive interview*. Interview questions were designed to investigate participants' subjective perceptions of the different level crossing controls used in the study, as well as the acceptability and perceived convenience of each. Questions also related to the participants' typical behaviour at traffic control devices, and what they believed to be the appropriate behaviour at various level crossing and traffic controls. The *post-drive interview* took approximately 10 minutes to complete.

Results

Number of violations

The simulated oncoming train associated with each level crossing type was triggered according to the approach speed of the subject vehicle, which meant that the train arrived at approximately the same time point (20 seconds after the arrival of the subject vehicle) for all drivers. To determine whether a driver violated a level crossing control (i.e., drove through the crossing before the oncoming train arrived), two sources of data were consulted. First, minimum speed within the 50 metres before each level crossing was determined. If this speed was less than 10 km/h, then the driver was deemed to have stopped before that particular crossing. If the minimum speed was above 10 km/h, the driver was deemed to have driven through that particular crossing and this was defined as a violation.

These data were then compared to the experimenter's notes taken during testing and, in cases where there was a discrepancy between the two, further investigation took place. Only two cases were identified where a violation had occurred, even though the minimum speed was less than 10 km/h (both cases were at Stop sign-controlled crossings, where the subject vehicle slowed and then continued across the tracks despite the presence of an oncoming train). Percentage of completed stops vs. violations across each of the three level crossing controls is depicted in Figure 2. Chi-square analysis revealed a significant effect of level crossing type on proportion of violations, $\chi(2) = 7.36$, $p < .05$.

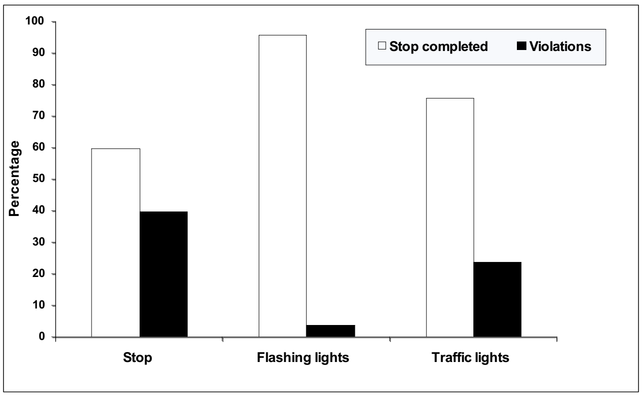

Figure 2. Proportion of drivers who violated the level crossing across conditions

Subjective data

Preferred level crossing control

In response to the question 'What do you think is the best form of traffic control device for level crossings—flashing lights or traffic lights?', 14 participants (56%) reported preferring flashing lights, while 11 (44%) reported that they preferred traffic lights.

Reasons offered for the preference of flashing lights included:

- The flashing lights represent trains, while traffic lights represent intersections ('historical presence')
- They 'grab your attention', are more 'obvious', offer better visibility, are more 'salient'
- They indicate danger more 'actively'
- They 'always mean stop'.

Reasons offered for preferring traffic lights included:

- They always mean the same thing
- Their purpose is more clear (than red flashing lights—these may just indicate a warning)
- They provide a warning phase (amber light)
- People are 'more used to them', and can be certain that they are working.

Confusion regarding level crossing controls

Participants were asked whether there were 'any railway crossings in the simulated drives at which they were confused about what to do'. Five drivers (20%) reported confusion at the Stop sign-controlled crossing; the most common reason provided for this confusion was that they could not adequately identify the stop sign in sufficient time to respond. Only two drivers reported confusion at the Flashing light-controlled level crossing.

Five drivers (20%) reported some confusion at the Traffic light-controlled level crossing. One reported that they felt confused until they saw the amber light change to red. Another reported that the traffic lights made sense, but seemed to be 'out of context'. This driver also stated that he did not expect to see a Traffic light-controlled level crossing out in the country, and that he thought this situation could be potentially dangerous. Other reasons offered for the confusion at the Traffic light-controlled level crossing included that the red light was not visible or 'didn't look red', that its activation was 'too late', and that the bells seemed quieter (than bells that sounded at the other controls).

Understanding of level crossing controls

Participants were asked to indicate what they believed to be the appropriate driving behaviour when approaching level crossings with various types of controls. For the Flashing light-controlled level crossing, all but one driver reported that the correct behaviour is to stop if approaching a level crossing where the red lights were flashing and bells were operating. When asked about the appropriate driving behaviour when approaching a level crossing with lights off and no bells ringing, 14 participants reported that the correct behaviour was to slow down and/or look and check for trains before proceeding. Three participants reported that it was correct to stop completely before proceeding, and five reported that it was correct to 'proceed with caution'. Three participants simply reported that it was correct to proceed and did not make any further comments.

When asked about approaching a level crossing controlled only by stop signs, 14 participants reported that the correct behaviour was to slow down and/or look for trains. Seven participants correctly reported that it was obligatory to come to a complete stop before looking and proceeding across the level crossing. One participant simply reported that it was correct to 'obey the signs'. Three participants reported that the correct behaviour was to 'proceed with caution'.

For Traffic light-controlled level crossings, 13 participants reported that the correct driving behaviour was to proceed through a regular traffic light showing green, and did not make any further comments. The remaining 12 participants reported that the correct driving behaviour at a green traffic signal was to proceed with caution, either slowing down, checking for trains or both. All participants reported that the correct driving behaviour when approaching a level crossing with a normal traffic light showing red was to stop.

When questioned regarding what to do if the traffic light was showing amber, 12 participants reported that the correct driving behaviour was to stop, while 11 reported that the correct driving behaviour was to stop if it was safe to do so and, if not (such as when the drivers considered themselves to be too close to the crossing), to proceed across the level crossing. One participant reported that the correct driving behaviour at an amber level crossing traffic light was to slow down, and one reported that the correct behaviour was to proceed.

Discussion

Drivers made fewer violations of level crossings controlled by flashing lights than of those controlled by traffic lights. When questioned, 56% of the same drivers reported preferring flashing lights to traffic lights as an active level crossing control. Reasons offered for this preference related primarily to the saliency of flashing lights, their ability to indicate danger more actively, and their strong association with rail level crossings (i.e., their historical presence). Some drivers expressed confusion regarding encountering traffic lights at a level crossing because they had not had prior exposure to this situation.

The observed violation data are in contrast to previous real-world results [5] that showed 80 per cent fewer drivers crossing during the red traffic light compared to during active flashing lights. The contrasting results may have been due to methodological differences between the two studies. For example, in the present study, only driver responses to active level crossing treatments where an immediate decision was required to brake and stop safely or to proceed through the crossing were examined. This design was deliberate, and while representative of safety-critical situations where an immediate decision to cross/not to cross was required, represents only a restricted set of level crossing experiences. It is unclear whether the proportion of violations would decrease in the active warning conditions if the active level crossing treatments had been activated several seconds earlier.

It is possible that the proportion of drivers who, in this study, did not comply with the red traffic light at a level crossing did this because they were not expecting to encounter such a level crossing control. If the use of traffic lights as level crossing controls was more common in the real world, or if the simulated traffic light control in the present study had been situated in an environment where drivers might be more likely to expect to see one, such as an urban environment, the relatively high number of violations might not have been observed.

Compliance at passively controlled level crossings was unexpectedly low. Forty per cent of drivers made violations of the Stop sign-controlled level crossing. When questioned, only 28% of drivers correctly stated that 'coming to a complete stop' was the required behaviour at this type of crossing, while 68% incorrectly reported the appropriate response to 'slow down and look for trains'.

Participants' understanding and interpretation of the correct behaviour when encountering level crossing controls in a variety of states of activation was quite varied. Of particular concern is the finding that over half of participants believed that the correct behaviour at a Stop sign-controlled level crossing is to slow down, and not to stop completely. This misunderstanding would be expected to have serious consequences at a real road-rail crossing equipped with a stop sign, as these crossings are designed to allow for a minimal driver line-of-sight to an approaching train when a vehicle is in a stopped position.

Previous field studies of level crossing violations [2], as well as road-rail collision statistics, illustrate why the safety of level crossings remains a priority among road and rail safety authorities. The present study assessed driver behaviour at, and understanding of, two different level crossing controls, and raised some subjective possibilities as to why drivers may react differently to different controls. In order to better understand this critical compliance issue, it is important that complementary real-world research also be conducted.

Simulators are excellent tools with which to investigate variables or factors that influence driving behaviour at the operational level; however, it is very difficult, if not impossible, to measure or address higher-order influences, such as motivation and drive, that shapes realistic human behaviour. Another limitation of the present study and of simulator studies in general is that participants were briefed on the general nature of the study beforehand. It is possible that they behaved differently compared to how they might in the real world because they knew they were being observed.

Another critical avenue for future research related to level crossing controls includes their assessment in urban environments. Lower speed limits, as well as increased visual clutter and greater potential for distraction in urban environments, may all impact driver behaviour. Drivers may also be more used to experiencing traffic lights in urban environments and, therefore, the confusion indicated in this study by some participants at the presence of traffic lights at a level crossing may be reduced.

Further, the extent to which a driver is distracted when they encounter a level crossing may interact with the saliency of certain level crossing controls. Given that the saliency of flashing lights was one of the reasons commonly given for the preference of flashing lights over traffic lights, it is important that future studies look at the effect of driver distraction on level crossing control saliency to determine whether crossing controls deemed salient and effective at low levels of distraction remain effective at high levels of distraction. Also relating to the issue of distraction, future studies could examine the potential benefits of in-vehicle train warnings at level crossings

In conclusion, although the present study was limited in that it only assessed driver compliance to level crossing controls situated in a rural environment and under very specific circumstances where an immediate decision was required to brake and stop safely or to proceed through the crossing, the finding that drivers made more violations of Traffic light-controlled level crossings than Flashing light-controlled level crossings suggests that the use of traffic lights in this capacity in real-world situations may not result in any additional safety benefits over and above those provided by flashing lights.

The subjective data provides further support for this notion. However, the reader is cautioned that more research on the issue is necessary before reliable conclusions can be made and on which related policy decisions should be based. Finally, the large number of violations seen with the stop sign condition underscores the importance of continuing to upgrade current passive level crossings to active status.

Acknowledgements

This research was performed under contract for VicRoads. We would like to thank the following members of the stakeholder advisory group for their inputs in project discussion. In particular we note the following members of the stakeholder group for their input to the development of the simulated level crossing scenarios: Mr. Colin Kosky; Mr. Ken Hall, VicRoads; Mr. Peter Upton, V/Line; and Mr. Jim Warwick, VicTrack. We also thank VicTrack for providing detailed data for level crossings scheduled for future upgrades to help inform the design of the simulator scenarios.

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An analysis of road signage and advertising from a pragmatic visual communication perspective: Case study of the M1 Motorway between the Gold Coast and Brisbane

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Abstract

This paper analyses examples of road signage and billboard advertising along the M1 Motorway between the Gold Coast and Brisbane from a pragmatic visual communication perspective. Such a perspective requires that two studies be conducted simultaneously. One study examines how people use designs while the other examines how features of designs meet people's needs.

For this research, the first study consisted of a literature review aimed at determining how people use road signage and advertising. Results indicate that drivers attend to signs differently depending upon personal variables such as driving experience, environmental variables such as traffic density, and sign variables such as the message and visual design.

The second part of the research involved comparing all types of signs along the M1 to best practice in the visual design of roadway information. In this paper, designs that follow best practice were considered to be those that follow principles of positive guidance. As part of this research, the author took photographs of signs in August and September 2008.

Results indicate that research could be conducted on a few types of sign designs. For road signage, it would be useful to study the effectiveness of educational messages placed on variable message signs and whether M1 drivers would find it

helpful to have graphics placed on these signs. It would also be useful to study the use of more mixed-case text and the Clearview font on signs, and the effectiveness of tourist signs. Further, it may be useful to develop a more detailed taxonomy of driver types on which to test signs. For advertisements, it would be helpful to provide additional guidance to billboard designers on making messages more effective and appealing, and to test what creates distracting content. This paper should be useful to traffic engineers, and teachers and students of roadway information design who would like to increase their knowledge of signage design and design research.

Introduction

Signage and billboard advertising along motorways can impart important information to drivers. Signage can provide directional guidance, reassure drivers about their location, indicate sites of local services, state the speed limit, and warn of upcoming changes or hazards. Given the value of such information, it is important that signs be designed and placed so that drivers can locate, read and comprehend them within a timeframe appropriate for changing their plans and behaviour.

Billboard advertising also serves a useful role. According to the Queensland Government Department of Main Roads [1], this advertising is useful both for 'business, as suppliers of goods and services, and for the public, as consumers' (p.1-2). The Department states that billboard advertising is a legitimate form because it takes at most 2-3 seconds to read one advertisement and local businesses depend upon it to direct customers their way. Therefore, billboard designs need to be attractive to be effective. However, although the Department allows billboard advertising, it is important that these signs do not impact upon driver safety. Traffic authorities around the world have long been concerned about whether distraction by billboards can lead to accidents (for example, see Green [2]). An important question, then, is how to make effective billboards that are not overly distracting.

Given the importance of signage and advertising to drivers as discussed above, this paper takes a pragmatic visual communication approach to understanding how the design of such information might be improved and suggesting areas for further research. Cases of signs for discussion are taken from the M1 Motorway between Queensland's Gold Coast and Brisbane. In this paper, signage and advertising are considered together to provide a more complete picture of the information environment.

Taking a pragmatic visual communication perspective requires that the researcher conduct two studies simultaneously. One study examines how individuals use a particular design and the other looks at how features of the design meet individuals' needs. For this research, the author first conducted a literature review of how drivers attend to roadway signs and advertising, and then compared messages on and visual features of different types of signage and advertising along the M1 to best practice in the design of such information. This type of research is useful for establishing what types of drivers are using particular types of signs under what conditions and for what reasons, and how the visual features of signs meet those drivers' needs. It also provides the opportunity to compare signage and advertising along a relatively recent stretch of roadway in Australia to current ideas on signage design.

Research method

The first research step involved reviewing literature on how drivers use different types of roadway signs and advertising. For this study, the focus was on drivers' *attention to these signs*. The second step involved collecting examples of all types of signs and all billboard advertising along the M1 motorway between Brisbane (Exit 2) and the Queensland-NSW border at Tugun. This stretch of roadway was selected partly for convenience, but also because it is a good example of a modern Australian motorway that should follow signage regulations set by the Queensland Department of Main Roads, as well as use relatively current signage research and technology.

Examples of the types of signs collected were permanently-mounted variable messages signs (VMS), and guide, tourist, service, truck-driver message, transit lane and warning signs. Particular cases were selected for discussion based upon how their messages and visual features met the *principle of positive guidance*, which Russell [3] defined as 'the concept that a driver can be given sufficient information where he/she needs it and in a form he/she can best use …to safely avoid a hazard'. (p.155)

A more detailed description of this principle is provided later. Visual features examined in the signs included the amount of information contained on a sign, information arrangement, use and design of symbols, font, colours, relative sizes of typefaces, and redundancy of information. The visual features were then compared to literature on best practice in signage design. To gather examples, an assistant drove while the author took photographs. Photographs were taken with a Sony A100 ten megapixel digital camera on 16 and 18 August and 14 September 2008.

The author also examined messages and visual features in the advertising billboards. This information was compared to guidelines provided by the South African National Roads Agency Limited (SANRAL) [in 4] and research by Van Meurs and Aristoff [5] on how to create effective and appealing advertisements. Conclusions were drawn regarding how messages and visual features of the signage and billboards met guidelines for best practice, and where additional research might be conducted.

A model of driver attention to signs

Although Luoma's [6] eye movement research suggested that drivers look at almost every traffic sign, other research has indicated that drivers attend to signs differently depending upon personal variables such as driving experience and route familiarity; environmental variables such as traffic density, and day or night-time driving; and sign variables such as the message, visual design and placement. In this paper, attending to a sign means reading and processing it. Figure 1 presents a summary of variables that affect drivers' attention to signs.

Figure 1. Variables affecting attention to road signs

Although signs are important, research indicates that it is the road itself that provides most of the information that drivers need [7]. That is, drivers navigate by reading the path of the marked bitumen within the landscape, and noting objects along the road, and the presence and speed of other vehicles. Therefore, traffic authorities can help drivers most by designing, building and maintaining safe roads. That said, however, signage needs to be designed so that it helps drivers when and where they need it. Drivers do not attend to every sign and it is probably not cognitively manageable or safe for them to do so. However, when a driver does need a sign, it should be available and in a useful form to help the particular driver. Therefore, all signs need to be well designed for all types of drivers under a variety of driving conditions.

Attention based on personal goals and characteristics

This section reviews theory and literature on how drivers' attention to signs varies with their driving goals, driving expertise and physical characteristics.

Attention based on drivers' goals

Neisser's [8] theory of attention, which says that attention varies according to people's interests, provides one useful tool for explaining research results on road sign attention. Consider first the difference in attention to signs by younger and older drivers. Milosevic and Gajic [9] found that younger drivers (aged 25 or less) were more likely to attend to signs than older ones (aged between 26 and 55). Using Neisser's theory of attention to explain this difference, novices may better attend to signs because they are just learning to drive and therefore find all signs to be important. At the same time, more experienced drivers have learned which signs are most useful to them and filter out the rest.

Milosevic and Gajic [9] provided other evidence that attention to signs varies according to interests. Their research found that those who drive more than 10,000 km per year, professional drivers and those who are driving on official business are more likely than other drivers to attend to warning signs. The long distance, professional, or official driver appears to have a stronger interest in maintaining a license than other drivers, and therefore cannot afford to ignore warnings (e.g., speed limit signs) that could lead to loss of license and job.

Other researchers provide further evidence that drivers' attention to signs varies according to their goals or interests. Consider the research of Johansson and Rumar [10] and Johansson and Backlund [11], who found that drivers in general are more likely to recall more personally threatening warning signs than other warning signs. These researchers found that drivers in general are more likely to remember signs that indicate a change in speed limit or a police control area than signs that indicate a general, non-specific warning or a crosswalk. Applying Neisser's theory to the results, drivers remember these particular signs because of their personal interest in avoiding speeding fines and police interaction.

Further, research shows that different types of drivers attend differently to a particular type of sign, the variable message sign (VMS). According to Chatterjee and McDonald [12], who studied VMS in European cities, these signs are typically used to display messages about 'hazards, traffic conditions, parking, public transport or the environment' (p.560) with the intent of decreasing driver stress and improving road use efficiency by encouraging drivers onto other roads. The study reported that as few as one-third of drivers notice these signs.

A study by Peeta and Ramos [13] offers insight into who attends to VMS and why. These researchers found that males, younger drivers, those who drive regularly in an area and well-educated people are more likely to attend to VMS to take alternative routes. The researchers hypothesized that each of these driver types wants to save travel time. Another explanation, however, may be that they simply do not like to wait. The researchers believe that males and younger drivers will divert because they are more willing to take a chance on an alternative route, and educated people divert because they value their time more highly. Those who travel regularly in an area will divert because they have a good understanding of alternative paths.

Attention to signs also varies depending upon whether drivers are familiar with a route. Mourant, Rockwell and Rackoff [14] found that drivers on unfamiliar routes are likely to spend a larger percentage of their time, 7.5 per cent, viewing signs than those on familiar routes who spend 5.4 per cent of their time. It is reasonable to assume that these drivers are interested in signs because they need help with way-finding and learning the road.

Attention based on expertise

Borowky, Shinar and Parmet [15] found that experienced drivers have expectations about where particular signs should be placed. The researchers shifted the positions of *no right turn* and *no left turn* signs to unexpected locations and found that experienced drivers were less likely to notice them than inexperienced drivers. However, when the signs were placed as expected, the experienced drivers were more likely to notice them. The results of this study indicate that drivers develop *schemas* or cognitive patterns regarding where signs should be placed and that authorities should therefore design for these schemas.

Anderson's [16] cognitive learning theory, which describes three stages of learning, provides a useful tool for explaining how such schemas develop. When first learning something, Anderson says that we are in the *cognitive stage*, which is when we develop 'explicit knowledge which we can report and of which we are consciously aware' (p.234). In Queensland, drivers are in this stage while studying for the multiple choice test required for a learner's permit.

Anderson's second stage of learning, known as the *associative stage*, describes what happens when learners begin performing and gradually becoming more competent at a skill. During this stage, 'errors in the initial understanding are gradually detected and eliminated… and the connections among the various elements required for successful performance are strengthened' (p.274). Regarding the use of road signs, novice drivers in this stage begin attending to signs and adjusting their behaviours according to messages received.

Finally, during Anderson's third stage of learning, known as the *autonomous stage*, 'the procedures become more and more automated and rapid' (p.275). When in this stage, drivers know how to scan the environment for relevant signs. They have a well-developed schema of where different types of signs are placed and what the signs look like so that they can respond automatically.

Attention based on physical characteristics

One physical characteristic that appears to affect attention to signs is a person's age. Milosevic and Gajic [9] found that drivers aged 56 and over are less likely to attend to signs than other drivers. This finding may indicate that these drivers may have reduced vision, which prevents them from easily reading the signs, or reduced reaction time, which causes them to place more attention on the road and surrounding traffic than on signs. Either cause indicates that design efforts should be aimed at helping older drivers.

Conclusions regarding attention to signs based on personal goals and characteristics

The above research provides some clues on how to design signage to meet drivers' needs based upon their personal goals and characteristics. First, signs should be placed where experienced drivers expect them to be so that they will not miss them. Second, sign content should be short and visually clear so that it can be seen and read quickly by a variety of driver types including novices who need to keep their eyes on the road and traffic, drivers on unfamiliar routes, and older people with reduced vision and reaction time. Lastly, it may be worthwhile to develop a more detailed taxonomy of drivers so as to better understand their particular needs. As Green and Low [17] wrote:

> *In most areas of design, it is possible to create usable artifacts … that serve large groups well. However, there is much work spent in identifying typical users, defining their mental models, doing task analysis, defining goals and testing proposed designs. (p.35)*

Attention based on the driving environment

Research by Shinar and Drory [18] shows how drivers' attention to signs is correlated with both their personal goals and the driving environment. The researchers found that drivers attend to signs better at night because their reduced vision means that they can access less information from the road itself than during the day. Therefore, drivers' interest in signage increases as darkness falls and they need alternative information for navigating. The section of this paper devoted to sign characteristics will discuss research on how to better design signage for night-time drivers.

Changes in traffic density can also affect attention to signs. Bhise and Rockwell [19] found that drivers who were travelling in low-density traffic and following an unfamiliar route spent an average of 2.6 seconds viewing signs that were useful to their way-finding. In contrast, drivers who were travelling in high-density traffic and following an unfamiliar route spent an average of 0.9 seconds. These results indicate that signs need to be designed so that they can be easily read by drivers who need to devote a greater portion of their attention to the surrounding traffic.

Sign characteristics that affect attention

Attention to signs can also be affected by manipulating features of signs themselves. As discussed in the research method section, a useful principle to follow in sign design is that of positive guidance. Ideas covered thus far on meeting drivers' signage needs all fall under the umbrella of positive guidance.

Positive guidance emphasises the principles of *primacy, spreading, coding, and redundancy*. When following the principle of primacy, signs are placed only where needed and in the order needed. When following the principle of spreading, the amount of information is kept within cognitive information processing limits. For example, if drivers need more information at a particular time than they can effectively read and comprehend from a single sign, then the information should be spread across multiple signs. According to Smiley and colleagues [7], a sign is made 'comprehensible through word messages and symbols that have been tested… and shown to be understood by the majority of road users' (p.5). Keeping a sign within cognitive information processing limits also involves ensuring that a sign is *conspicuous*, which means it should 'attract the driver's attention, even in a cluttered background' (p.5).

The principle of coding is that standard information can become more recognizable if it is visually coded in a standard way, for example with the same shape and colour. Effective coding also considers that signs are made *legible* through the 'use of optimum letter fonts and line spacing, and optimum background colour and luminance contrast' (p.5) [7]. Finally, the principle of redundancy is that drivers will be more likely to understand a sign if it provides the same information in more than one way, for example as with both words and an image, as discussed earlier. To these principles, it is also helpful to add another design principle promoted by Smiley and colleagues [7], which is that signs should 'produce the desired driver behavior' (p.5).

Designing for the principle of primacy

Along the M1 section under study, this research noted that the principle of primacy is sometimes violated for one type of sign, which is the VMS. Messages on these signs often contain public service or educational rather than traffic guidance information. Sometimes the signs are blank, but little traffic-related information is given because there is little need for it. Examples of VMS educational messages are 'Every k over is a killer', 'Keep left unless overtaking', 'Report traffic incidents call 13 19 40', 'Slow down stick to the left', and 'Police now targeting defective vehs'. Figure 2 presents an example of one of these signs along the M1.

Figure 2. Example of a VMS along the M1

Regarding VMS messages, Dudek and Ullman's [20] VMS design manual for the Texas Department of Transportation states the following:

Messages will be most effective when they encourage some type of response from the motorist, such as to:

- Reduce speed
- Move out of a blocked or closed lane, and/or
- Take an alternative route (p.3-3).

The M1 educational messages are meant to encourage a long-term behavioural change rather than just an immediate response. On the M1, more research is needed to determine how drivers use these messages. As discussed earlier, since younger drivers attend to more signs than experienced drivers, it is possible that educational messages targeted towards younger drivers may be helpful. However, there is some danger that drivers may ignore these signs altogether if the drivers do not perceive the messages as credible. According to Dudek and Ullman [20], VMS credibility will be reduced if messages are inaccurate, not current (e.g., they remain the same each day), irrelevant, obvious or trivial.

The visual design of M1 VMS messages is discussed under the section titled 'Designing for the principle of coding'.

Designing for the principle of spreading

Figure 3 shows a typical example of a guide sign along the M1, which follows the principle of spreading in that it stays within cognitive information processing limits by presenting a reasonable amount of information in a clear and easy-to-read format.

Figure 3. Example of a guide sign along the M1

Some tourist signs along the M1, however, appear to contain a great deal amount of information and in a smaller size of text, which would make them difficult to read in the short amount of time available. Figure 4 presents an example. This sign may be particularly difficult for older drivers to read.

Figure 4. Tourist sign

Designing for the principle of coding

Signs along the M1 also follow the *principle of coding*, which is that standard information can become more recognizable if it is visually coded in a standard way – for example, with the same shape and colour. This principle also includes the concept that signs should be legible and conspicuous. Returning to Figure 3, guide signs along the M1 all follow a standard format. As shown in the example, each type of information has a unique design created by its position within the sign, choice of upper or mixed-case font, and colouring of the text and background. The font used throughout the sign, which is highly legible, is from the series AS 1744-Standard Alphabets for Road Signs.

The mixed case for the suburb names works well since people can recognise familiar words faster when printed in mixed than upper case [21]. One explanation why people recognise words faster when they appear in mixed case is that the words have a more unique shape. Another explanation is that people are simply used to reading in mixed case and are therefore faster at it.

In recognition and legibility tasks, Garvey, Pietrucha and Meeker [22] compared the distance from which drivers could read signs containing place names that were printed in uppercase and mixed-case text. In the recognition task, drivers were told what word they were looking for and were asked to indicate the moment when they recognised the word on a sign. In the legibility test, drivers were asked simply to read a word as soon as they were able. In the legibility test, there was no significant difference in reading time between mixed case and uppercase for text of the same size. In the recognition task, however, the 'same-sized mixed-case fonts performed significantly better than the all-uppercase' (p.10).

Although the experiment [22] showed no difference in legibility for place names that were presented in uppercase or mixed-case text, there may be a difference for longer phrases composed of more familiar words. Therefore, it may be valuable to test whether a sign such as that in Figure 5 would be read faster if presented in mixed case.

Figure 5. Sign printed in all uppercase letters

For the purpose of reducing irradiation or halation of text on road signs, Garvey and colleagues [22] have designed a font specifically for roadway usage called Clearview, an example of which is shown in Figure 6. Irradiation describes the blurring of text lines against 'high-brightness reflective signage materials' (p.7) (see Figure 7). The Clearview font helps to reduce irradiation by having 'more open interior spaces' so that when irradiation does occur, there are still open areas within letters. The font also uses tighter tracking (the space between letters) so that word shapes are more distinctive. According to the researchers [22],

> Under daytime conditions, the [US] Series E(M) and both of the Clearview fonts had essentially equal readability distances. At night, however, with headlamps and bright signing materials, the Clearview font that took up the same amount of sign space as the Series E(M) resulted in significant improvements in readability distance… This was true in both the legibility task and the recognition task. (p.11)

The researchers reported a 16% increase in recognition distance for night driving. As stated earlier, since drivers generally use signs more at night than during the day and since older drivers may have reduced vision, it would probably be worth testing the Clearview font on road signage under Australian conditions. More than twenty US states have adopted Clearview [23].

Figure 6. Comparison of Australian standard road sign font with Clearview font

Figure 7. Example of irradiation [24]

It is also useful here to discuss the coding of VMS. Along the M1, VMS messages are presented in simple text, which Chatterjee and McDonald [12] have found to cause 'few problems with … legibility and comprehensibility' (p.570). Further, M1 VMS messages are amber-coloured, which in another study [23] was found to be preferred over red or green. In addition, M1 VMS consist of no more than two frames, have no more than two lines of text per frame, and for single frame messages, do not flash. This design follows that set by the US Department of Transportation [25]. Regarding flashing, a study of drivers in a simulator by Dudek, Shrock, Ullman and Chrysler [26] found the following:

> Most subjects (60%) preferred the one-phase static messages to the flashing message (40%)… The most common reason for preferring the flashing message was that it gets the attention of drivers. The most common reasons for those who preferred a static message was that it gives the driver more time to read the message and that it is easier to read. (p.126)

Thus, the non-flashing, single-frame VMS used on the M1 should be the design that is most preferred by drivers.

Designing for the principle of redundancy

The principle of redundancy states that drivers will be more likely to understand a sign if it provides the same information in more than one way – for example, as with both words and an image, as discussed earlier. A study by MacDonald and Hoffman [27] found that placing a symbol in a sign makes it more memorable for many drivers. These researchers studied drivers' attention to signs by asking them to make in-vehicle oral recordings of everything in the driving environment of which they were aware at particular points along a route. The researchers measured attention using a 'ratio of reports mentioning correct sign information to the total number of reports for that site' (p.592), which they named *the level of reported sign information (RSI)*. They found that signs containing a symbol were 'associated with a small but significant increase' in the RSI (p.600).

In another study, Jacobs, Johnston and Cole [28] ran experiments aimed at comparing recognition distance between signs encoded with a pictorial symbol and those with text. They found that that well-designed and easily-encoded symbolic signs are read from greater distances than textually-encoded signs. It is noteworthy that many M1 signs contain symbols (e.g., emergency phone signs, railway station signs).

Wang, Hesan and Collyer [23] studied the effectiveness of using graphics on VMS. They found that graphics helped both native and non-native English-speaking drivers with sign comprehension and response, but helped the non-native speakers more. In this light, it may be useful to study the effectiveness of placing graphics on M1 VMS.

The M1 'Transit Lane' sign in Figure 8 shows excellent usage of symbols. This sign uses a combination of symbols and words to attract drivers' attention to the specific information that describes their situation. The vehicles are presented in their best view, which is side on, and the symbols face towards the text, thus creating pointers towards it. The symbols also provide redundancy in message delivery.

Figure 8. Multi-symbol sign on the M1

Figure 9. Sign designed to attract additional attention with fluorescent-orange border

Redundancy also occurs when the same message is provided on more than one sign. It is noteworthy that along the M1, merge, speed limit reduction and guide signs are presented in duplicate to assist drivers. For example, Figure 9 presents an example of an M1 speed limit reduction sign that is placed and visually designed to maximise attention. Copies of this sign are placed on both the left and right sides of the southbound M1 lanes, and following them are the speed limit signs. The sign also works to attract attention by using larger than usual text and a wide fluorescent-orange border.

Roadside advertising

To give a more complete description of roadway information, it is useful to look at the design of roadside advertising and its place in causing driver distraction. Wallace [2] reviewed literature on distraction from billboard advertising and found that accident rates seem to be correlated with billboards placed at intersections or junctions. He theorised that at such places, if drivers are searching for information, any advertisements might slow reaction time. Wallace found no evidence, however, that billboards in and of themselves cause accidents.

Ady [29] studied changes in accident rates before and after the placement of three billboards. He found that two of the billboards showed no effect, but the third did at the .05 level of significance. This last billboard was placed on a sharp bend. Wallace [2] hypothesized that it caused accidents because it was overly surprising to drivers. On the stretch of the M1 being considered, none of the billboard advertisements are placed in locations that would cause accidents as identified in the literature reviewed by Wallace.

Coetzee [4] noted that it is difficult to define what is a high-attention advertisement, or one that could lead drivers to have accidents. He said that 'it is obvious that advertisements containing human faces or the human body … attract attention' (p.8). According to Wallace [2], problem signs could contain 'primary colours, bright lights… flashing neon, [or they could be] information-rich … (with moving images for example), [or be] sexually or otherwise explicit…' (p.55).

A useful tool for considering what is a reasonable amount of information for a billboard is provided by the South African National Roads Agency Limited (SANRAL [in 4]). These regulations limit the message length of billboard advertisements as measured in bits of information using the criteria presented in Table 1.

Content	Bits
Words up to 8 letters	1
Words > 8 letters	2
Numbers to 4 digits	0.5 bits
Numbers 5 – 8 digits	1
Symbol/Abbreviation	0.5
Logo/graphics	2 bit

Table 1. Bit values of information on signs (SANRAL Regulation 1 in [4])

The bit limits were established based upon reading time, which SANRAL wanted to keep low so that drivers would have time to react to events ahead of them. SANRAL uses the following formula to determine road sign reading time:

T = (0.32N – 0.21) x D [1]

T = Reading time
N = Bits on signs
D = Distraction Factor
D = 1.00 straight roads, less than 5000 vpd (vehicles per day)
D = 1.25 straight roads with 5000 – 30,000 vpd
D = 1.50 freeways, roads in urban areas, more than 30,000 vpd

Other SANRAL regulations useful here for a discussion on billboard content are that they 'may not distract [the] attention of [a] driver in a manner likely to lead to unsafe driving conditions'; 'may not affect conspicuousness by virtue of potential visual clutter'; 'The color, or combination of colors in advert may not correspond with colors of road traffic signs'; messages should be amenable and decent; messages should be concise; 'No advertisement displaying a single message may exceed 6 bits on freeways and 10 bits on other roads'; 'Combination signs, or any other advert displaying more than one message may contain more than 6 bits per enterprise, service or message'; 'Numbers longer than 8 digits [are] not allowed'; and 'No message [can be] spread across more than one advert' [in 4].

While measuring the bits of information on a sign as outlined in these regulations may not be a perfect system, it is useful for considering what amount of information drivers can read safely in the amount of time in which the billboard is legible to them. Coetzee [4] measured this time by making assumptions about the size of text on a billboard. If, for example, text is 1 metre high, then drivers should be able to read it from 500 metres away. The text will remain readable until the billboard is outside the driver's 15 degree cone of vision, as shown in Figure 10. These assumptions mean that a sign is only readable over a length of 350 metres.

If a driver is travelling at 110km/h, which is the maximum speed along the stretch of M1 considered in this paper, then a sign with 1m high text is readable for 11.5 seconds. Based upon the distance at which drivers travel behind one another, which Coetzee [4] says is anything between 10 and 30m in South Africa, there is a margin of 1.5 seconds in which it is safe for a driver to glance away from the traffic at something like a billboard and not run the risk of colliding with a vehicle in front should traffic suddenly slow. Coetzee assumes that a full glance at a sign consists of '3 seconds – 1.5 seconds [for] looking away and 1.5 to assess the road ahead' (p.9). This assumption means that about four glances or 6 seconds of reading time would be available. Substituting 6 seconds into the SANRAL reading time formula yields a maximum of 13 bits of information per 500m. This value is used as a point for comparison of M1 advertising in the following paragraphs.

Figure 11 presents an example of an M1 billboard that presents a large quantity of information. Using the SANRAL guidelines, it is questionable whether drivers would have time to safely read this sign since it contains 29 bits of information and a web address.

Figure 11. Billboard advertisement containing a large amount of information

The billboard in Figure 11 does, however, follow many of the guidelines for creative appeal and advertising effectiveness that are recommended by Van Meurs and Aristoff [5]. They defined effectiveness as the '(average) amount of time it takes a consumer to recognize the product/brand in the first fraction of a second of exposure' (p.83), and measured creative appeal by asking subjects how much they would like to see an advertisement again. The researchers found that creative appeal was higher for advertisements with short headlines that did not mention the brand name or price, featured 'a clear branding product shot' (p.90), showed people against a realistic background, and were coloured predominantly in blue.

To achieve faster product recognition, results indicated that advertisements should include the product name and a product photograph (but the photograph should not be 'in the bottom right corner'), and the photograph should not include a person,

Figure 10. Coetzee's [4] critical zone for reading a billboard (p.9)

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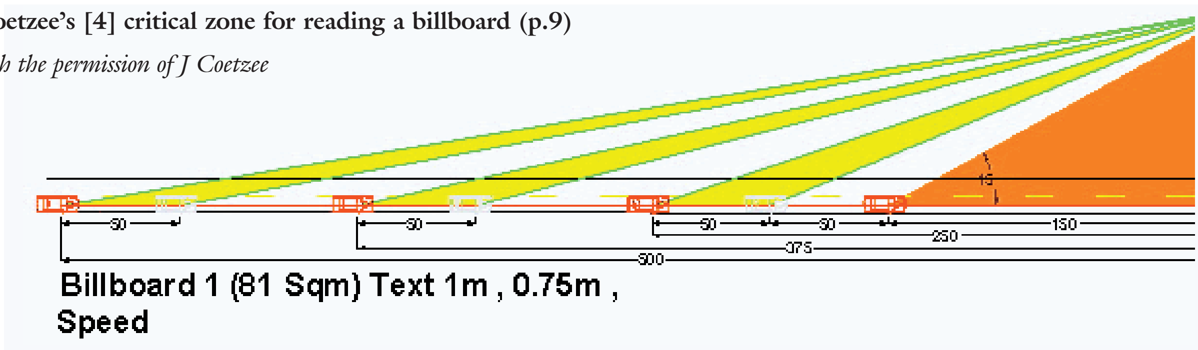

especially one appearing to make eye contact with the viewer. Further, the information content should be low, and the advertisement should use fewer colours and make use of blue but avoid red as the dominant colour. The advertisements should also 'highlight new-product information' and 'use a black font and avoid a white font' (p.89).

To achieve faster brand recognition, the researchers found that advertisements should present the brand in a large font, place the logo in the upper half of the advertisement and not in the 'lower-right corner', keep the amount of information low, 'highlight new-product information', 'include a picture, but … not of a woman or an illustration', keep the advertisement simple with a short headline in a small black font, and avoid humour (p.90).

To create both safer and more effective billboards, it seems important to limit the amount of information presented. Results of the Van Meurs and Aristoff [5] study are conflicting, however, regarding photographs of people. These photographs make an advertisement more appealing but slow down product and brand recognition. More research should be aimed at the effects on advertising appeal and driver safety of showing the human face or body in billboards.

Returning to the billboard in Figure 11, it follows guidelines recommended by Van Meurs and Aristoff [5] since it contains a product photograph, has the product and brand in the headline, has black text, and announces something new about the product. The one design element that could be improved is the logo placement, which should be in the upper half of the billboard and not in the lower right.

Figure 12 presents a billboard that could use better alignment of information to convey its message. It contains 20 bits of information, a phone number, a web page, and an additional message below the billboard. A more consistent layout would allow for easier scanning. It also contains white text in the heading.

Figure 12. Sign with poor alignment

Figure 13 presents four signs that may be overly attractive to some drivers. The Coomera Waters sign may be overly attractive because it contains materials that sparkle in the light, and the others may be overly attractive because of their subject matter and the use of women's bodies and faces.

Conclusions

In conclusion, signage along the M1 between Brisbane and the Gold Coast follows the principles of positive guidance in many ways. By comparing examples of signs and advertisements with research on how drivers attend to signs and visual communication principles for good design, a few issues have been identified for further research. For signs, studies could be conducted on how and which drivers use public service and educational VMS messages; whether more mixed-case text would improve word recognition; whether the Clearview font would improve night-time sign reading, especially for older drivers; and whether a reduction in information content and an increase in font size on some tourist signs would make them more readable.

Further, it may be worthwhile to develop a more detailed taxonomy of driver types on which to test various signs. For advertisements, the issues are in providing guidance to billboard designers on how to make messages more effective and appealing, and in testing what creates distracting content, particular in regard to the presentation of human faces.

Acknowledgements

The author wishes to thank the Faculty of Humanities and Social Sciences at Bond University for funding this research with a Department of Education, Science and Training (DEST) small grant.

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Figure 13. Potentially over-attractive signs

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Work-related road safety as a conduit for community road safety

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Abstract

The aim of this paper is to review the potential of work-related road safety as a conduit for community road safety based on research and practical experience. It covers the opportunity to target young people, family and community members through the workplace as part of a holistic approach to occupational road safety informed by the Haddon Matrix.

Detailed case studies are presented based on British Telecom and Wolseley, which have both committed to community-based initiatives as part of their long-term, ongoing work-related road safety programs. Although no detailed community-based collision outcomes are available, the paper concludes that work-related road safety can be a conduit for community road safety and can provide an opportunity for researchers, policy makers and practitioners.

Introduction

This paper is based on a combination of research [1], discussions with industry experts [2-4] and applied practical experience with organisations like the two cases described below; it aims to identify the ways in which work-related road safety can be a conduit for community road safety. From a research perspective, a recent major review of work-related road safety in Australia [5] indicated that there may be some type of 'work driver effect' that could be harnessed in a positive way to improve road safety in the wider community, in that if work drivers could 'take safety home', employees' private driving would be safer and their influence on family members could be positive. In particular, the review cited DuPont. One of the motivators for its extensive work-related road safety program in Australia and around the world is the humanitarian and business benefits, where crashes occurring during a driver's private time, or involving their family, will inevitably affect their working life. Clarke [6] also focused on the safe driving of family members. More recently, Murray et al. [7] identified a growing trend for large, brand-conscious organisations to focus on road safety in their organisation and in local communities as an integral element of their corporate social responsibility (CSR) programs, in many cases working with agencies such as the Global Road Safety Partnership and the road safety charity Brake.

Many issues remain unknown, however. These include:

- Does the influence of organisational safety culture remain with drivers after leaving the work environment?
- Can organisations gain political or public support through a well managed safety program?
- To what extent can organisations gain a competitive advantage by being ahead of, and helping to shape, road safety policy and laws?
- Does a good safety reputation help recruit and keep better quality, more loyal employees?
- From an image perspective, can a work-related road safety program have marketing, image and branding benefits – for example, with regulators and customers – for personal, organisational and community gain?
- What are the negative aspects of corporate road safety programs [8], and how can they be overcome?

While it is beyond the scope of this paper to address all these questions in detail, the remainder of the paper will focus on how these ideas were developed into practical outcomes, including a summary of the relationship between safety and marketing, and how the large corporations British Telecom (BT) and Wolseley have successfully tailored road safety interventions for young workers, family members and the local community through the workplace as part of their CSR and community development programs. The paper also aims to show how a risk factor categorisation tool, known as the Haddon Matrix, has been adapted and used by organisations to build community-based initiatives into their wider work-related road safety programs.

Work-related road safety, CSR and marketing

Many organisations have large and distinctive fleets and it is important for both employees and customers that they demonstrate a proactive approach to managing foreseeable risks. Due to their public exposure, it is in their best interests to inform customers of road safety initiatives and their outcomes.

Corporate social responsibility (defined as the role of organisations in protecting people, profit and the planet) has grown increasingly important. Many organisations now have a CSR strategy or statement of intent. In recent years, more proactive organisations have begun to see the link between CSR and road safety – which clearly has a potential impact on people, profits and the planet. Good work-related road safety helps to protect people from injury, saves money and is good for the environment. Several examples of positive work-related road safety CSR, including Johnson & Johnson, Shell and others, are described by Murray et al. [7]. Overall, from a societal or CSR perspective, there appear to be many good reasons for organisations to focus on community initiatives as part of their work-related road safety.

Over the last few years, the authors have discussed the relationship between work-related road safety and marketing with many stakeholders and published a brief guidance paper on it [9], in part influenced by the work of Laflamme et al. [10]. Many stakeholders at workshops, in-company events and conferences (for example, see [2-4]) were asked to think of two extreme options:

1. An organisation has a major incident on which their marketing/public relations (PR) department will have to spend a great deal of effort on damage limitation to manage the 'crisis', suppress any bad publicity and protect the brand.
2. An organisation wins a prestigious safety award, speaks at a major conference about their initiatives or is involved in their local community. This provides at least three opportunities to enhance brand reputation – through positive PR, the media power of the organising body and via local community groups.

Perhaps not surprisingly, option 2 was always the preferred choice.

As an example, organisations actively involved in initiatives, such as the UK National Road Safety Week organised by the road safety charity Brake, are mentioned in almost every local and national media outlet around the country. For only a small investment of time/funds, this allows active participation in the local community and provides a great deal of media coverage. Internal Brake data made available to the authors suggest that Road Safety Week alone has generated the charity over £7.1 million of 'free' media coverage for road safety over the last three years.

Based on experiences over the last few years, there is no doubt that good safety performance can guarantee much more media coverage and speaking opportunities on the safety, transport, fleet, environmental and management conference circuit and opportunities to contribute to industry publications than any amount of planned business development activity. In other words, there are tangible marketing benefits from safety, and in the cases described below, the safety professionals involved have communicated and worked closely with the marketing/PR people in their organisation to gain maximum internal and external publicity for their initiatives.

As well as external coverage, this can also benefit safety performance internally, as a large element of safety improvement work by both government and organisations involves marketing and communication – persuading people to change the way they behave. This means that working closely with, learning from and gaining the support of marketing people in organisations can help safety champions to develop better internal marketing campaigns aimed at promoting safer driving, and importantly confirm and reaffirm the importance of work-related road safety to senior managers. Particularly in larger organisations, experience suggests that this is of vital importance in making the business case to invest time and resources. In making this business case, such programs are important for a number of reasons, which have been identified through previous research [1, 5] and cases [11]:

1. Society – using the road is the most dangerous activity most people undertake. People aged under 25 are particularly at risk, making up approximately 10% of drivers in most developed countries, but being involved in 25% of fatal collisions [12].
2. Legally organisations have a duty of care to follow the rules of the road and ensure that their people drive carefully, in vehicles that are roadworthy, licensed, certified and insured.
3. For the business, it is important that employees and their family remain fit and healthy – and avoid being involved in collisions. Taking the DuPont line mentioned earlier, if employees are off work due to their own or a family member's injury, it has a major impact on company performance.
4. From a financial point of view, road accidents involving employees or their family members are very expensive. Wheatley [13] quoted Australian Industry Commission data, which estimated that the costs of road accidents at work are shared 40% by the employee, 30% by the employer and 30% by the community. In accidents at home or involving family members, the costs are met totally by the employee and the community.

Safety can also help support an organisation's marketing effort to get involved in their local community. As Figure 1 shows, many work related crashes happen close to home, meaning that fleet operators have a major impact on their local community, including their own employees and family members. These data were based on UK Department for Transport funded research with 50 organisations [14], and similar patterns have emerged in other unpublished studies with a range of organisations around the world. Particularly when organisations operate in certain territories, or on quite fixed stopping and starting locations, many vehicle collisions happen very close to home, or at regularly visited locations. This means that organisations can have a major positive or negative impact on the road safety in the communities in which they operate.

A fleet risk-management program can have wider benefits for the organisation than just safety. Based on our experiences observing and working with major organisations all over the world, there appear to be clear links between work-related road safety and other core business activities such as quality, efficiency, the environment, marketing and branding. It also gives an opportunity to play a wider role in the community, be seen as proactive about its corporate responsibilities to people and the planet, and to enhance its reputation. Finally, a fleet safety program can help to enhance safety and to meet transport, safety and other legal obligations.

This is important because many issues described in this paper are much wider than just road safety. For example, how do wider business changes affect people's driving safety? How do work schedules, payment systems and bonus schemes affect the

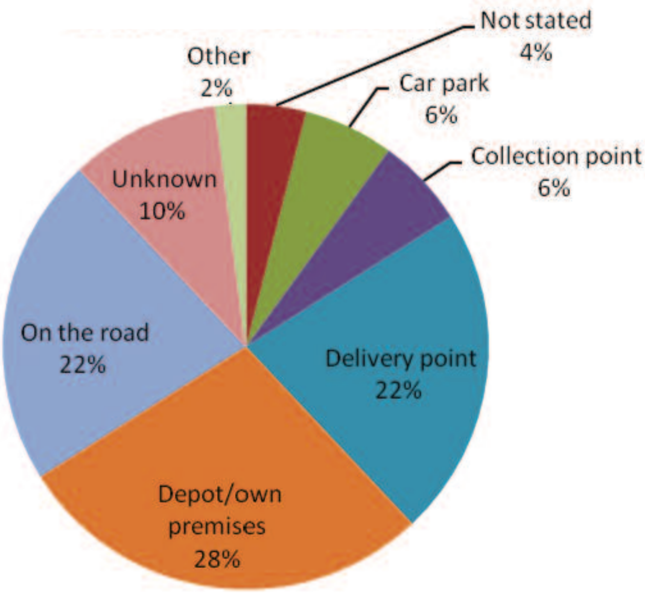

Figure 1. Fleet vehicle collision locations, based on data from 50 fleets[1]

risks drivers have to take? What work instructions are staff given and how do they affect driving? Have any business changes affected the way people report incidents?

An effectively run 'culture/community/management-based' program can motivate managers and staff to become change agents who lead by example and also bring many wider business, branding and corporate social responsibility opportunities. For this reason, we have developed a road safety model, based on the Haddon Matrix [15-18], and extended it [7, 11] in Figure 2 to include community engagement as a key component.

Although there are many positive aspects to such programs, questions have also been raised about the 'corporatisation' of road safety [8] – particularly, for example, where the power of the motor industry focuses road safety investments on vehicles rather than changing policy on land use planning and safer modal choice issues.

It is important, therefore, that such initiatives are based on sound science and well researched road safety and journey planning-based interventions that reduce exposure and promote safer and more sustainable ways of travelling and communicating, as well as safer driving and vehicles. In this regard, the road safety model informed by the Haddon Matrix provides a very useful framework that an increasing number of organisations have utilised to help focus on improving their road safety – and obtaining the many societal, legal, business and cost benefits that it can bring. Two cases are described below.

Examples of successful corporate community road safety programs

Case studies from BT and Wolseley are presented to highlight examples of how community road safety outcomes can be successfully achieved by organisations as part of their wider fleet safety initiatives. Both organisations have used the Haddon Matrix and identified the importance of their role in society through the types of external road safety initiatives listed in the final column in Figure 2. For example, both are regularly invited speakers on the fleet safety conference circuit and both have embraced initiatives such as Road Safety Week, the European Road Safety Charter, Private Sector Road Safety Collaboration and the UK government-backed Driving for Better Business program as a way to launch, invigorate and communicate road safety initiatives. A range of cases of other organisations that have also embraced community road safety are described by the UK road safety charity Brake [19] and in other research involving the authors [1, 7], but the remainder of this section focuses on BT and Wolseley.

British Telecom

BT has approximately 44,000 cars and light commercial vehicles driven mainly by engineers and managers. A further 50,000 BT staff may be called upon to drive while at work. Since 2003 when BT's Health and Safety Group identified driving as its biggest and most expensive risk, BT's quarterly meeting Motor Risk Management Forum (MRMF) has worked on a range of innovative work-related road safety initiatives, including a detailed 14 element work-related road safety strategy based on the Haddon Matrix. Element 12 of the strategy says:

> Online driver assessment and training tools freely available to family members of BT people and non Occupational Drivers to promote the community road safety agenda. In-vehicle training heavily discounted for family members, via BT Benefits Plus program.'

BT has invested a great deal of time and financial and intellectual capital in road safety and is highly committed – not only for BT, but also for the local communities in which it operates. Due to its scale and commitment, BT has the potential to influence general road safety within the wider communities in which it operates for the benefit of society as a whole, particularly in the following ways.

1. As part of its wider Corporate Social Responsibility (CSR) program, BT works as a Corporate Partner with road safety charity Brake, including hosting a number of high-profile projects and events in recent years. It is also involved as a Champion in the Driving for Better Business Program supported by the UK Department for Transport, and has signed the European Road Safety Charter, committing itself to some very ambitious road safety targets.
2. By working closely with vehicle manufacturers, BT has influenced them to change the safety specification of their vans. Due to BT's scale, they have then become standard features, meaning that the wider van-buying public and eventually society get better and safer vehicles. BT and other fleets sell their vehicles on typically within three years, so the

Figure 2. Summary of work-related road safety program countermeasures in the adapted road safety model based on the Haddon Matrix

	Management culture	Journey	Road/site environment	People	Vehicle	Society/community/brand
Pre-crash	Business case Policy and procedures Organisational climate tools Management structure Board level champion Safety or quality-led Safety committee Safety pledge Contractor standards	Travel surveys Purpose Need to travel Modal choice Journey planning and route selection Shifts/working time	Risk assessments Guidelines Site layouts Road improvement	Select Recruit Induct Handbook Assess Train Driving pledge	Selection Maintenance Checking Telemetry to monitor	Marketing program Community involvement Safety groups Road Safety Week European Road Safety Charter Driving for Better Business Conference circuit CSR, media and PR Safety awards External benchmarking Regulator briefings and involvement Family/young driver program
At scene	Emergency support to driver		Manage scene	Known process to manage scene	Crashworthy Telemetry to capture data	Escalation process
Post-crash	Report, record, investigate and evaluate Review & Change manage	Debrief and review	Investigate and improve	Driver debrief Counselling & support Reassess/train	Investigate Telemetry data Vehicle inspection & repair	Manage reputation and community learning process

more safety features they have, the safer the overall UK vehicle fleet will be in a relatively short time.

3. Detailed analysis identified that a significant minority, in the region of 5%, of BT's motor vehicle collision claims involved family members driving BT vehicles. This led to new policies and procedures, a communications program and family members being offered access to an online training module called One More Second, supported by discounted on-road defensive driver training. This initiative was launched to coincide with Road Safety Week 2006, and is now re-launched annually as a community initiative. So far, over 4000 BT family members have logged onto One More Second. If each employee could persuade one of their family members to take part, over 100,000 people in the community would be affected.
4. BT's Group Risk Manager has become a sought-after speaker on the 'work-related road safety circuit' and has undertaken many motivational speeches on the issue in the UK and overseas during the past six years.
5. BT has engaged with other fleets to work together and benchmark their performance, with BT being a founder member of the Fleet Safety Benchmarking Group (www.fleetsafetybenchmarking.net).
6. BT has an ageing population pyramid amongst its workforce, and in recent years has been recruiting a large number of young people into its business as apprentices. General road safety research and BT's own internal data have shown that young drivers and new starters are statistically more prone to collision involvement than older drivers and existing staff. For this reason, the company has focused heavily on young drivers and new employees through its Apprentice, Induction, Starting Point and Van Familiarisation initiatives.

Limited evaluation data are available at this time to assess the effectiveness of these community-based initiatives. Discussions and ongoing work with BT, however, have confirmed that they have derived many benefits from their work-related road safety programs, including the following:

- Monthly claims rate reduced from 60 per 1000 vehicles in 2001 to 30 per 1000 vehicles in 2009 (Figure 3) and significant cost reductions in the region of £10 million per annum
- Managers and drivers achieved personal scorecard targets

- Profile, awareness and brand raised internally and externally, including major contribution to Corporate Social Responsibility (CSR) program
- Led to internal and external funding for program (e.g., Driver of Year prizes funded by insurer)
- Cost-effective targeting of interventions and training for the 5% of drivers who were most 'at-risk' and 75% of drivers identified as being at 'medium risk'
- Visibility, integration and indexing of assessment data with previously 'invisible' training and crash data
- Reduced fleet's calamity claims premium and employer's liability (EL) insurance costs
- Established safety credentials – 65,000 drivers risk assessed and 35,000 trained either online or in-vehicle, and more than 2000 managers trained
- Allowed proactive management of key government agencies and regulators
- External recognition received, including the Brake Fleet Safety Forum, Prince Michael Road Safety, Fleet News, European Strategic Risk awards, European Road Safety Charter and Driving for Better Business.

Wolseley

With operations in Europe and the Americas, Wolseley is one of the world's largest building and plumbing suppliers to both trade and private customers. It operates more than 1800 retail outlets across the UK and Ireland. To support this massive outlet network, Wolseley operates a fleet of around 3000 commercial vehicles and a similar number of company cars.

Wolseley's Fleet Safety Steering Group (FSSG), established in 2004, meets quarterly, and comprises internal managers from health and safety, transport, operations and fleet. It also has many influential external participants, including its fleet insurer, insurance broker, fleet leasing company, accident management company and risk management advisors. Over the past three years, the FSSG has made a great deal of progress (described in detail in [11]). Many initiatives have been, or are in the process of being, implemented based on the Haddon Matrix shown in Figure 2. One of these is a focus on community road safety, which is seen as an opportunity to develop the company's brand in the communities in which it operates.

As an example, during 2006, 2007 and 2008, Wolseley actively supported National Road Safety Week, run by the road safety charity Brake, as part of its comprehensive drive and investment in work-related road safety. Events and initiatives arranged for the week by Wolseley were aimed at urging all employees and their families to travel safely.

The company's extensive health and safety program features a regular monthly communication designed to promote a safe working environment across all Wolseley locations. For two years the November Essential Safety Theme supported the National Road Safety Week theme. The company's Essential Safety Theme pack, issued to all location managers, consisted of a Wolseley poster campaign for fleet management, briefing notes and a simple checklist – plus thousands of posters from Brake focusing on various risks associated with road safety. Employees were required to sign and acknowledge that they had read and understood the key messages relating to work-related road safety highlighted in the theme and the posters.

The main theme of Brake's Road Safety Week in 2006 was the safety of young drivers, as this group is involved in a disproportionate percentage of the fatal collisions on UK roads. For this reason, Wolseley invited all its first year graduate recruits to participate in the company's online driver RoadRISK assessment program. The assessment, developed with the company's insurers and risk management advisors, enables the identification of potentially 'at risk' drivers, so that preventive measures can be taken.

In addition, the company showed the Brake road safety DVD 'Busy Enough to Kill' to all graduates based at its UK head offices. The DVD is full of case studies of events that have caused families to lose loved ones due to unsafe driving practices. All graduates who attended were also given a copy of the Wolseley Company Car and Safe Driving Handbook, which contains tips and guidance on company safe driving policy, procedures and best practice.

To demonstrate Wolseley's commitment to employee and community road safety, the company sponsored two giant Road Safety Week banners, which were placed in prominent locations in the two head office towns. In addition, a number of provisional driving licence-holder students from a local school were provided an opportunity to attend a practical and theory-based safe driving workshop hosted by Wolseley's national fleet training company.

For Road Safety Week 2007 where the theme was vulnerable road users, a more comprehensive program was implemented, and the company's Safety, Health and Environment Manager successfully challenged all the internal and external members of the company's Fleet Safety Steering Group to pledge to undertake at least one positive road safety action during the week. One example is the fitment of 'cyclist beware' (Figure 4) decals on all its commercial vehicles, partly as a result of research showing the high risks that cyclists face when travelling near trucks.

All the work-related road safety initiatives Wolseley has put in place over the last few years, including its community-based programs, have brought many benefits to the company, including the following:

- Independent fleet safety audit results showed improvements in all areas and against industry standards
- Collision data and insurance loss ratios have improved substantially, with approximately 1000 collisions a year avoided
- Uninsured loss recoveries alone have funded the program, and insurance premiums have reduced

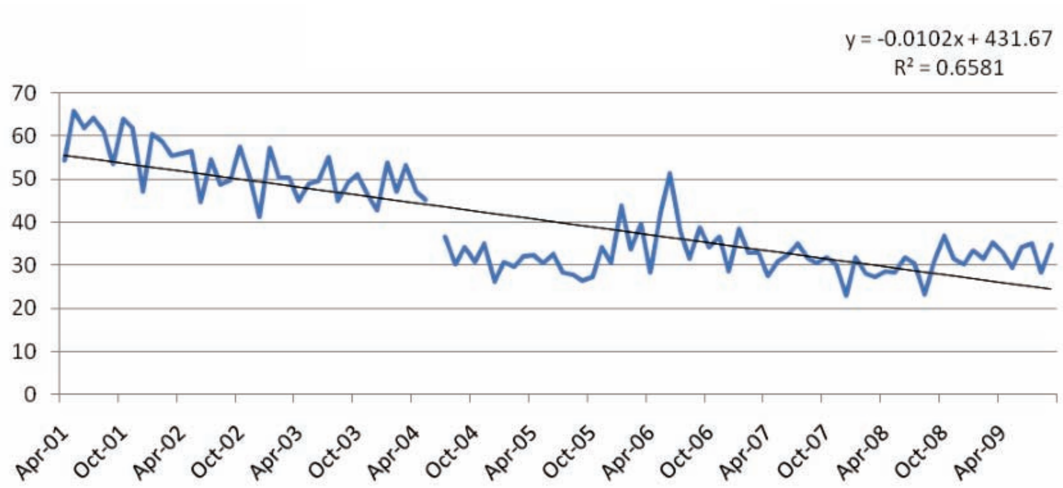

Figure 3. BT claims rate per 1000 vehicles 2001-2009 (Source: Internal BT fleet data)

- Important external recognition has been received from Brake, the Prince Michael Road Safety Awards and the Royal Society for the Prevention of Accidents.

Figure 4. Wolseley cyclist beware decals

Discussion and conclusions

An increasing number of organisations are proactively managing the road safety of their workers and of members of the communities in which they operate [1, 5, 6, 7, 11, 19]. Based on the discussion and case studies in this paper, focusing on community road safety as one element of a wider fleet management program can lead to positive community-based road safety initiatives. Externally, large employers have such a presence locally that they can do a great deal to affect the local communities in which they operate. As shown in the BT and Wolseley cases described, such initiatives include the following:

- Building in road safety as part of the organisation's CSR strategy
- Joining and being proactive members of safety groups such as Brake, the Private Sector Road Safety Collaboration, Fleet Safety Benchmarking Group and Driving for Better Business
- Being involved in Road Safety Week, the European Road Safety Charter and other local community events
- Entering award schemes to encourage, promote and evaluate good practice initiatives
- Including family members in safety initiatives and communications
- Presenting papers on safety at relevant conferences
- Doing PR and publicity around safety performance
- Developing an ongoing 12-month rolling program of work-related road safety initiatives
- Working closely with industry regulators, and inviting them to review and comment on aspects of the operation
- Developing a 'pledge to drive safely' program to engage employees and local communities
- Having a post-event escalation process to manage reputation and community learning
- Linking safety and environmental initiatives, particularly through smarter ways of working involving less need to travel, optimised journey schedules to minimise mileages and opting for safer transport modes.

Although evaluating the direct road safety outcomes of such programs is difficult, at the very least they provide clear CSR, community building, PR and brand development benefits. This approach is sometimes criticised as being merely marketing or the corporatisation of road safety by large organisations with vested interests [8]. However, as long as there is substance and a sound road safety basis for the program, such initiatives are a positive step and should be encouraged.

The examples of BT, Wolseley and others [1, 7, 19] show that there is an opportunity to engage corporate organisations, and individual managers within them, in road safety initiatives for the benefit of the organisation, its workers and the wider communities in which they operate.

In the cases described, individual managers in the organisations identified the benefits that such a focus on the community could bring both to them as individuals and to the organisation as a whole. The multiple road safety awards and company and personal recognition obtained provide an indication of the opportunities.

Based on the experience of BT, Wolseley and others, work-related road safety can be a conduit for community road safety programs. The workplace is an opportunity to target young drivers, family members and local communities – who are a captive audience because employers affect them economically and have a degree of control over them. In both the cases described, there are several things in place that provide a good practice guide for researchers, policy makers and practitioners wishing to replicate such programs:

- The organisations already have in place a business model; a holistic approach based on the Haddon Matrix that shows the societal, business, legal and cost reasons to improve road safety; and processes that can easily and naturally be extended to young workers, family members and the local community.
- Proactive health and safety managers who can see, or have data to show, the benefits to themselves and their organisations of investing some time, resources and energy in community engagement as part of their CSR and brand-building initiatives.
- Support from senior managers in the organisation and external agencies, including willing suppliers, contractors and sub-contractors.
- Regular opportunities to review and promote safety outcomes – for example, through board reporting, benchmarking, award schemes and other outreach opportunities such as conferences and research.
- Detailed evaluation and continuous improvement programs in place, focusing on both process and outcome measures. This means that although the impact of the specific community-based initiatives cannot be quantified, the overall programs can be on several legal, business and cost-based indicators.

Overall, work-related road safety can be an excellent conduit for community road safety. Organisations can gain many benefits, some that can be quantified and others that are more qualitative. Research and practice is continuing in this area, with an increasing number of corporate organisations making successful business cases for engaging with initiatives such as Road Safety Week and the European Road Safety Charter.

Notes

1 **Data for Figure 1**

Not stated	4
Car park	6
Collection point	6
Delivery point	22
Depot/own premises	28
On the road	22
Unknown	10
Other	2

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